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Research on the Assessment of Specific Barriers to District Heating Deployment in Ireland

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Summary for All

This report has been developed to support decision makers in Ireland to take the next steps in expansion of district heating, targeting the identification of barriers that need to be overcome. The report is of a non-technical character and the intent is that anyone interested in understanding more about district heating, and the district heating context in Ireland, should be able to understand and assimilate the content of the report.

Part of the report targets knowledge transfer from other district heating markets in the EU. Section one, for example, contains an overview of what district heating is and how price models are configured. The report also sheds light on how district heating has developed in different markets and the characteristics of district heating in mature, expanding and new district energy markets are presented. Earlier experiences can serve as input to how district heating policy can be built for the Irish context. Policy pathways are displayed and important aspects to consider from an Irish policymaking perspective are highlighted. Additionally, financing options for an Irish roll out of district heating are addressed – an important aspect to consider- taking into account that district heating is a capital intensive infrastructure with a long, operational life.

Last but not least, customer awareness and how DH uptake can be triggered are discussed, based on 22 interviews undertaken with DH companies and DH customers in six European countries. In dialogue with the respondents, advice from existing district heating professionals and customers, has been included in this section.

Executive Summary

This study was undertaken to meet three objectives. These are:

(1) **Objective 1:** To consider the costs of district heating deployment in Ireland including estimated costs for domestic connections to a district heating network.

(2) **Objective 2:** To consider the appropriate policy and financial supports to be provided (where district heating meets the definition of efficient district heating under the Renewable Energy Directive (recast of 2023)) to support overall capital costs in delivering district heating as well as to support domestic and commercial network connections consistent with other decarbonised heat sources.

(3) **Objective 3:** To review examples of the implementation of district heating networks in other jurisdictions from an end-user perspective, in terms of awareness raising and how the development of networks is communicated, how applications for connections are managed and interventions to boost uptake of district heating.

The report is structured around these three objectives and addresses each of them in turn. The main takeaways, per objective, are presented below.

Key Takeaways on the Costs of District Heating (Objective 1):

Reviewing the CAPEX/OPEX structure of several heat supply alternatives, the conclusion is that when evaluating capital costs of district heating systems, the value of electricity generated for example by Combined Heat and Power (CHP) along with fuel availability/acceptability in terms of emissions, constraints on power availability and OPEX costs (compared to individual heating solutions) must be weighed against upfront investments to make fully informed adoption decisions.

In existing district heating markets, combustion-based technology such as CHP technology dominates as a heat source. In the Nordic countries, the main driver for district heating was the demand for electricity and heat leading to initial fossil fuelled installations. After the oil crises, fossil fuels were phased out and replaced by other high temperature combustion alternatives such as biomass. Over time, there has been an increasing interest in using heat sources that are otherwise wasted in district heating systems, like waste heat from various urban infrastructures (IT, transportation, and sewage) and from industries.

A shift towards larger volumes of heat supply from non-combustion heat sources is seen across Europe, making the network the main asset of a district heating grid. The ability to resort to the most cost-efficient heat source at different points in time, ensures flexibility and gives rise to an ability to store heat. Against this backdrop it is important, in the Irish context, to consider a combination of heat supplies to find the most efficient mix for Ireland.

Connection costs are difficult to identify across countries in the EU since this data is not readily available. The data is not usually publicly available and oftentimes requires a direct request to the district heating companies to access it. A range of costs across different markets are presented in this review.

A key driver of connection costs is whether the heat exchanger is included as part of the connection and the distance from the building to the district heating network. In the mature markets reviewed in this study, district heating companies are increasingly interested in controlling as much of the heat supply as possible. Secondary systems (the part of the district heating system that the customer owns and operates) are often associated with inefficiencies as it is difficult for the district heating companies to ensure that the heat transfer is carried out as efficiently as possible (rendering a low return temperature of the heat which supports the efficiency of the overall system). To motivate the customers, motivational tariffs have been developed in some countries that incentivize customers to behave in a way that is efficient for the system as a whole. One trend that is emerging in mature markets, identified in the interviews carried out as part of this study, is that the district heating companies want to own and operate the substations located at the customer buildings. Offering customers a service where they do not have to worry about the substation is becoming increasingly popular, reflecting the overall trend of energy as a service being in demand.

Key Takeaways on relevant Policy and Financial Support to be provided to support District Heating expansion in Ireland (Objective 2):

An efficient policy takes local constraints into consideration (including local structures, control mechanisms, politics, skills and culture). For Ireland, an important starting point is to understand at what geography district heating should be planned and developed: local, regional or national? It is, for example, important to decide on which elements of policy should be centralized and which should be delegated to local government. It is also important to identify that district heating is part of an overall energy system and its impact on the system must be accounted for when rolling the technology out. Additionally, fostering sector coupling should be investigated. Ireland has an opportunity to develop DH in the context of the wider energy system. This may be critical as the viability of DH schemes without access to large amount of waste heat sources might be partly dependent on access to keenly priced electricity.

Over time, different circumstances in different countries have propelled district heating development. In Sweden, for example, a need for more electricity in the 1950s and 60s drove district heating development which started up in the municipal context. Ample funds were invested over time (1970s to 90s) to transition away from fossil fuels (to biomass). In Ireland, the main driver for the development of district heating is not the need of additional electricity but rather a need to phase out fossil fuels. The context of Ireland is different than the context in which district heating expanded in Sweden decades ago. Ireland resonates with the ambition of the EU of climate neutrality and the logic of green investments for decarbonization, a context where commercial viability for district energy expansion is imperative. To reach commercial viability many decisions need to be accounted for; establishing an efficient market framework, initial mandating for system developmentand establishing a critical mass of skilled professionals and contractors on the market are examples.

The DH return profile is such that the return profiles for DH projects tend to be low and many schemes are likely to require capital funding support. Projects are likely to need significant development funding to develop early-stage concepts and move them through commercialisation to delivery. The Irish Government should consider whether it wishes to provide and amend proposed market mechanisms to include DH. There are public debt products but also private finance. The Irish Government should consider whether it intends to make or work with the EIB to make public debt products available to DH and it is important to consider at an early stage of the development of the DH market whether private finance will be welcomed into projects.

Key Takeaways on District Heating from an End-User Perspective: Awareness, Uptake and New Customers (Objective 3):

20 interviews were performed with district heating companies and end-users in mature markets (Sweden, Denmark, Finland), an expanding market (Germany) and new markets (Spain and the Netherlands).

Awareness raising:

In terms of the unique selling points of district heating, the aspects of comfort, a resilient system, price competitiveness and a green solution are mentioned by respondents across countries. In all markets, new customers are often identified by being part of the city planning process and respondents from district heating companies note that being synchronized to municipal development plans is critical. In the mature markets and in Germany, customers often contact the district heating company to connect but there is also active outreach to interested new customers. In Germany, a new building code has been important for increased uptake of district heating.

A similar situation is present in Spain where district heating improves the energy class of buildings. In Spain outreach to customers is important. During the interviews with district heating companies in Spain, three different actions were identified. One company works closely with the municipality and its planning process, one establishes a local office in cities that the company wants to enter, and one company engages with the providers of substations to the buildings rather than the building owners themselves.

In the Netherlands, a new Heat Bill is coming into force. Within this Bill, private district heating companies will need to become a public-private collaboration with at least 51% public ownership. This upcoming change has halted the expansion of existing, private district heating companies whereas new municipally owned companies are being established.

District Heating Uptake:

In the mature markets, none of the district heating companies resort to heat density as a main indicator when deciding to invest in district heating expansion. In Germany, one of the companies addresses heat density as one of several measures considered. The same applies to two of the Spanish district heating companies. More important than one key parameter, is the overall analysis of the neighbourhood. The composition of buildings, if there are large buildings in the area that can serve as “anchor” customers and future development plans of the city must be considered.

In the mature markets, the concept of energy as a service is discussed by respondents, which can increase the overall system efficiency and also generates a gain for the customer (win-win arrangements). Again, in the mature markets, motivational tariffs are applied to some extent. In Germany, Spain, the Netherlands and Denmark there is support for district heating expansion.

New Customers - Managing District Heating Applications:

All respondents, across markets, said they do not have a queuing system or waiting list for connection to a district heating network because of the customer dialogue they have, making such a system redundant. No district heating company necessitates new buildings to be connected to be at a specific energy efficiency level. The energy efficiency of the building is only required to be known if a low temperature system is installed.

In the mature markets, the oversizing of the systems that occurs as energy efficiency measures are undertaken over time, has freed capacity up to expand the grid. Hence, in retrospect, the oversizing of systems fitted to energy inefficient buildings, has been an efficient way to expand district heating over time.

In the mature markets, customers that combine district heating with a heat pump exist. This can be troublesome because the building owner will use the heat pump when electricity is cheap and district heating is reduced to a peak load. In the mature markets the price model has been adjusted to manage this kind of customer. In Germany and the new markets, customers combining the two systems are not common.

Objective 1

Objective 1 of this study aims to consider the costs of district heating deployment in Ireland including estimated costs for domestic connections to a district heating network.

To reach this goal, a desk review has been undertaken focussed on understanding how district heating has been rolled out in mature and maturing district energy markets in Europe. The review encompasses existing studies including the SEAI National Heat Study and additional information that the partners have developed (Codema and Resourceful Futures, working with the Swedish Environmental Institute) prior to this project.

1. Introduction

1.1 History of District Heating

To understand how to efficiently expand district heating, it is important to have a basic knowledge of how district heating systems work. This section provides an introduction to district heating and its development. Subsequent sections focus on shedding light on the costs of district heating deployment in Ireland including estimated costs for domestic connections to a district heating (DH) network.

DH is an old technology for providing buildings with heat and hot water. The first commercial systems were introduced in the US in the 1870s (Collins, 1959). In the 1920s, the European systems started to become common. The planned economies of the Soviet Union and China introduced district heating in the 1930s and 1950s, respectively. Today, Moscow, St. Petersburg, Beijing, New York, Kiev, Seoul, Warsaw, Berlin, Hamburg, Helsinki, Stockholm, Copenhagen, Paris, Prague, Sofia, Bucharest, Vienna, and Milan are examples of cities with large scale DH systems (Werner, 2017). Currently, the main user categories of district heating are industries and buildings. These customers consume approximately 3194 TWh of heat from DH (IEA, 2016). Russia, China, and the European Union are responsible for 85 percent of these heat deliveries (Collins, 1959).

District Cooling (DC) systems started to develop in the 1960s. Major DC systems appear in cities such as Singapore, Tokyo, Stockholm, Paris, Dubai, Chicago, Toronto, Courbevoie outside Paris, Helsinki, Barcelona, Vienna and Berlin. Current annual district cooling deliveries can be estimated to be around 83 TWh per year, thereof around 56 TWh in the Middle East, 22 TWh in USA, 4 TWh in Japan, and 3 TWh in Europe. The volumes of district cooling deliveries in the world are significantly smaller than DH deliveries (Collins, 1959).

1.2 How District Heating Works

1.2.1 Heat distribution

Heat is provided to customers by means of a distribution network. The energy carrier in the network is water. The heat is pumped to the building where a substation is installed. The substation is often a heat exchanger, but it can sometimes be a heat pump. In the substation, the heat from the distribution network is switched over to the water-based heating system of the building (radiators), heats the building and provides it with hot water. The water in the distribution network is cooled down as the heat is switched over to the building and is returned to the central heating unit of the network. The difference between the heat supply temperature to the building and the temperature of the water returned to the central heating unit is referred to as “delta t: ΔT”. The larger the temperature drop, the more efficiently the system operates.

1.2.2 Heat supply

In the kind of networks most common today, referred to as third generation networks (see more on generations below), the heat is generated at a few, central locations and distributed across the network. In such networks, the heat is often generated by resorting to a combustion technology. Examples of combusting technologies are boilers (often resorting to wood pellets) or a combined heat and power plant (CHP; resorting to oil, gas, biomass or waste). CHPs have the advantage that both electricity and heat are co-generated. The caveat is that combustion technologies will likely have a smaller role in the future. The heat supplied from combusting units has an approximate supply temperature of 86˚C (Fredriksen, 2017). Some heat sources are of such a high temperature that they can be used directly in the network (waste heat from industrial processes, geothermal heat or solar thermal for example). Other heat supplies need electricity to reach desired temperature levels; such supplies can be waste heat from urban infrastructure (data centres, transport, buildings). By utilising heat pumps, such sources can be important heat supplies in a network as their temperatures can be boosted to the desired temperature level. The larger the variety of heat sources in a system, the more complex it is and the smarter it needs to be (digital infrastructure is increasingly important). Systems with several heat supplies are often equipped with one or several storage units with different temporality.

In the figure, a conventional setup is shown. It encompasses the customer building (1), the heat exchange from the DHN to the customer (2), the distribution pipes (3) and the heat centre (4).

Figure 1 A District Heating Distribution Network (DHN) (Werner S. , 2013)

1.3 District Heating Technology Generations: Impact of the Temperature of the Distribution System

Four generations of DH technology are outlined here; each has been Best Available Technology[1] (BAT) for DH for a duration of 40-50 years. The first generation (1GDH) used a

[1] Best Available Technologies (BAT), are technologically innovative techniques which are economically viable.

steam-based distribution method (BAT between 1890-1920). Steam based technology necessitates high population density to allow for low distribution costs. To increase efficiency, water was used as a heat carrier (second generation 2GDH). The supply temperatures were high (even above 100 °C) with a large temperature difference between supply and demand (ΔT) allowing the dimensions of the pipes to be lowered. 2GDH was BAT between 1930-1980. In the 1970s, the world experienced two oil crises. System efficiencies were sought for and realized by supply temperatures below 100°C in combination with pre-fabricated and pre-insulated pipes and pre-fabricated substations. The third generation (3GDH) (BAT since the 1980s) is still the technology resorted to when expanding existing DH networks. Common features between 1GDH-3GDH are that (i) heat is supplied from one or several, large heat plants, (ii) the heat supply temperature is high enough to meet the demand of all customers and (iii) the capacity to generate heat is large enough to ensure heat availability in the system. The three generations are all referred to as "warm district heating" (Lund & et.al, 2014).

The fourth-generation concept is linked to the current challenge of shifting into a 100% renewable energy system and is becoming the new BAT of the DH sector. The district energy sector needs to go beyond increased efficiency by means of lower temperatures and pre-fabricated pipelines and substations. Lower temperatures are valuable since heat supply to low-energy buildings with low grid losses is facilitated. In addition, low-temperature heat can be used in an efficient energy system, improving the environmental performance of the DH industry. Apart from the reduced climatic impact, the lower distribution temperatures will also enable and improve the utilization of renewables and excess heat sources in general. The next generation of DH technology is foreseen to increase the usage of low temperature heat sources either in combination with existing 3GDH systems or as stand-alone solutions. Heat supply in fourth generation systems has an annual average heat supply temperature of 70˚C (Lygnerud & et.al, Low temperature district heating implementation guidebook, 2021).

Discussing generations of DH, sometimes referred to as fifth generation DH must also be mentioned. In parallel to the 3GDH installations, since the 1980s, systems using low temperature heat sources appear. In these systems, decentralized heat supplies are used: either inside a 3GDH system or separately. The heat supply has a lower temperature than what is conventional in the 3GDH systems. Early heat sources include ambient heat from the sea, lakes and sewage water. Low temperature systems that are stand-alone and not linked to a 3GDH system differ from the 1GDH – 4GDH systems in that: (i) the locally supplied heat only meets the demand of a few buildings (not the entire system) and (ii) the temperature of the locally supplied heat needs to be boosted by means of a heat pump or a boiler which creates a dependency on electricity (Buffa & et.al, 2019).

A complication of lower temperature systems is that the bacteria Legionella can grow in water that is standing still and small drops of infected water can be inhaled and lead to a severe form of pneumonia. As a result, building codes tend to require that water used for domestic uses is provided at a temperature that eliminates the bacteria.

1.4 The Efficiency of the District Heating System

1.4.1 Substations in buildings

The efficiency of DH networks can be improved by managing elements of the system including heat supply, distribution losses and water flow. For maximized efficiency it is, however, important that the substations and the water-based systems in end-user buildings are also operating efficiently. One way to remedy customer inefficiencies is for the district heating company to control the substation in end-user buildings (either by purchasing and operating the equipment or by operating it for the customer). The practice on this differs across district heating providers, however assuming ownership to exert control over the substation is increasingly important where a DH company offers heat as a service. This is because there is no room for errors in the substation when the DH company is delivering a service of a specific indoor climate, i.e., a specific temperature.

1.4.2 Energy efficiency of buildings

For a system to be as energy efficient as possible, the energy performance of buildings is also important. The more energy efficient the buildings are, the lower the need for energy and as a result the lower the heat demand in the system overall.

In relation to low temperature DH it has been shown that in climate conditions like those in Denmark and Sweden, there is no need to first undertake energy efficiency measures in buildings. If a water-based heating system with radiators already exists, the radiators will need an upgrade if lower temperatures are supplied as they would need a larger surface area which enables the radiators to provide more heat with the same amount of energy (Østergaard, 2018). There is, however, a risk of oversizing the heat network if it is built to meet the heat demand of a building stock that will be made more energy efficient over time. In such a context, a solution could be to scale the district heating system according to the foreseen heat demand of the area, taking energy efficiency, improved system control and larger radiator sizes into account and for a transition period provide the heating by resorting to district heating and another, transitional heat supply (for example by keeping some gas boilers or installing heat pumps) that can be phased out once the desired measures have been performed.

1.5 Irish District Heating

Ireland currently ranks in the bottom five in the EU for the shares of DH and renewable heat. The top-ranked EU countries for renewable heat shares also have high shares of district heating. By contrast, Ireland has a few small-scale DH networks contributing less than 1% of the total heat used in Ireland (SEAI, 2022). Ireland's government has set targets to deliver 2.7 TWh/year of heating through district heating by 2030. This represents 10% of total heat demand in Irish buildings of 27 TWh.

Studies have shown that 54–57% of total heat demand could be supplied through district heating networks in Ireland (SEAI, 2021; Irish Heat Atlas, 2019). This could complement the installation of individual heat pumps in appropriate locations to decarbonise the built environment sector in addition to retrofit and energy efficiency measures.

2 CAPEX and OPEX of DH

2.1. Cost Assessment for Replacing Fossil Fuel Boilers with District Heating

To provide an understanding of true DH pricing one must account for technical costs (CAPEX and OPEX) and experiences from market interventions (targeting a decarbonized energy supply) applied in other countries. The analysis performed to address objective one of this study “to consider the costs of district heating deployment in Ireland including estimated costs for domestic connections to a district heating network" is built around this logic, illustrated in Figure 2.

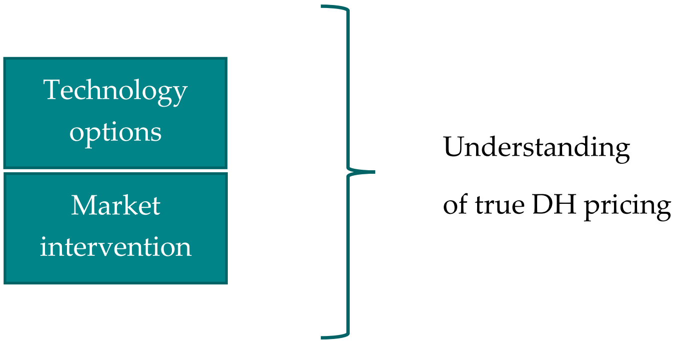

Figure 2 Concept developed for understanding the true pricing of DH

2.2 CAPEX and OPEX - Based on Costs of District Heating Generation Technologies

2.2.2 Heat supply in Ireland

It is estimated in the National Heat Study that over 50% of Ireland's building stock would be suitable for connection to a district heating network. This potential includes the major urban centres in Ireland and the large regional towns, particularly those where the economics are more favourable because of the widespread use of oil heating.

A critical element of the development of a district heating system is to identify existing and potential sources of heat within an area. Potential heat sources and areas where they could be most cost-effectively adopted for district heating have been identified in Ireland (SEAI (2022); Irish Heat Atlas (2023)).

Heat recovery should be possible from (i) existing gas fired CHPs used for power generation and servicing airports, hospitals and industries: one example of this is Aughinish Aluminia (ii) industries such as metal, cement, refining, wood products, other minerals, food and drink, lime and chemicals (iii) geothermal assets have been identified but not quantified, they exist in the carboniferous basins in the East, Midlands and Southwest, (iv) 24 data centres were identified across Ireland (out of which most are located in Dublin)[2], (v) waste to energy plants (in Meath and Dublin) and (vi) buildings with high energy consumption that could generate waste heat: one example given is the University College Hospital Galway (SEAI, District heating and cooling: spatial analysis of infrastructure costs and potential in Ireland, 2022).

2.2.3 Heat supply in Dublin

The majority of projects currently in development in Ireland are based in Dublin, where district heating has been most progressed in Ireland to-date. The Dublin Region Energy Masterplan

[2] SEAI's Heat Study noted that while data centres have significant potential for waste heat recovery, particularly around Dublin, better public information on how they operate would be required to understand the potential fully.

has noted that district heating could potentially supply 87% of Dublin's heat demand by 2050 and identified potential candidate areas for Local Authorities.

The figure below (Figure 3), was developed by Codema as part of the Dublin Region Energy Masterplan (2021) and provides a breakdown of the heat sources identified in County Dublin. This provides an indication of the likely heat sources which could be utilised by DH networks in Ireland initially and the ones which might provide the greatest opportunity in terms of total quantities of heat available. The costs for the most relevant heat sources are provided in

Table 1 CAPEX and OPEX of DH generation technologies mapped per technology group, configuration and fuel

Table 1 in the following section.

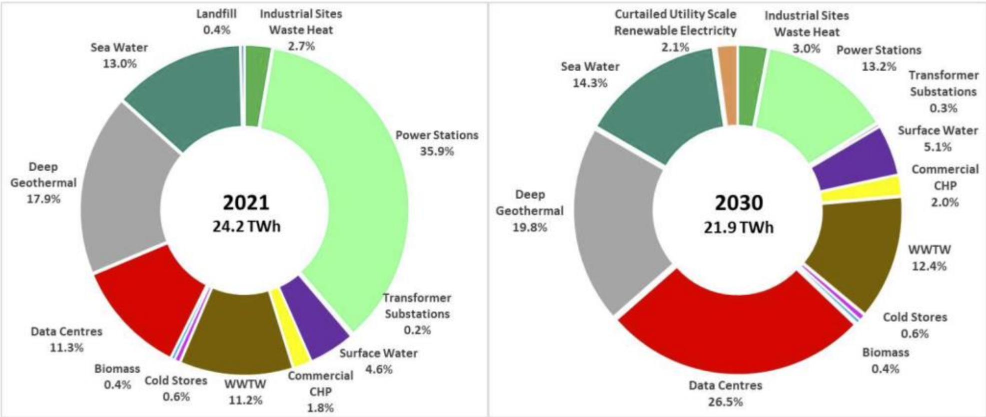

Figure 3 Breakdown of Estimated Total Heat Available for 2021 and 2030 in TWh (Codema, 2021)

As noted above, in the Section 1, the temperature of the heat supply will be decisive for the kind of DH technology resorted to. Hence, it is relevant to understand the available heat sources by expected temperature as set out in Figure 4.

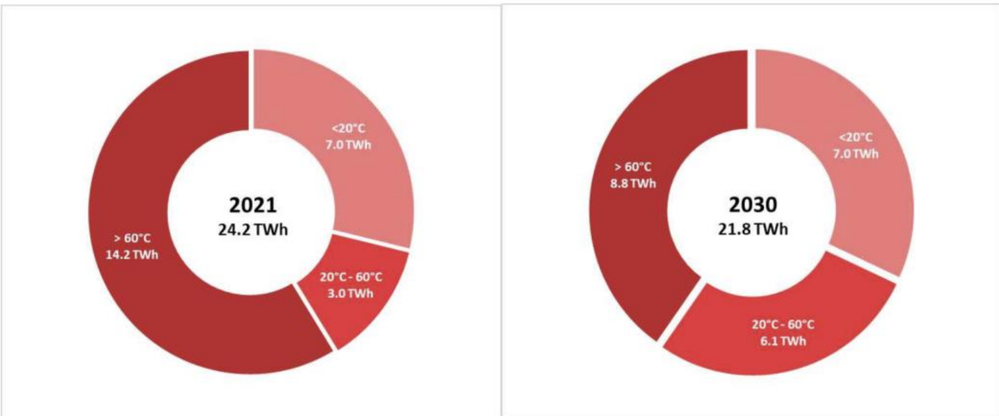

Figure 4 Heat sources per temperature range in 2021 and 2030 (Codema, 2021)

2.2.4 CAPEX and OPEX of different technologies

Costs differ across countries in the EU, and it is difficult to arrive at one single number. To arrive at a relevant estimation, we have chosen to screen technology options for heat generation from previous work on energy system modelling in different EU funded projects (These include REWARDHeat (REWARDHeat, u.d.), REUSEHEAT (EC, 2022), Flexi-Sync (IVL, 2022)). CAPEX and OPEX costs of different heat generation technologies in DH have been identified. Resorting to the National Heat Study Report on Low Carbon Heating and Cooling Technologies, a relevant structure to map CAPEX and OPEX per technology was identified and applied here (the structure of

Table 1). Most of the data in the table has been collected from the 'Technology Data for Generation of Electricity and District Heating' provided by Danish Energy Agency under Technology Catalogue data (Danish Energy Agency, 2022). The information provides detailed costs for many DH technologies. The costs are "raw" in the sense that they are given without accounting for the cost impact of any government interventions.

Table 1 CAPEX and OPEX of DH generation technologies mapped per technology group, configuration and fuel (Danish Energy Agency, 2022)

Plant type	Fuel	Capacity (MW)	Electrical Efficiency (annual average) (%)	Heat efficiency (annual average) (%)	Life (years)	CAPEX[3] (MEUR/MW)	Variable O&M[4] costs (EUR/MWh)	Fixed O&M costs (EUR/MWh)
CHP[5]	Natural Gas	83	40%		25	1	5	20,736
CHP	Natural Gas	23	35%		25	1	6	20,736
CHP	Natural Gas	300	56%		25	1	5	31,157
CHP	Natural Gas	55	48%		25	1	5	31,157
CHP	Natural Gas	6	45%		25	1	6	10,368
CHP	Biogas	6	41%		25	1	8	10,368
CHP	Waste	52	22%	80%	25	8	27	197,787
CHP	Waste	47	20%	76%	25	9	29	219,055
CHP	Waste	19	22%	80%	25	10	27	278,604
CHP	Waste	8	22%	80%	25	11	28	437,046
HOP	Waste	37	106%	-	25	2	8	82,943
CHP	Biomass	183	29%	83%	25	3	5	101,020
CHP	Biomass	170	27%	83%	25	4	5	108,464
CHP	Biomass	24	28%	83%	25	4	5	158,443
CHP	Biomass	3	14%	97%	25	7	10	298,808
CHP	Biomass	268	32%	67%	25	2	2	65,929
CHP	Biomass	253	30%	66%	25	3	2	70,183
CHP	Biomass	25	29%	69%	25	3	2	131,858
CHP	Biomass	3	15%	84%	25	6	4	288,174
HOP[6]	Biomass	7		114%	25	1	3	34,560
HOP	Biomass	52		115%	25	1	3	44,662
HOP	Biomass	103		115%	25	0	3	36,793

[3] CAPEX: Capital expenditure

[4] O&M: Operation and maintenance costs

[5] CHP: Combined heat and power plant

[6] HOP: Heat only plant

HOP	Biomass	6		101%	25	1	2	34,772
CHP	Biomass	258	41%		25	3	3	73,373
CHP	Biomass	358	43%		25	2	1	58,485
Air source HP[7]	Elc.	1		290%	25	2	3	2,127
Air source HP	Elc.	3		340%	25	1	2	2,127
Air source HP	Elc.	10		380%	25	1	2	2,127
Industrial Excess Heat HP	Elc.	1		410%	25	1	3	2,127
Industrial Excess Heat HP	Elc.	3		460%	25	1	2	2,127
Industrial Excess Heat HP	Elc.	10		510%	25	1	2	2,127
Sea water HP	Elc.	20		370%	25	1	1	4,253
Absorption HP	Elc.	12		171%	25	1	1	2,127
Sea water HP - large	Elc.	65		301%	25	1	1	2,047

The capital cost of heat-only boilers is lower than that of combined heat and power (CHP) plants. However, income derived from the electricity generated by CHP plants also needs to be factored into investment decisions. For CHP plants fuel availability and acceptability (in net zero terms) becomes an important consideration where they are reliant on fossil fuels for example.

Large-scale heat pumps can be cost competitive with heat-only boilers, but their electricity input could be a bottleneck to the adoption of this technology in grid constrained areas.

The conclusion is that when evaluating capital costs of heat and power systems, the value of electricity generated by CHP along with fuel availability/acceptability, constraints on power

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[7] HP: Heat pump

availability and higher OPEX costs of CHPs (compared to individual heating solutions) must be weighed against upfront investments to make fully informed adoption decisions. There is also a caveat in that it is likely that combustion technologies will be phased out in favour of other renewable alternatives (geothermal heat, solar thermal and waste heat based for example).

2.3 Piping Costs and Costs of Connections to District Heating Networks

2.3.1 Piping costs

In terms of piping costs, is important to know that there are different kinds of district heating pipe solutions/culverts depending on the system design. There can be 2 or 4 pipes in a culvert, depending on the mechanism used to heat domestic hot water. With a 2 pipe culvert, a water heater/ heat exchanger is required in the house which heats the water when it is being tapped. In a 4 pipe culvert, there are 2 pipes for heating and 2 for domestic hot water. As a result of this hot water circulation hot water is always available at the tap. In these systems, the heating circuit is separate from the hot water provision and can even be turned off during summer (Elgocell, 2023). In collating price estimates, related to different piping solutions we have only been able to identify if a distinction of 2 or 4 pipes in one study. The more commonly available information influencing this cost element is pipe diameter.

Pipe construction costs (including the cost of the pipe, trenching and other civic works) for different diameters were collected for some European countries, see Figure 5 below (sEEnergies, 2019).

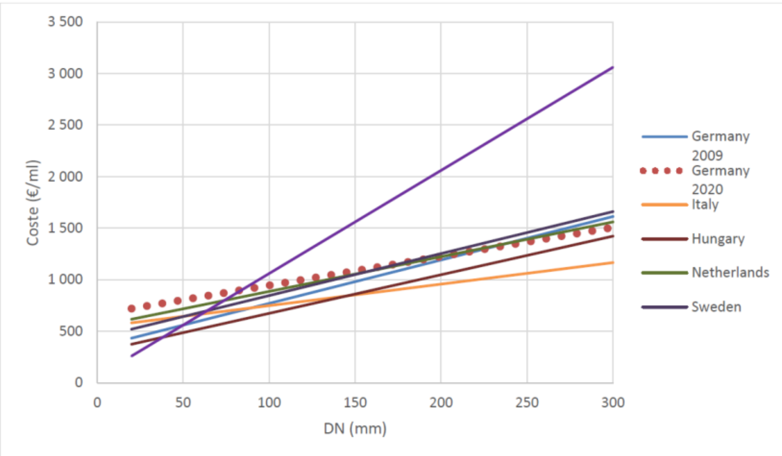

Figure 5 Construction costs of district heating pipes for different diameters in various European countries (DN represents diameter in millimetres: Source SEENERGIES project)

From the European graph above, it can be identified that the cost expressed in Euro/meter ranges from 71 Euro/meter (Lithuania) to 664 Euro/meter (France) across the smallest diameter range.

A deep dive into 16 Danish DH projects provides similar spread within one country (Denmark) see Figure 6 below.

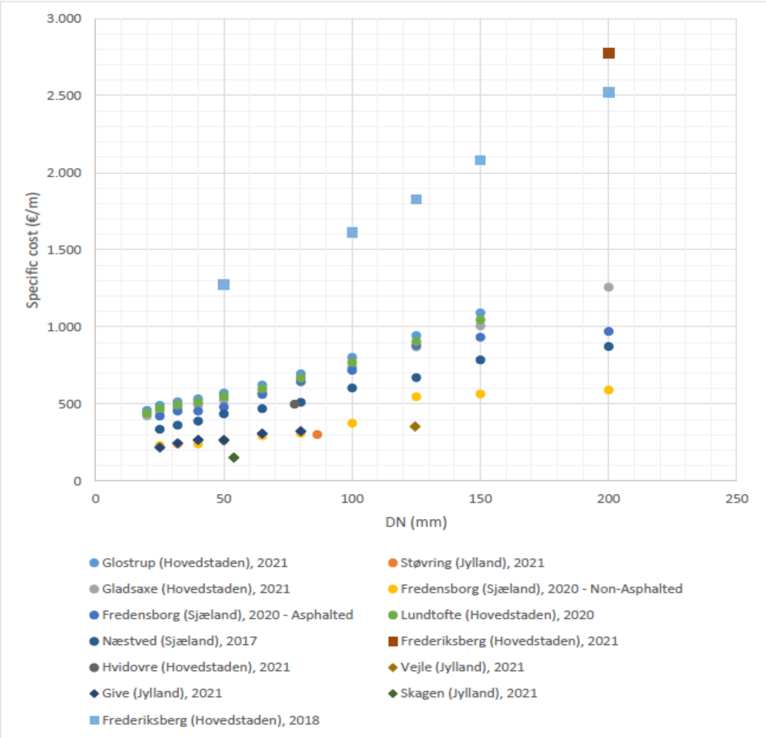

Figure 6 Construction costs of distribution district heating pipes in various Danish projects (DN indicates diameters in millimetres, Source SEENERGIES project)

From the Danish dataset above it can be identified that the cost in terms of euro/meter ranges from 150 EUR/m (55 mm) to 2,750 Euro/m (200 mm). As expected, costs increase as diameter increases. Another cost driver is the cost of labour. It is interesting that Sweden and Denmark both have high labour costs (44 EUR/hour and 36 EUR/hour) but similar installation costs to other countries with lower salary levels: possibly explained by high efficiency in the construction of DH networks in mature markets (Ibid).

The costs for trenching and piping are the biggest single cost of a network and outweighs the cost of the pipework. Depending on the terrain, the excavation costs will vary. In city centre areas the costs per meter of trench are most expensive. In the outskirts of cities, the cost is approximately 20% lower than in city centres. In parks, the costs are even lower than in the outskirts (23% lower), (SvenskFjärrvärme, 2007). Additionally, minimizing lengths and reducing the number of crossings (with rivers, motorways, rail lines etc.) reduces civils costs. In discussion with a DH company in Sweden, it was found that a trench of 1.5 meters depth in asphalt comes at a cost of 400 EUR/m.

In summary, the costs of trenching and piping are substantial, depending on the local conditions they will vary across cities.

2.3.2 Connection costs

The costs for connection of customers to a network includes the cost of the heat interface unit or heat exchanger, the heat meter and control system and the installation of a pipe to connect to the main network. The cost of connecting existing buildings to district heating depends on the number of houses or buildings connected in an area, with shared connections leading to greater efficiencies and lower costs. It also depends on the current heating system in a house. Most existing radiators can be maintained if they are of sufficient size and any existing boilers would need to be replaced with a heating interface unit or heat exchanger.

As a result of the European heat market being heterogenous both in terms of regulation and heat supply options, no centralized database exists of district heating costs including the costs to connect to a network and operational costs. The European regulation on price transparency only covers electricity and gas prices, resulting in a lack of standard regulations for district heating prices (Billerbeck et al, 2023). Since most DH markets are local, it is difficult to find information that applies across cities and countries.

Connection costs to the network are not always made publicly available by pipe providers. Some indication of costs can be found by performing a desk-based review for different countries and contexts, but it is not possible to give an accurate cost estimate or comparison of connection DH costs across Europe. Another drawback of the current level of data availability is that cost information tends to become outdated and is not adjusted regularly for inflation, energy price increases, policy interventions and other aspects which may impact on end-user costs. Hence, we advocate caution in making comparisons of costs identified below. The numbers should be seen as an indication rather than firm facts.

For Ireland, we identified that Codema carried out a comparison of costs between connection to the Tallaght District Heating Scheme and the connection of individual gas boilers, including investment costs, annual heating costs and maintenance cost (estimating a 20-year investment timeframe), finding that the heat cost for an individual system would be ~56 EUR/MWh and for district heating would be ~50 EUR/MWh (HeatNet NWE, 2018). Sweden was chosen for an in-depth review of DH prices as most of the information is made publicly available. In a review of Swedish district heating webpages information was identified for four DH companies on domestic connection costs. Tekniska verken i Linköping (www.tekniskaverken.se, 2023) state that the connection fee (which includes trenching in the street and the owners' property (up to 15 meters from the main pipeline), resetting the excavation and providing advice once the installation is in place) is 5,500 EUR[8]. If trenching beyond 15 meters is required, there is an additional cost of 500 EUR/m. The cost of the substation and its installation (and removal of the old unit) comes at a cost of 4,625 EUR. Additional costs can also be incurred where required, including for example for ventilation works, and a shift from a direct electric heating system (such as electric storage heaters) to a water-based system at the building level. The company Mälarenergi (www.malarenergi.se, 2023) offers a package including the substation at 11,000 EUR. Gävle Energy (www.gavleenergi.se, 2023) has a similar offer at 12,900 EUR, with packages available for the installation of broadband simultaneously. Hässleholm Miljö (www.hassleholmmiljo.se, 2023) indicates a cost of 9,000 EUR and above and the cost per meter of civic works (beyond 10 meters) is 390 EUR/m. Sweden was chosen for an in-depth review of DH prices as a majority of information is made publicly available. In a review of Swedish district heating webpages information was identified for four DH companies on domestic connection costs. Tekniska verken i Linköping (www.tekniskaverken.se, 2023) state that the connection fee (which includes trenching in the street and the owners' property (up to 15 meters from the main pipeline), resetting the excavation and providing advice once the installation is in place) is 5,500 EUR[9]. If trenching beyond 15 meters is required, there is an additional cost of 500 EUR/m. The cost of the substation and its installation (and removal of the old unit) comes at

[9] Assuming an exchange rate of 10 Swedish Crowns per Euro

a cost of 4,625 EUR. Additional costs can also be incurred where required, including for example for ventilation works, and a shift from a direct electric heating system (such as electric storage heaters) to a water-based system at the building level. The company Mälarenergi (www.malarenergi.se, 2023) offers a package including the substation at 11,000 EUR. Gävle Energy (www.gavleenergi.se, 2023) has a similar offer at 12,900 EUR, with packages available for the installation of broadband simultaneously. Hässleholm Miljö (www.hassleholmmiljo.se, 2023) indicates a cost of 9,000 EUR and above and the cost per meter of civic works (beyond 10 meters) is 390 EUR/m.

Older information (2015) was identified for the UK. Buried heat network pipework costs average around 1000 GBP/m over a heat network, although this ranges from 422 GBP/m to 1472 GBP/m depending on the size and nature of the schemes (DECC, 2015).

Some information was identified for the Irish context, for example from Glen District DH (County Cork): This DH scheme in Cork comprises 58 houses, four residential spaces within a community centre and the actual community centre itself. One biomass boiler generates the heat. The report estimates there was an initial pipe network installation cost of 10,000 EUR per customer. Once the network was established, the scheme predicted the cost of new connections to network would cost approximately 4,500 EUR per customer.

(SEAI, District heating and cooling: spatial analysis of infrastructure costs and potential in Ireland, 2022).

In summary, the connection costs of customers will vary depending on if the heat exchanger is part of the purchase or not but also depending on distance from the building to the district heating network. To find and compare customer connection data across countries in the EU is challenging since this data is not readily available.

2.3.2 Possible pathways for DH expansion, inspiration from the UK

A study carried out for the UK market, points to eight items to account for when implementing DH in the country which can have an impact on overall costs of a network and end costs for consumers (Aecom, 2017). There is a lack of embedded knowledge within the UK on how to design and construct heat networks cost-effectively. Hence, there is a need to establish a District Heating Knowledge Centre that coordinates: research, training, dissemination and innovation across the industry. Next, there is a need to design for efficiency by utilising lower flow rates and reduced pipe diameters (achieved by minimizing peak demand and lowering return temperatures).

The amount and cost of trench excavation can be reduced by resorting to alternatives (either by piping external walls of buildings, within loft spaces or cellars). The use of trenchless technology (such as controlled drilling) can also reduce the costs of trench excavation (especially for branch connections). Provision of design information to contractors prior to commencing work on site can also increase efficiency. If possible, it is also useful to collaborate with other utility companies that are planning works in the same area. This allows for cost sharing.

Retention of existing hot water cylinders when present and adoption of simple system design using direct connection Heat Interface Units (HIUs) can also help to reduce costs. In addition, the cost of the HIUs can be reduced by means of standardization and design for manufacture and assembly. Following the listed items an estimated capital cost saving of 32% is achievable (Aecom, 2017).

2.3.3 Heat density as a driver for district heating expansion

Efficient DH expansion is linked to finding the most efficient areas to connect and also has an impact on end user costs. Heat density is an important factor to make these choices. Irish specific information is outlined below.

Heat density is a result of the kind of buildings erected. In areas with multi-family homes (e.g. apartment blocks), the heat density is, for example, higher than in areas where there are single family houses. In a study of the EU28, 6 heat density classes were identified. They are measured in kWh/m2. They go from no heat demand (0 kWh/m2), very sparse density (0-5.6 kWh/m2), sparse (6-14 kWh/m2), moderate (14-33 kWh/m2), dense (33-83 kWh/m2) to very dense (above 83 kWh/m2) (Person & et.al, 2019). In Ireland, 85% and 13% of the land is in areas with none or very sparse heat density. In these areas, approximately 4% and 21% of the population resides. The majority of the population (45%) is found in areas with moderate heat density. These numbers are summarized in Table 2 below.

Table 2 Heat density classes as share of land and population in Ireland (Source Person et al, 2019)

Heat density class	Share of land (%)	Share of population (%)	Heat demand/ class (%)
None	85	4	0
Very sparse	13	21	23
Sparse	0.9	26	20
Moderate	0.6	45	26
Dense	0	2	2
Very dense	0.06	3	28

In summary, a small share of the land (largest cities and towns) has the largest heat demand in Ireland. **The conclusion is that DH expansion should be initiated in the very densely, densely and moderate densely populated heat density classes (e.g. in Dublin and the largest cities).**

Reviewing heat demand in different building categories, the greatest demand is found in the residential sector (19.4 TWh/year) and in the industry sector (17.5 TWh/year). Public and commercial buildings have a heat demand of 3.5 TWh/year and 5.7 TWh/year respectively. In Ireland, a large share of the residential building stock is detached houses (42%), semi detached (29%) and terraced houses (17%) whereas only 12% are apartment buildings (SEAI;b, 2022). **The conclusion is that DH expansion should either be initiated in areas with apartment buildings or higher density public, commercial or industrial sites.**

In a study carried out to consider decarbonisation of heat across Europe (Person & et.al, 2019), it was identified that at a DH market share of 50% in the EU 28, set as the saturated deployment level, the distribution capital cost (the annuitized network investment cost by unit of delivered heat) would be 0.03 EUR/kWh. The Irish level of market saturation, for the EU 28 to arrive at a 50% level overall, is assessed at 32% targeting the very dense and dense heat density classes (the cost per kWh is then foreseen to be 0.06 EUR/kWh).

Ireland is identified to exhibit favourable economic suitability up to heat market shares of 32% (Ibid). In the Regional Energy Masterplan of Dublin, DH could supply 87% of the heat demand of the city in 2050. In the national heat study SEAI identified national DH potentials ranging from 2.7-8.1 TWh/year in three different scenarios (SEAI, National Heat Study, 2022). The target of Irish DH under the 2030 climate action plan is 2.7 TWh/year, equivalent to 200 000 homes (IrDEA, 2023).

3. Best Practices

To identify best practices for deployment of DH, information from mature (Sweden, Denmark, Finland), expanding (Germany and France) and new DH markets (Spain, Netherlands and the UK) has been collected. Best practice information presented in Section 3 addresses technical choices and how the heat supply was steered away from fossil fuels (3.1), government/ market intervention (3.2) and customer pricing plans (3.3).

3.1 Technical Choices and Market Intervention to steer Heat Supply away from Fossil Fuels

3.1.1 Mature Markets (Denmark, Sweden and Finland)

In the three mature countries identified for this study, the DH heat market share is above 45% (55% in Denmark, 50% in Sweden and 45% in Finland). The main competition to DH in Denmark is gas (multi-family buildings) and biomass boilers or heat pumps (single-family buildings). In Sweden and Finland is the main competition is heat pumps or direct electricity.

The dominant heat generation technology in each mature country is combined heat and power (CHP) generation, and biomass is the most commonly used fuel (61% of the heat supply in Denmark, 43% in Sweden and 44% in Finland). In Denmark, other heat supplies include waste (11%), gas (9%) and coal (6%). In Sweden, waste combustion represents 21% of the heat supply, while waste heat accounts for 19% and centralized heat pumps 6%. In Finland, there is 15% peat, 13% coal and 10% waste heat in the heat supply. The choice of CHP and biomass reflects the fact that the countries have a long DH tradition and resorted to biomass when phasing out oil in the aftermath of the oil crises of the 1970s and 80s.

In Denmark, the shift towards biomass was steered by making it tax exempt whereas coal was taxed and thereby phased out. Currently, a low tax on electricity used in DH is applied which incentivizes the use of heat pumps in DH systems and thereby low temperature waste heat recovery.

In Sweden, the shift towards biomass was initiated by soft loans and grants under different support schemes (1970s-90s) for refurbishment of existing units and for DH expansion. Sweden has a tradition of applying energy taxes. In addition to such, the country implemented the first tax on CO_2 emissions world-wide (1990), this further supported the expansion of biomass in DH. Landfill was banned in 2002 (non-organic) and 2005 (organic) which led to an increased focus on waste incineration. From 1997-2008 support was given to building owners to convert from direct electricity. In an assessment report of this support, it was concluded that initially the majority of applications were to convert to DH, however later the share of applications to convert to heat pumps increased. Around 2008-2010, DH support was phased out and the market was identified as mature. In summary, the case of Sweden indicates that a combination of research/demonstration, grants and tax levies was efficient for DH expansion and decarbonization.

In Finland, a similar pathway as in Sweden has been identified. A Bioenergy program (1993) focusing on developing new technologies for biomass fuels was developed. In 2011, an Energy Tax Reform was introduced and coal, natural gas, and oil are taxed both on energy and CO_2 content, but peat was only subject to fiscal tax. Renewable fuels were excluded from taxation.

In the mature markets, a shift away from combustion is currently being discussed. The main drivers are that (i) the EU Taxonomy first identified combustion of biomass as a non-sustainable alternative (however this was revised and currently biomass is seen as sustainable) and (ii) that the European work on circularity will reduce the volumes of waste to combust. The mature markets are increasingly acknowledging a need to shift away from combustion technologies and heat sources (including biomass and waste combustion).

Ireland is a country with planned offshore and numerous onshore wind farms which makes it relevant to discuss the situation in Denmark, which is similar in terms of renewables deployment. Another similarity is that in both countries there is a Transmission System Operator (TSO). Electric boilers in a DH system can offer demand side flexibility - they can be turned on when a lot of electric power is available and be turned off when the electricity supply is limited. For DH companies to utilize the flexibility potential of electric boilers, two basic conditions need to be fulfilled: 1) that there are incentives for DH companies to invest in electric boiler capacity, and 2) that the electric boilers are the optimal dispatch choice when power prices are low, and suboptimal when the power prices are high.

While the first condition requires that the long-term marginal cost of heat from the electric boilers are low compared to competing technologies, the second condition indicates that the short-term marginal costs needs to be sufficiently low for low power prices. Thus the two conditions are related: the short-term marginal cost determines the potential number of operating hours, which in turn determines the size of the fixed costs allocated to each hour of operation which is included in the long-term marginal costs.

A study comparing the short-term marginal costs for electric boilers in a DH system in Sweden, Denmark and Norway addresses five aspects: energy taxes, electricity certificates, grid costs and maintenance. These numbers are contrasted to the marginal costs of heating alternatives (CHPs and heat only boilers) (Sneum, 2018). For electricity, the energy tax and grid costs are the main cost items. For both CHPs and heat only boilers fuel cost is the main cost item. For both Denmark and Sweden, electrical boilers are more expensive than biomass fired CHPs and boilers. In Norway, the electricity tax is low and would make the electrical boiler the efficient alternative. Another study, targeting Sweden arrives at the conclusion that even when electricity prices are negative, the current energy tax setup makes electricity boilers in DH systems a cost inefficient solution (Averfalk, 2018). To conclude on this matter, if Ireland targets the use of excess electricity for heat generation in DH systems, energy taxes and short-term marginal costs need to be tailored to support this purpose.

In the Table 3, key takeaways and areas for further evaluation are summarized.

Table 3 Key takeaways and areas for further evaluation per country (technical choices & market intervention: mature markets)

Country	Dominant DH technology	Dominant heat supply	Policy focus
Denmark	CHP	Biomass	Regulated DH market
Sweden	CHP	Biomass	Research/demonstration, grants and tax levies
Finland	CHP	Biomass	Research/demonstration, grants and tax levies

3.1.2 Expanding Markets (Germany and France)

In Germany, the DH heat market share is 14% and in France it is 4%. Both countries have a long DH tradition while gas solutions dominate the heat market and remain the main competition.

In both countries, the dominant technology is combined heat and power (CHP) generation. Gas dominates the DH fuel mix (48% in Germany and 37% in France). In Germany there is also coal (14%), biomass (10%), waste combustion (8%), lignite (6%) and renewables like solar and geothermal in the fuel mix. In France, waste heat is at (25%), biomass (22%), coal (7%) and geothermal at (5%).

In Germany legislation was introduced in 2002 focusing on CHP generation (this was updated in 2022[10]) ((Bundesgesetzblatt, 2002) & (Bundesministeriums der Justiz, 2022)). The idea of the Act was to promote modernization of existing plants, the installation of new ones and increased energy efficiency. The target in 2002 was to increase electricity generation from CHPs from 12% to 25% by 2020. In 2002, the electricity generated by CHPs was subsidized. In 2009, the subsidy was extended to electricity fed into non-public grids and electricity used for self-supply. The Act also served as the implementation of Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market (the Cogeneration Directive), later replaced by the Energy Efficiency Directive in 2012. Since the outbreak of the war in Ukraine, Germany has been forced to heavily reduce its use of gas, this also applies to the DH sector. Germany is the only country in the world that has subsidized low temperature waste heat recovery in DH networks (the program Wärmenetze 4.0 (Bundesamt fur Wirstschaft und Ausfuhtkontrolle, u.d.)).

The main response to the oil crisis in France was to invest in nuclear power. Simultaneously, tax breaks and subsidies were developed to incentivize the use of wood-based heating, as wood was seen as a renewable and locally available alternative to oil. These policies helped to spur the growth of the DH industry in France. The CHP technology was also subsidized but this subsidy has been removed.

In Table 4, key takeaways and areas for further evaluation are summarized.

Table 4 **Key takeaways and areas for further evaluationper country (technical choices & market intervention: expanding markets)**

Country	Dominant DH technology	Dominant heat supply	Policy focus
Germany	CHP	Gas	CHP and recently low temperature
France	CHP	Gas	No more CHP subsidies, tax breaks and subsidies for wood based heating

3.1.3 New Markets (Spain, Netherlands and the UK)

In Spain, the DH share of the heat market is 1%, in the Netherlands it is 6% and in the UK it is 2%. In all countries, the main competition to DH is gas. The dominant technology is combined heat and power (CHP) generation. In the UK, CHP has now been excluded from government support as a shift to encourage networks utilizing waste heat and excess electricity is desired. In Spain, the most frequently used fuel in the DH fuel mix is biomass (69%) and gas (19%), followed by electricity (5%); while small and rural networks are often biomass. In the

[10] Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung [Act for the Maintenance, Modernization and Expansion of Combined Heat and Power Generation]. 2023. *https://www.clearingstelle-eeg-kwkg.de/sites/default/files/2023-01/KWKG_221220.pdf*

Netherlands, gas is the largest share of the DH fuel mix (62%), next is biomass (19%) and waste (17%). As in the Netherlands, gas is the largest proportion of DH heat supply in the UK (91%), followed by electricity (5%), biomass and waste combustion.

In Spain, CHP generation is supported through a premium tariff for renewable electricity production. Also, a special tax on hydrocarbons (including gas) exists but CHPs are exempt from it. In the Netherlands, the sector is not subsidized apart from low-rate government loans for DH projects (with a 7% interest rate). In the UK, a shift away from gas and biomass fired CHP generation is desired, switching to an increased use of waste heat.

It is worth noting that policies to reach climate targets by phasing out the use of fossil fuels, such as natural gas, have been ongoing at a different pace in different countries; reflected in desirable GHG emissions being established per unit of delivered heat by 2025 (200 g/kWh) , 2026 (150 g/kWh) , 2035 (100 g/kWh), 2040 (45 g/kWh) and 2050 (0g/kWh) (EC, 2023). As a result of the war in Ukraine, the speed of the phaseout has increased, pointing to heat pumps as an important part of the solution in the short term. The increasing need to shift away from gas in the short term is likely increasing the inclusion of heat pumps in the heat supply mix of DH in existing systems and systems in development.

In Table 5, key takeaways and areas for further evaluation are summarized.

Table 5 Key takeaways and areas for further evaluation per country (technical choices & market intervention: new markets)

Country	Dominant DH technology	Dominant heat supply	Policy focus
Spain	CHP	Biomass	CHP and tax breaks
Netherlands	CHP	Gas	Low rate government loans
UK	CHP	Gas	Switch away from biomass fired CHPs to use of waste heat

Key takeaways and areas for further evaluation on Technology choices and dominant DH Heat Supply

- CHP is the dominant technology in mature, expanding and new markets (a shift away from this technology is explicit in France and the UK)
- In the mature markets reviewed in this section, decarbonization was initially undertaken by biomass usage but these countries are experiencing a need to shift to alternative heat supplies (there is a demand for biomass for alternative uses than heating and mentioned above, it was once classified as non-sustainable in the EU Taxonomy which was later changed which generates uncertainty around the future use of biomass for heating)
- In expanding and new markets gas or biomass currently dominates heat supply, again a discussion about shifting away from biomass is ongoing
- Europe needs to phase out gas and other fossil fuels which, in the short term can lead to an increasing use of heat pumps in DH systems
- Germany is the only country in the world that has a programme dedicated to low temperature waste heat recovery implementation
- The solution to go for combustion technology for heat generation chosen by the mature markets should be reconsidered for a market like the Irish where there is a

need to decarbonize and making use of locally available heat sources. In Ireland, the prevalence of datacentres is an important heat supply to consider.

3.2 Government/Market Interventions

3.2.1 Mature Markets (Denmark, Sweden and Finland)

In Denmark, the DH market is regulated, and municipal ownership dominates. DH was mandated until 2018. Until this point there was an obligation to connect, that could be imposed on both new and existing buildings. Decisions on DH connections were made by the City Council. There was also an obligation to remain connected (Danish Energy Agency, 2015). These regulations were revoked in new legislation in 2018 (Ministry of Climate, Energy and Supply, 2022).

Cooperative ownership forms exist in rural areas. The DH companies operating in these areas are not allowed to make a distributable profit. Companies can be both vertically integrated or specialise in distribution or heat generation.

In Sweden, the heat market was deregulated in 1996 (in conjunction to the deregulation of the electricity market). Prior to that, DH activities were the responsibility of municipalities (first managed by the municipality as part of municipal activity and later in the form of municipally owned limited companies) and adhered to a principle of self-cost (e.g. any revenue generated would cover costs but companies would not make any profit). DH was never mandated, instead it filled a demand for heating of new buildings erected in the 1960s and 70s and was complimentary to the provision of electricity by the hydropower installations in place. Additional electricity generation from CHP units was much needed for the development of society and the residual heat had a natural use in the new building stock.

Deregulation was followed by a period of price increases across DH companies which led to a DH Act in 2008 which aimed to safeguard the interests of customers (Fjärrvärmelag (2008:263), 2008). In conjunction to the law, a mediation board was established where any disputes between DH companies or DH companies and customers are addressed. In 2009, the Swedish competition agency advocated that DH prices should be regulated but this was never realized. Instead, the industry initiated a voluntary initiative to foster transparency and customer dialogue; called the “price dialogue”.

Most companies in Sweden are vertically integrated, and the owner of the company also operates it, 65% of the companies are municipally owned (companies are mostly fully owned but some public-private organizations exist).

In Finland, the development of DH has been similar to the Swedish case. The heat market was deregulated in 1998 (in conjunction with the deregulation of the electricity market). 97% of the companies are municipally owned. DH falls under the Finnish competition legislation and there is no dedicated DH Act and DH prices are not regulated.

In Table 6, key takeaways and areas for further evaluation are summarized.

Table 6 Key takeaways and areas for further evaluation per country (government intervention: mature markets)

Country	Market setup	Mandating	DH law	Dominant ownership
Denmark	Regulated market	Yes	Regulated market	Municipal
Sweden	Deregulated since 1996	No	Yes, since 2008- focuses on customer protection	65% municipal

Finland	Deregulated since 1998	No	No- DH falls under the Finnish competition legislation	97% municipal

3.2.2 Expanding Markets (Germany and France)

In Germany, the heat market was deregulated in conjunction with the deregulation of the electricity market in the 1990s. A DH Act was in place before the deregulation (introduced in 1980). After this period of privatisation two thirds of DH companies remain municipally owned (often these companies are small). The remaining companies are either privately or privately-publicly owned. Municipalities are allowed to mandate DH and approximately 35% of the DH customers in Germany have been mandated. It can be pursued if it is in "the best interest of the public". The mandating applies to all areas (not only new buildings or reconstructed buildings) but also in areas where competing heating alternatives already exist. Exceptions from mandating can be granted if they do not make the DH system unprofitable. Companies are usually vertically integrated.

In France, DH ownership structures include municipally managed companies (in small cities), private contracts through leasing, and private contracts through concession (the dominating form) often on a 15-30-year contract. There are three large DH providers in France that dominate the DH market. The municipality is the responsible agent for the public DH service, i.e., the proper functioning of the network. Thus, if the operator has made commitments towards the end-users on, for example, the proportion of renewables used in the heat generation mix, it is up to the municipality to ensure that the commitments are fulfilled. There is no mandate to connect to DH network for existing buildings unless they undergo major renovation. New buildings or buildings undergoing major renovation must connect to the existing heating network if the buildings are located in a priority development area for DH, as determined by the municipality, and the network is aligned to certain standards. Such a network must be powered by at least 50% renewable or recovered energy, the energy delivered per delivery point must be metered, the financial equilibrium during the amortization period of the installations must be ensured, and there has to be an economic interest for customers that connect to the network. A connection obligation only applies if the heating network provides an environmental benefit. These networks are also eligible for a reduced VAT rate.

France has worked in tandem on energy efficiency measures in buildings and to promote renewable energy. The Law on Energy Policy, also known as the POPE Law (Programmation fixant les orientations de la politique énergétique: in short energy legislation), was introduced in 2005 by the French government. The law aimed to reduce France's dependence on fossil fuels and increase the use of renewable energy sources. It set out targets for reducing greenhouse gas emissions and increasing energy efficiency, with the goal of reducing France's overall energy consumption by 50% by 2050. As a part of this policy, the government implemented new building regulations in the 2000s, which required newly constructed buildings to meet certain energy efficiency standards. In recent years, the French government has been focused on improving existing DH systems to make them more sustainable and efficient. This has involved integrating renewable energy sources such as solar power and geothermal energy into the systems. The government has also introduced regulations to promote the development of DH systems, such as the Energy Transition for Green Growth Law (2015), which aims to reduce greenhouse gas emissions by 40% by 2030 compared to 1990 levels.

The Thermal Regulation (RT) 2012 requires new buildings and renovations to meet energy performance standards, including the use of renewable energy sources or DH systems for space heating. The National Heat Fund (Fonds Chaleur, introduced in December 2008) provides financial support for renewable energy heating projects, including DH systems. The Urban Heating Plan (Plan de chaleur urbaine) offers technical and financial support to local authorities and companies to promote the development of DH networks.

Finally, the National Program for Sustainable Management of Urban Waste (Plan National de Gestion des Déchets Urbains from 2019) encourages the recovery of energy from waste through the use of waste-to-energy facilities to produce heat for DH systems.

It is interesting to note that Germany has introduced similar policies to France to review building standards (Building Act 2020 (Bundesministerium des Innern und für Heimat, 2020)) and heat planning (2020s). Addressing energy supply and building energy efficiency simultaneously is a powerful strategy for achieving climate goals. The current climate crisis is likely the primary driving force behind the combined effect of various policy tools designed to tackle these issues.

In Table 7, key takeaways and areas for further evaluation are summarized.

Table 7 Key takeaways and areas for further evaluation per country (government intervention: expanding markets)

Country	Market setup	Mandating	DH law	Dominant ownership
Germany	Deregulated since the 1990s	Yes (by municipalities)	Yes, since 1980 - focused on CHP production. Lately combined with other measures: building act reviewed in 2020, heat planning forthcoming.	66% municipal
France	Deregulated	No	No- combination of energy savings measures in buildings, integration of renewables in DHNs and urban heating planning. Dedicated heat fund since 2008.	Municipal: concession arrangement: long contracts 15-30 years

3.2.3 New Markets (Spain, Netherlands and the UK)

The Spanish DH market is not regulated and there is no particular DH Act. Responsibility for DH development has been delegated to the local authorities which leads to a heterogenous market. As a result the local authorities have much decision-making power about DH installations, pricing and taxation. 57% of the networks are public, 40% are private and 3% are mixed. Vertical integration is common.

While there is no specific target for expansion of DH in Spain, it is supported through various policy documents. For example, the National Energy and Climate Plan includes several measures to increase the share of DH as part of the heating and cooling sector (EC, u.d.). Also, in the National Programme to Control Atmospheric Pollution seven measures (EE1.1-EE1.7) explicitly or inexplicitly support DH (Spain NAPCP 2020, 2022). Spain is explicitly transitioning away from gas and therefore, currently the largest heat supply in DH comes from biomass rather than gas.

The DH companies in the Netherlands are operating on a deregulated market, there is a Heat Supply Act[11] is updated in 2024 (Wettenbank, 2024). There is a mix of municipally owned networks run as concessions, public-private partnerships, networks owned by publicly owned energy companies, and privately owned networks.

The Netherlands has worked on several complimentary measures outlined in its National Energy and Climate Plan (EC, u.d.). The plan explicitly addresses the district heating and cooling sector; it is stated that there will be a yearly average of 1.3% increase in the share of renewable energy in heating. 1.5 million existing buildings are foreseen to be natural gas free by 2030, meaning these will have to transition to a low carbon heating supply by this point. Municipalities are responsible for the targets on the built environment. CO_2 emissions from heating must be reduced by 70% compared to the current situation by 2030 and by 2050 the heat supplied must be 100% from sustainable resources. As a result, there is much discussion on the future ownership of DH networks. Currently the plan is to re-municipalise (make the private networks municipally owned again to at least 51% publicly owned).

In the UK, the heat market is currently deregulated. Prices are currently unregulated with companies in some cases encouraged or contractually bound to price at or below the level calculated by the Heat Trust for a gas boiler counterfactual. Market Framework including regulation, zoning and mandatory connection policy under development and likely to be in force from 2025. Municipal ownership with concessions dominates the city-scale networks. Private ownership dominates new build networks. Long term form of Government support is unclear. Current support through Green Heat Network Fund but this is likely to be fully committed quite quickly in the short term.

The Commission has revised the Energy Efficiency Directive (EED) (Directive (EU) 2023/1791) as part of the EU Green Deal Package[12] published in the Official Journal on 20 September 2023. Under the Directive, certain regional and local authorities will be required to prepare local heating and cooling plans. In the Netherlands, municipalities are required to plan the energy transition for the heating sector and the government is proving €400 million for this specific project. This is proactive and reflects the upcoming requirement at EU level for all municipalities with 45,000 inhabitants or more to conduct heat planning (Comission: EU, 2023).

In Table 8, key takeaways and areas for further evaluation are summarized.

Table 8 Key takeaways and areas for further evaluation per country (government intervention: new markets)

Country	Market setup	Mandate	DH law	Dominant ownership
Spain	Deregulated but heterogenous: delegated to local authorities	No	No, included in other climate related legislation	57% Public

[11] Warmtewet [Heat Supply Act]. 2024.*https://wetten.overheid.nl/BWBR0033729/2024-01-01*

[12] EC. Energy Efficiency Directive. *https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en*

Netherlands	Deregulated	No	Yes, since 2019, is being revisited and complemented by energy and climate legislation	Mix of municipal owned networks run as concessions, PPP, and privately owned networks
UK	Deregulated	Under way	Under way	Municipal ownership with concession dominates

Key takeaways and areas for further evaluation on Technology choices and dominant DH Heat Supply

- Of the countries reviewed in this section, only Denmark chose a regulated DH market pathway
- Networks in Sweden, Finland and Germany were largely built under a regulated market that was then deregulated; these countries deregulated the heat market in conjunction with the deregulation of the electricity market
- Mandating has been effective where it has been used. Where mandating was not introduced, other planning or tools or incentives have been important to ensure sufficient heat loads for a viable network.
- Sweden and Finland combined incentives for DH expansion with energy taxes
- France, Spain and the Netherlands have applied combined legislation targeting both energy and building efficiency simultaneously. Germany introduced this aspect of building efficiency (in the 2020s): the combination of energy efficiency and measures advocating district heating are efficient pathways to reach climate goals
- Sweden, German and the Netherlands have Heat Acts. The UK is currently working on its market framework (targeting regulation, some mandating and zoning)
- All countries have some form of either specific DH or more general consumer protection regulation that applies to DH
- Different ownership configurations exist, in all countries but the Netherlands municipal ownership dominates
- France has chosen a specific model where the municipalities resort to long term concession contracts to ensure their citizens have heating

3.3 Customer Pricing Plans - All Markets

Price models for the current, dominant DH technology, 3rd generation, are similar across countries. This includes a fixed component, **FC**, (to cover fixed costs of the DH company) and a variable component covering energy consumed, **EC**. This can also be adjusted to address the size of the equipment installed to ensure heat to a certain capacity **(CC)** when it is cold comes at a price for the DH company and the flow of water **(FoW)** through the substation. This can be expressed in the following way:

$$Price = FC + EC + CC + FoW$$

As mentioned above, the system as a whole is increasingly efficient if the substation works efficiently. In cases where the substation is owned and operated by the customer itself, there are sometimes motivational aspects included in the price model. These aspects can for example encourage proper operation of the substation by providing the customer with a negative cost when ensuring that the water returning from the building has a ΔT of a certain size or is within a certain range. Other motivational aspects can be to encourage the customer to invest in energy efficiency measures in the building, thereby lowering the energy demand from the DH system or to encourage the customer to provide the DH company with waste heat streams generated in the customer's buildings (in the ventilation shaft or from other processes). A motivational tariff **(MT)** component added to the equation above would look like this:

$$Price = FC + EC + CC + FoW - MT$$

Active engagement with customers to motivate them to ensure efficient functionality of their building systems is not yet widely adopted (Lygnerud & et.al, 2023). Price models across countries are similar and they have a fixed and one or several variable components. In some countries, the underlying customer contracts are long (as long as the concessions in France) whereas in other countries the customer has a 3-month termination time. In the context of long term contracts, the incentive to generate win-win solutions with the customer, for example by offering energy as a service solution, is higher. The variable components target energy consumption and sometimes also the water flow through the customer unit (m^3) and the effect (capacity/ size) that the installation necessitates at peak load. In Denmark and Sweden motivational tariffs are identifiable and they can, for example, be linked to the return temperature of the water from the customer building or to energy savings.

The ownership of the substation has conventionally been with the DH customer. As a result, the DH company has no control over the functionality of the building level energy system. A recent study identified that it is rare to establish motivations for the end-user to optimize its own system at the building level but that such motivational components should be the next step in DH price model design (Ibid). With the development of provision of energy as a service, there is increasing interest in DH companies owning the substations: making it possible to offer the customers a controlled indoor climate rather than hot water and heating (Fransson & et.al, 2022).

A special note on price regulation in the new markets considered in this review (Spain and the Netherlands)

In Spain, no price regulation at national level is applied. However, regulation can appear at local level (for example the case in Barcelona). In the Netherlands in 2023, a price cap was applied for gas, electricity and district heating for households and other small-scale users. This means that up to a certain level of consumption, these users did not pay more than a maximum tariff. For most users, the price cap resulted in a rebate on their energy bill. The matter will be further updated in the upcoming, revised, Heat Act.

Key takeaways and areas for further evaluation on Pricing Schemes

- Ongoing tariffs are composed by a fixed component and one or several variable components
- Motivational tariffs are commonplace in the mature DH markets of Sweden and Denmark

- DH in Denmark is not permitted to generate a profit which impacts the price level of DH
- A price cap linked to the price of natural gas is in place in the Netherlands
- Prices can be regulated at the municipal level in Spain

4. DH and Heat Pumps (HPs)

4.1 Heat Pumps as Heat Supply in the District Heating Supply Mix

HPs can be integrated centrally in DH systems (involving large-scale absorption or compression HPs) and can serve as one heat supply, enriching the DH heat supply mix. The source is then low-grade environmental energy (air or ground) or low-temperature waste heat. This is distinct from decentralised HPs installed in individual buildings, discussed in Section 4.2 below. A supply temperature of at least 86◦C must be delivered if the DH system is a conventional, 3rd generation high temperature system (a booster HP is used in such cases). In Sweden, electricity was cost efficient in the 1980s, then a large number of centralized HPs were installed across DH systems. The main heat source that they resorted to was sewage water (Lygnerud & et.al, 2021). Over time, the cost of electricity increased and with higher prices the business case of the HP integration was eroded resulting in many of them not being reinvested in once their operational life was terminated. Including HPs in DH networks involves coupling of the heat and electricity sectors. Studies of low temperature HP heat recovery have shown that PV installations in combination with HP investments are imperative for the HP installation to be bankable (Lygnerud & et.al., handbook for increased recovery of urban waste heat, 2022). Renewable electricity is desirable for HPs in DH networks, however, renewable electricity production is volatile and electric and thermal storage often have to be integrated on both building and network levels to ensure environmentally sustainable HP operation (Ochs & etal., 2022).

In the Irish context, it is worth noting that centralised HPs would be expected to have a reduced impact on the electricity grid compared to decentralised HPs leading to reduced levels of investment needed for grid reinforcement. This is due to a number of factors: large-scale heat pumps using sources like waste heat are more efficient and therefore require less electricity for the same heat output, centralised HPs mean the electrical load no longer has to pass through as much of the electricity grid and therefore less of the grid will require upgrades (particularly the lower voltage network) and diversity of demand reduces the peak seen by the electricity system at point of heat production. Also, environmental considerations such as noise, vibration and cold nuisance could be more of an issue with distributed HPs. Importantly, distributed HPs generally go unmonitored and are badly maintained so there is a risk in terms of worsening performance compared with centralised systems where the DH business case is based on an efficiently operating HP.

4.2 Decentralized Heat Pumps for Heating Individual Buildings

Decentralized HPs can service a building block or one individual building. Integrating HPs in buildings can make DH redundant. Increased volumes of HPs in combination with renovation of the building stock, and new buildings in Europe reaching a net-zero standard, a future decrease of district heating demand is anticipated. However, research has shown that much of the theoretical reductions are not realized due to the rebound effect brought about by changes in behaviour of occupants and modelled energy savings not representing as-built reality (Aydin & et.al., 2013), (Visscher & Meijer, 2016). For Ireland, due to expected population growth and the focus on the use of vacant land a reduced demand for district heating may not materialise.

In Ireland, 78% of the residential buildings, 66% of the commercial buildings and 47% of the public buildings are suitable for heat pumps without any additional energy efficiency improvements. This rises to 82%, 97% and 98% with maximum energy efficiency improvements in these three sectors (SEAIc, 2022). The drawback of HPs are, as mentioned above, that they run on electricity, which is not always green and may drive greater requirements for grid reinforcement. The Irish target for grid electricity is to be 80% renewable by 2030 (up from 40% in 2020) which vouches for increasing availability of renewable electricity also for HPs.

To balance the expansion of DH and the application of individual HPs **it can be concluded that in higher heat density classes any new decentralized HP installations could be a temporary solution, awaiting DH roll out and/or expansion. In the moderate heat density class, the combination of HP and DH needs to be balanced to avoid the DH business case being eroded. Granular heat planning can help with identifying what technology should be used where.**

In Sweden, some building owners with DH installed an additional HP. For the DH companies this was detrimental since the building was using the HP when electricity prices were favourable whereas DH was resorted to during the coldest times of the year only. In some companies, this was counteracted by including a capacity dimension to the customer price model ensuring that customers pay for the maximum effect outtake, not only energy consumed. The weather conditions in Ireland are different from those in Sweden, and the combination of systems (DH and HP) in a building appears unlikely. Another Swedish study has shown that including the decentralized HPs of buildings with both DH and HPs, so that they are part of the DH supply mix, is an alternative that can generate win-win to both the DH company and HP owner (the building company). This kind of collaboration is new and necessitates that both parties trust each other, establish an efficient contract and a possibility for the DH company to operate the HP in the most cost-efficient way. Currently, this kind of collaboration is rare in Sweden (Lygnerud & et.al., 2022). **From the Swedish experience, it can be concluded that price model adjustments in combination with win-win arrangements between DH companies and building owners with installed HPs is a viable way to arrange the interaction of the DH and HP technologies.**

4.3 CAPEX and OPEX based on Costs of Individual Heat Pumps

As noted above, the sectors of largest heat demand in Ireland are residential and industrial. Hence, it can be assumed that HPs will mainly be installed in that context. For residential use, units of 20kW should be the relevant size (Ochs & etal., 2022) whereas for industrial use larger units that can generate temperatures of relevance for different processes are needed. CAPEX and OPEX have been identified from two different sources 40 By 30 (REI, 2021) and the Danish Technology Catalogue Individual Heating Technologies (2020).

Table 9 CAPEX and OPEX for Individual Heating in Residential Buildings

Technology group	Technology type	Building type	CAPEX (kEUR/unit)	OPEX (kEUR/unit/y)
Individual Heat Pumps	Ground Water HP	Single family house	9.7	0.3
		Apartment buildings	117.0	1.5
	Air to Air HP	Single family house	1.1	0.2
	Air to Air HP	Single family house	6.1	0.3
		Apartment buildings	123.5	2.2

4.4 Inspiration from New Large Scale HP Application in the UK

A recent piece of news from the UK (December 6, 2023: (Holton & et.al, 2023)), is relevant to this HP discussion. In Swaffham Prior, eastern England a vast heat pump generates enough warmth to supply houses throughout a historic village. It is a pilot project testing ways to spur renewable energy use in a country that is falling behind its net zero targets.

The heat pump produces water hot enough to feed existing domestic systems, removing the need for costly home retrofits. A 60-year funding scheme removed upfront costs. Supporters say the network, the first of its kind in rural Britain, not only shows one way for the UK to catch up with Europe on heat pump adoption but addresses how it can fund the wider net zero transition when household finances are tight.

A majority of homes were heated by oil and the team tested multiple scenarios to drive uptake. They found one large network would be more efficient than individual heat pumps, while the community approach and lack of upfront payment meant residents were more willing to sign up.

The £12 million cost was covered by a £3 million government grant and a loan secured by the local council which will be repaid via household bills over 60 years. To help the switch, bills are index-linked to be in line or less than the cost of heating oil and will in time be indexed to the price of electricity.

So far in a village of two churches, two windmills and around 300 houses, more than 60 are connected to the heat pump which uses both air and ground heat sources. More than 35 are ready to be added, and others are deciding whether to join.

Those behind the project say it will not work for all communities - rural or urban - but it shows how the costs of the energy transition can be made more manageable.

Objective 2

Objective 2 of this study aims to consider the appropriate policy and financial supports to be provided (where district heating meets the definition of efficient district heating under the Renewable Energy Directive (recast of 2023)) to support overall capital costs to deliver district heating and to support domestic and commercial network connections consistent with other decarbonised heat sources.

To reach the objective, we have resorted to earlier work on market development in different countries across Europe. This includes work conducted locally in Dublin by Codema (The Dublin Region Energy Master Plan) along with interpretation and opinion provided to investors seeking to enter the DH market in the UK and Ireland. We have taken this body of work alongside additional sources and considered its relevance to the emergence of a DH market in Ireland.

5. Policy and Financial Supports

This section considers the appropriate policy and financial supports to be provided (where district heating meets the definition of efficient DH under the Renewable Energy Directive (recast of 2023)):

- to support overall capital costs
- to deliver district heating and
- to support domestic and commercial network connections consistent with other decarbonized heat sources

5.1 The Policy Making Process

DH can be considered as a relatively simple infrastructure type with a relatively complex set of policy considerations. This is due to the nature of DH networks as:

- **monopoly supplies** (assuming users disconnect from their existing generation source)
- an essential service that must be maintained in all circumstances with a minimum of downtime at times of heat demand
- **requiring high level of upfront conviction** and commitment due to high initial capex
- **requiring disruptive construction programmes** with high levels of co-ordination required with local stakeholders
- to reach their full potential, requiring **integrated thinking around energy systems coupling**

Due to the high initial conviction required to justify investment in the high capital cost of DH, there is a risk that an under-developed and stress-tested policy framework may not create the desired momentum in terms of expansion of DH. The following themes have emerged within DH globally.

Politics	DH projects have significant development and deployment timelines. Investors will not invest unless policy frameworks are considered to be stable and political risk is perceived to be low.
Culture	End-users have become used to a particular form of utilities market within Ireland. DH is unfamiliar to most. Any programme seeking to encourage switching from existing provision to DH needs to take account of existing cultural norms and how to bring about behavioural change.

Structures	Heat is a critical utility yet DH is a nascent market in Ireland. Policy will need to sit within a visible market framework that ensures a critical utility is delivered appropriately. National Government will need to decide through a market framework how it guides market participants to engage with the opportunity and on what terms.
Controls	DH tends to be a monopoly supply. As with any monopoly supply, the state will usually need to implement regulatory measures to ensure the monopoly position is not abused. The core themes within DH are around pricing and quality of construction and maintenance of networks.
Skills	DH projects are of significant scale and the assets are long dated. In any nascent but growing market there is likely to be a skills gap. Policy should seek to address how to overcome any gap to ensure development and deployment of high-quality, best-in-class DH networks.

5.2 Main Aspects to consider for DH Policy Making: Returning to the Capital Cost Profile of DH and input from other DH Markets

DH networks in new markets need to connect both existing and new-build buildings. DH networks in mature markets range in size with the smallest networks serving a few buildings and the largest serving whole cities.

In new markets, Government needs to decide on the types of networks it wishes to encourage through its policy signals (Ruth E. Bush, 2016). Both small and large networks can be efficient in the right circumstances. However, there can also be a tendency to focus on smaller network sizes in new markets where confidence levels are insufficient to encourage ambition. Policy should therefore be 'right-sized' to ensure smaller networks are permitted but larger networks are encouraged and supported where scale is appropriate.

5.2.1 Policy input based on the capital cost profile of DH

The core capital cost components of a DH network are:

1. **Heat Plant Initial Investment**: This includes the cost of planning, designing, and constructing the heating plant or energy centre, which may use a variety of fuel sources such as biomass, heat pumps or waste heat. This is a capital-intensive part of the DH investment and will necessitate some kind of incentive in a new DH market.
2. **Distribution Network:** The costs associated with laying the pipes that connect the heating plant with the end-users. This can be a significant portion of the total capital cost, especially in urban areas where excavation and road reinstatement are expensive. The cost of the distribution network will depend on the material used. Steel pipes are still common in high temperature systems but also in the high temperature context plastic pipes are increasingly used. Plastic pipes tend to be cheaper than steel pipes. One main driver for this cost is the trenching, if it can be done in parks, across lawns etc. the investment cost is lowered. Regardless of pipe material and trenching circumstance, the costs of the distribution network will be substantial and will necessitate some kind of incentive in a new DH market.
3. **Substations and Building Connections:** Each building connected to the district heating network requires a substation where the heat is transferred from the network to the

building's own heating system. This includes the cost of internal modifications needed to connect buildings to the district heating network. The greater control the DH company has of the performance of the secondary system, the higher the efficiency of the network will be. Hence, incentives should be provided allowing the DH companies to own the substation along with a regulatory framework to support this.

4. **Contingencies and Engineering Costs:** Additional costs for unforeseen expenses, project management, and engineering services. It is known that changes and additional work in a construction process can amount to a significant share of the final cost. Incentives to share gains and losses between the project owner and the contractors should be mandatory in the context of DH expansion.

5.2.2 Policy input from other DH markets

The core inputs from other DH markets are:

1. **Deliver networks in phases.** A key feature of DH implementation is the need to deliver networks in phases. A full network will never be established at once. It will be initiated in an efficient area (in terms of heat density) and then gradually grow over time. It takes decades for DH systems to reach a level of maturity. Each phase will need to be right sized to maximize technical and operational efficiency whilst also representing a commercially viable scheme.

2. **Energy efficiency in buildings.** When designing a district heating network for a building stock, there is no need for the building stock to be energy efficient (unless the DH system established is a low temperature system as such require energy efficient buildings), (from interviews under Objective 3). Improvements in building efficiency will occur over time which means that the initial system will be oversized for the initial buildings. This oversizing is however, not a drawback instead it allows an ongoing expansion of the network to new customers.

   Designing policy for a new heating technology, like DH, it is important to synchronize legislation on energy efficiency and policy for DH expansion to ensure that are complimentary rather than opposing. As mentioned, in markets like Germany and Spain, the interconnection between energy efficient building policy and district heating expansion has been strengthened.

3. **Commercial viability is a must.** DH systems in mature DH markets were built mainly under municipal ownership and with municipal funds (Ministers, 2017). The circumstances of the time allowed this kind of financing. In Sweden, for example, the DH expansion was propelled by a demand for electricity beyond the available supply from hydropower (before the country established nuclear power plants). Taking into account that municipalities cater for a large number of other activities it may not be realistic to assume that they could carry the burden of DH investment to arrive at the desired level of expansion for Ireland. Instead, the roll out needs to be financed by a number of public and private sources of funding. Hence, for an efficient roll out of DH in Ireland, commercial viability is needed. It is partly a product of the policy and financial supports provided by Government. Government policy can therefore have a direct effect on the size of phases delivered by relevant stakeholders. Where Government wishes to encourage ambition, it should undertake stress-testing of the potential effect of its policy on viability of phase sizing. Otherwise, there is a risk that stakeholders will limit ambition and deliver smaller phases that are not optimal in terms of overall systems design. Roll-out of phases may also become stunted through a lack of confidence in the potential commercial position of the relevant network extension.

4. **Reduce demand risk.** Another key feature of DH implementation is uneven linear heat density within urban areas. This is a particular feature in UK and Irish cities where there has traditionally been a tendency towards individual dwelling houses rather the apartment blocks that dominate inner-city areas in Scandinavia (Scotland, 2017). Policy and financial supports should seek to acknowledge this reality by, for example, providing targeted incentives for increasing the DH heat density in areas where the heat density would otherwise be low and thereby detrimental to the overall efficiency of the DH system. This kind of incentive also lowers the risk that there will be low demand for DH once available.

5. **Do not lock into single technologies.** In mature DH markets there is a dominance of CHP technology. However, taking forthcoming developments into account (such as the EU Taxonomy) it is likely that certain heat supplies like biomass and combustion of waste will be phased out in the future. There is a trend towards decarbonisation of existing networks and increased use of waste heat, further supported by the update of the European Energy Efficiency Directive in 2023, at high and low temperatures which necessitates a flexibility in heat supply, increased use of storage units and coupling with other energy sectors. When designing the DH policy framework for Ireland it is important to align with EU design criteria and avoid locking in or incentivizing individual technologies that can become obsolete over time.

6. **Foster sector coupling.** It is important to foster sector coupling to allow DH to balance the electricity grids, make best use of any otherwise surplus generation and to increase energy resilience overall (Lund H. W., 2014). DH has the potential to play a key role in reacting to intermittency through being able to provide grid balancing services and by drawing down power at times of surplus generation into cost-effective thermal storage (Boldrini, 2022). Policy makers need to understand the potential role of DH within the overall decarbonising energy system and the interactions required within the remainder of the energy system to ensure the optimisation of DH. Codema's recent study in this area (Ireland, 2023) is a useful first step. Further modelling work should be undertaken to fully understand the opportunity and its potential economic impact on the energy system as a whole and for the economics of DH specifically. For instance, it may be that the financial returns are higher for DH projects that are able to interact with the power grid and generation in an optimal fashion. This may reduce the need for direct fiscal support in the form of grants and other interventions. However, it is likely new policy will be required to realise such an opportunity.

7. **Customer protection.** In mature DH markets there is existing DH legislation. One important aspect to consider is customer protection. This is important from the point of view of customer rights but also from the point of view of avoiding as sense of being 'locked in' and in the hands of a monopolist which could trigger customers to disconnect from the DH grid or to install multiple heating systems (DH and HP) to the detriment of DH system efficiency (Lygnerud K. , 2018). On the customer side, a clear and standardized framework is key. Taking the desired increase in use of non combustion assets like waste heat it is also relevant to incentivize waste heat owners to provide waste heat to DH systems.

5.3 Key Policy Questions for Ireland to reach DH Goals

Ireland is a new DH market. As such, its policy considerations most closely align with the new markets identified in Section 3.2.3 above, Spain, Netherlands and the UK ("New Markets").

Each of the New Markets has had to face a series of important key policy questions in their attempts to establish policy to support the sector in achieving the Key Policy Goals as defined in Table 10.

Table 10 Key policy questions faced by new markets in supporting the achievement of Key Policy Goals

Policy Level	
Roles and Responsibilities	Whether to establish policy at a national, regional or municipal level. Allocation of responsibility between each level and consideration of any potential interface or friction between levels.
Market Framework	
Setting out to the market a clear market framework that establishes how each market participant will be permitted to participate and on what terms.	A DH market framework should include: • The role of the public sector • The role of the private sector • The role of the regulator • Supporting legislation • How customer protection will be achieved (role of regulator, role of other stakeholders and supporting legislation and codes of practice) • Whether any particular technical, commercial and legal arrangements will be encouraged, discouraged or prohibited • The permitted routes to market for DH schemes • Permitted participants in the design, build and operation of DH schemes • Providing clarity on common planning issues, in particular ability to lay down infrastructure on, over or under public land including pipework and energy centres.
Planning and Zoning	
Zoning	Whether to designate where DH is an appropriate solution as compared with the relevant alternatives for heat. If so, the method of designation and the methodology to arrive at the designation.

Mandatory connections	Within any designation, whether to mandate connection of particular users (for instance, public sector or commercial buildings) to establish a base load that increases the opportunity to develop a viable project.
Heat Sources	How to encourage effective input of heat sources within identified DH areas
Identify relevant Economic and Financial Incentives	
Fiscal support	Provision of financial incentives such as subsidies, grants, or tax breaks for the development of district heating infrastructure, including for the integration of waste heat and renewable energy sources.
Balance sheet treatment	Clarity on Government balance sheet implications of public sector investment.
Crowding in private sector investment	Government role in crowding-in private sector investment.
Identify Relevant Regulations	
Establishing a clear and stable regulatory framework that allows the market to make the long-term investments required to deliver DH	The regulatory framework required to oversee the planning, development, and operation of DH. This potentially includes price regulation (as used in the Netherlands and some Spanish municipalities), consumer price regulation and the setting of standards for energy efficiency, emissions, and safety.
Synchronize with Building Regulations and Standards	
Ensuring Building Regulations are fit for purpose and do not contain disincentives to DH roll-out	Update of building regulations and standards to require or encourage the connection to district heating systems where available, potentially including requirements for building energy efficiency.
Innovation and Research Support and Knowledge Transfer from Other DH Markets	
Ensuring delivery of best-in-class systems	Support for the research and development of district heating technology and systems to drive innovation, efficiency improvements, and the integration of new energy sources.
Knowledge transfer	Identify what has been done in other DH markets before and learn from best practices but also from mistakes made elsewhere.

Key takeaways and areas for further evaluationon Policy

- **Policy level:** Decisions should be taken on which elements of policy will be centralised and which will be delegated to local government. The market may prefer consistent policy across Ireland, favouring a centrally delivered model. Where there are necessary policy interactions, mechanisms should be in place to ensure efficiency and alignment between levels in a manner that can clearly be described and utilised by market participants.

- **Market framework:** It is important for the market to understand the market framework in which it will be asked to operate. This should include detail on permitted market participants, routes to market, permitted corporate arrangements for heat network owners (public vs private ownership) and regulation, including consumer protection and supplier of last resort arrangements. New market entrants are unlikely to have confidence to invest significantly in personnel and resources in Ireland without certainty around the market framework.

- **Zoning/Demand risk/Mandating.** DH developers need certainty of off-take to be able to commit to large scale activity and investment. Gathering heat loads in a contractually certain manner can be challenging and frustrate efficient development of DH propositions. The UK is planning to answer this challenge by introducing zoning (to identify areas where DH is the lowest cost, low carbon heating solution) and mandating of public sector and large commercial loads. Similar techniques have been used by other countries (e.g. Denmark) in the past.

  There may be a case to incentivise end-users not subject to mandates to switch to DH. However, most Government's to date have opted to direct fiscal support directly to developers of DH. Any support to end-users may need to be in addition to not instead of such support.

- **Energy systems thinking:** DH forms part of an overall energy system. Central Government and relevant stakeholders should ensure that energy systems thinking is incorporated into policy development to ensure the full potential of DH is established and encouraged.

5.4 Funding District Heating in Ireland

5.4.1 The funding context

Most New Markets have identified the need to provide support to District Heating. Support is usually in the form of a mix of fiscal measures (subsidies, grants, or tax breaks) or direct or coordinated public and/or equity and/or debt (Deloitte, 2018).

Different countries have opted for a different emphasis between for instance tax breaks (such as in the Netherlands) or direct grant funding support (such as in the UK). It is evident that in some cases decision making on support has been piecemeal and, in some cases, ancillary or adjacent to support directed at other energy systems, such as power systems (CHP support).

In New Markets these mechanisms remain under-developed but there is useful reference material for Ireland in developing its concepts in this area. Core to developing an effective funding strategy within a new DH market is the need to deliver stakeholder and investor confidence in developing and then financing projects. DH projects tend to show a low financial returns profile in initial screening, potentially sub-zero percent and often in the 1-5% range (Gullev & Duedahl, 2019).

Projects can easily stall if not provided with:

- development funding to develop and optimise the project and returns profile, and;
- fiscal support towards capital costs to ensure stakeholders have the confidence to proceed to construct the network.

As a benchmark, private finance providers of infrastructure capital typically seek an equity return in the range of 10-15% and a debt return) in the range of 4-8% (on the basis of non-recourse project finance)[13] (Gullev & Duedahl, 2019). The range is particularly volatile at the moment due to recent inflationary pressures and subsequent re-pricing of equity and debt.

Those designing funding mechanisms may also wish to consider if it is desirable to direct limited available funding support to those projects that make most strategic sense. The ability to design such a system will in part be reliant on policy having been established on which types of projects should be prioritised. Potential reasons to prioritise certain projects may include:

- Projects serving particular types of heat load (public sector, social housing etc)
- Projects achieving a particular emissions or energy systems profile compared to the counter-factual solution (individual heat pumps etc)
- Projects producing a favourable energy systems outcome (for instance capability to provide grid balancing)
- Projects achieving a minimum overall viability threshold.

In DH there can be a logical overlap between those projects presenting the highest IRR's and those projects which are strategically sensible. For instance, projects utilising waste heat as the main thermal input are likely to demonstrate a higher returns profile due to the often low cost of buying in waste heat compared to the relatively high cost of, for instance, the use of electricity within large-scale heat pumps serving a DH network.

Finally, consideration should also be given to any funding strategies that may need to overlap with other energy sectors to become effective. For instance, Codema undertook an assessment of the integration of renewable energy across the electricity, heat and transport sectors, with a focus on the Poolbeg area of Dublin (Ireland, 2023). The planned Dublin District Heating Scheme (DDHS) in the Poolbeg area will supply heating to buildings in the surrounding area and will have associated heat storage (in the form of large insulated hot water tanks). Excess electricity can be converted and stored as heat for use in the district heating scheme.

Within the study, MullanGrid modelling results projected average wind and solar wasted energy (or curtailment) levels to be 6-23% for 2030-2035, and 14-16% for 2040. The study found that there are no clear policy measures to address excess or wasted renewables on the electricity system for the key 2040 energy system planning time checkpoint and that limited

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[13] Non-recourse finance is a type of commercial lending that entitles the lender to repayment only from the profits of the project the loan is funding and not from any other assets of the borrower.

modelling has taken place in Ireland to date for this time checkpoint. The priority order of measures to reduce excess or wasted renewables has not yet been defined – this will be a key step in future planning. The study found that DH with largescale storage represents a highly cost-effective measure to reduce curtailment and should form part of this priority order of measure.

District heat (with heat storage) can potentially reduce wasted wind energy (curtailment) by up to 70-86% in 2030 if the national district heat target of 2.7 TWh is achieved. Wasted (curtailed) electricity could supply 53.2% and 58% of heat demand in the DDHS by 2030 and 2040, respectively. The Dublin District Heating System could reduce national curtailment by 2.1% and 8.6% in 2030 and 2040, respectively.

Heat storage is significantly more cost and space efficient than battery energy storage. Analysis for the Dublin District Heating System shows that; Heat storage for the Dublin District Heating System is approximately 1% of the cost and uses less than 10% of the land area compared with battery storage of the same energy capacity. Heat storage has a lifespan which far exceeds battery storage with comparatively little degradation (heat storage greater than 50 years vs. Battery storage 5 – 15 years). Electric boilers with heat storage represent the best option for the Dublin District Heating System assuming access to free or low-cost curtailed electricity.

The study looked at the potential economic position of DH where it is able to access free or low-cost curtailed electricity. When the heat production equipment was connected behind the meter i.e., directly connected to the offshore wind farm, then heat production was cost competitive with the currently proposed heat supply from the Dublin Waste-to-Energy plant.

The study demonstrates the potential role of thermal storage within DHN to provide grid balancing at a lower cost than alternative technologies. To unleash this potential, it may be necessary to undertake a valuation exercise of the DH contribution to balancing of the power grid and efficient use of renewables capacity into the grid. This may require multi-systems thinking that can be lacking in new markets.

5.4.2 Who should support be offered to?

One of the core questions in designing an effective DH support mechanism will be deciding which parties are permitted to apply for and benefit from fiscal support. The answer to this question is intimately linked to the question of which parties may be permitted to act as project sponsors within a particular market, which may include:

- Local Authorities
- Delivery Organisations established by Local Authorities (for instance local energy/heat companies)
- Central Government
- Delivery Organisations established by Central Governments (for instance a Central Government DH Delivery Authority)
- Other public bodies (health authorities, universities, housing bodies etc)
- State owned utilities
- Private utilities/ESCO's/energy companies
- Others

Support for Developed vs End-Users

There is little evidence of support mechanisms for end-users to connect to heat networks. We believe this is because, for the most part, Governments have identified that for a DH developer to proceed, it needs confidence in advance of deployment that the overall project can be financed. Directing any support available to the DH developer rather than the end-user means that a substantial capital grant can be agreed upfront. Other providers of finance are then able to assess the project on the basis of the support provided by the grant. If the same support was distributed to end-users, any developer of DH would then need to encourage end-users to obtain and the developer would need to collect the grant. This is likely to be costly, inefficient and also difficult to achieve in a reasonable timescale.

Whilst it would therefore appear that the majority of support should be directed to the developer of DH, we believe there may still be a case for either mandates or an element of financial encouragement to switch to DH. Whilst mandating might be more appealing for some loads (such as public sector and large commercial in the UK for example), incentivisation may be more appealing where mandates may be more difficult to justify. For instance, individual dwelling houses. It may also be sensible to consider whether incentives for other solutions (such as individual heat pumps) should be offered within areas where energy planning suggests DH is the preferred solution.

Who should be incentivised to develop DH?

Some new markets have struggled to properly define which project sponsors will be permitted to develop DH, leading to an element of confusion and uncertainty in the market.

For instance, in the Netherlands, the market to date has welcomed both public and private sponsors but is now considering restrictions to favour public owners and operators. This is causing some concern from private infrastructure investors who have entered the market and are now unclear as to their potential future role (de Boer, 2023).

In the UK, funding to date has largely been targeted at local authorities who have then been the procuring authority for the underlying project (often through a concession or less frequently through a joint venture model). This has been undertaken within a policy void, with little specific legislation acting to provide a market framework (Frontier Economics Limited, 2015). This is now being remedied through the development of enabling legislation due to come into force in 2024/2025. However, significant uncertainty remains about which routes to market will be permitted under the legislation, and therefore who is likely to act as project sponsor. Concern has emerged about the capacity and knowledge of often financially stretched local authorities to procure ever-larger networks which constitute a commercial activity which carries significant commercial risks both in terms of project development and in execution of the DH plan.

It may be possible for Ireland to learn lessons from other new markets and seek to provide early clarity on the permitted market framework, market participants and recipients of funding support. This may act to bring early order and certainty to the market, building confidence in relevant stakeholders to undertake the significant effort required to pursue the development of DH projects.

5.4.3 Development Funding

To turn a nascent opportunity into a functioning sector, key stakeholders need sufficient confidence to enter the market. As DH returns can be challenging there can be reluctance to enter the market unless there is both sufficient clarity on policy and an organisation of the market to ensure returns of a certain level are available (to encourage stakeholders to act independently) or state support for development.

Experience from adjacent equivalent markets suggests that the Irish Government may need to offer generous early development funding for momentum and capacity to build in the market.

Case Study: UK Heat Network Delivery Unit

The UK Government introduced the Heat Network Delivery Unit (HNDU) to provide grant funding and guidance to local authorities in England and Wales for heat network project development (GOV.UK, 2024).

Since its inception, HNDU has run 12 funding rounds – awarding £33.8 million in total – and is currently running Round 13. Over 300 unique projects have so far been supported across 188 local authorities. As of Round 12, HNDU supports the following types of organisations:

- Local authorities (main recipients)
- Registered social landlords
- NHS Trusts
- Universities
- Other government departments
- Property developers

HNDU provides support to local authorities in England and Wales through the early stages of heat network development including:

- Heat mapping
- Energy master planning
- Techno-economic feasibility
- Detailed project development

HNDU support does not provide funding for commercialisation costs and costs associated with the construction, operation and maintenance of a heat network. This support is provided separately by the Green Heat Network Fund (GHNF) (a 288 million GBP capital investment programme providing support for the capital costs of heat networks.). Further information on the GHNF is set out in the following section.

5.4.4 National Grant Support for Capital Costs of Construction of networks

Ireland

The Irish Government has made grant awards to two DH projects in Ireland. They are the Tallaght District Heating Scheme (4.5 million EUR) and Dublin District Heating Scheme (20 million EUR) ((Codema, 2020) & (Dublin City Council, 2021)).

Germany (BEW)

The German Government introduced a federal funding programme for district heating's transition to renewable energy sources in 2023. In the period up to and including 2026, around 3 billion EUR will be made available for renewable heat generation using geothermal energy, solar thermal energy, large-scale heat pumps and further heat network infrastructure (Federal Ministry of Economic Affairs and Climate Action, 2022). The BEW backs the building of new heat networks where renewable energy and waste heat sources will constitute a share of at least 75%, as well as the decarbonisation of existing networks. A maximum of 40% of investments in generating facilities and infrastructure will be backed by funding.

Where individual measures can be implemented quickly, e.g. solar thermal systems, heat pumps, biomass boilers, thermal energy storage, pipes and district heating substations, funding can be applied for according to simplified requirements: in such cases neither a feasibility study nor a transformation plan is necessary.

Netherlands (WIS)

The Heat Networks Investment Grant is a Dutch grant scheme for the construction of new efficient heat networks (energy-efficient district heating and cooling). The grant is only for heat networks that make existing homes natural gas-free. (EGEN, n.d.)

Heat companies and businesses that invest in the construction of a new heating network. Emphasis is placed on parties with advanced plans who can quickly start the construction of the heating network. Provinces or municipalities may participate in a project (as shareholders participating in such a business) but cannot receive grants themselves.

The grant is intended as an impulse to bridge the 'unprofitable top' of heating network investments (the difference between the eligible investment costs and the operating profit).

The grant reimburses a maximum of 45% of the project costs, or a maximum of 6,000 EUR per realized small-scale consumer connection: the limit that is reached first applies as the maximum.

The maximum grant is 20 million EUR per project.

UK (GHNF)

The UK Green Heat Networks Fund (GHNF) is a 3-year 288 million GBP capital grant fund that supports the commercialisation and construction of new low and zero carbon heat networks and the retrofitting and expansion of existing heat networks. The scheme launched on 14 March 2022 and will run until 2025 (GOV.UK, 2022).

The GHNF is the successor to the Heat Networks Investment Project (HNIP), which provided 320 million GBP of capital funding to heat network projects in England and Wales between 2016 and 2022.

5.4.5 Public Infrastructure Banks

In addition to grant, the state can support investment into DH through public infrastructure banks or dedicated public equity and/or debt facilities.

The following public infrastructure banks have provided investment into heat networks in their respective countries or at EU level:

1. **European Investment Bank (EIB)**: The EIB, the lending arm of the European Union, has financed numerous heat network projects across Europe. (CEE Bankwatch Network, 2021)
2. **KfW Development Bank (Kreditanstalt für Wiederaufbau)**: This German government-owned development bank is involved in various international projects for energy efficiency, including the financing of DH projects. (KFW IPEX Bank, 2023)
3. **Nordic Investment Bank (NIB)**: The NIB is a multilateral financial institution owned by eight member countries in the Nordic and Baltic regions. It has financed several DH projects. (Nordic Investment Bank, 2024)
4. **European Bank for Reconstruction and Development (EBRD)**: The EBRD invests in changing the energy landscape of its regions of operation, which includes Eastern

Europe, Central Asia, and the Southern and Eastern Mediterranean. It has financed district heating projects to improve efficiency and integrate renewable energy sources. (European Bank of Reconstruction and Development , 2021)

5. **Green Investment Group (GIG)**: Originally part of the UK government (as the Green Investment Bank) and now owned by Macquarie Group, GIG has invested in various green projects, including heat networks. (Green Investment Group, 2016)
6. **The Municipal Green Fund (Kommuninvest in Sweden)**: While not a bank, Kommuninvest is a cooperative that provides financing to local governments in Sweden for various projects, including district heating systems. It focuses on sustainable municipal infrastructure investments. (Kommuninvest, n.d.)

Case Study: UK Infrastructure Bank DH Facilities

The UK Infrastructure Bank, the UK's replacement for the EIB function following Brexit, has recently issued a white paper setting out its objectives in developing finance for DH projects (UK Infrastructure Bank, 2023). The UKIB has identified the following challenges:

Policy Risk: The regulatory framework for heat networks is expected to come into force in 2025 (Zero, 2023). Recent progress on the Energy Bill and the developing pipeline, including the Advanced Zoning Programme, provide welcome clarity about the direction of travel for the sector. However, before 2025, there remains a lack of clarity about how, in practice, policy will address the off-take uncertainty and cost of heat which are deterring private investment in the sector.

Revenue Risk: Heat networks face significant revenue risks, particularly at the outset. Without heat zoning, developers face uncertainty about the proportion of consumers that will connect. Projects rely on 'anchor loads', large off-takers that can represent a large baseload of demand (c.30-40% of total network demand). However, even securing these anchor load clients can be challenging and their creditworthiness can be variable. Up-front connection costs can be significant and deter customers. Once operational, large heat networks can provide lower per-unit heating costs, which make the likelihood of attracting customers and achieving scale higher. Once fully established at scale, heat networks function as a mature infrastructure asset class with stable long-term returns.

The following solutions have been proposed by the UK Infrastructure Bank as a potential solution (UK Infrastructure Bank, 2023):

Connection charge facility:

Connection charges currently vary significantly and depend on whether the asset connecting to the heat network is domestic or non-domestic. Upfront connection charges can act as a disincentive for customers to connect to heat networks and are a barrier to networks achieving sufficient scale to provide heat at competitive prices. The UKIB wants to test whether a facility reducing upfront connection charges could bring customers and mandated buildings onto networks more quickly and, in time, help networks build out to full scale.

Green Heat Network Fund collaboration

The UKIB has an existing collaboration with DESNZ enables local authorities applying for GHNF funding to automatically apply for UKIB lending to meet any funding gap.

The UKIB wants to deepen this collaboration to encourage project sponsors to increase the scale and ambition of their heat networks.

Project gap funding:

The UKIB expects the initial phase of the most developed projects to exceed £500 million, with eventual total capex requirements exceeding £2 billion, a significant proportion of which will need to come from private investment.

The UKIB wants to facilitate the rapid delivery of these strategically significant projects that will stimulate the growth of the wider pipeline.

Many projects face a gap between their financial returns and the returns expected by private investors due to challenging project economics. The UKIB is exploring options for how it can play a role in bridging this gap, crowding in private investment and bringing more projects to financial close.

Construction / ramp-up guarantee or loan:

Policy risk and revenue risk have prevented commercial bank finance from being available during the construction and ramp-up phase of heat networks. To address this, the UKIB is considering piloting project guarantees or lending that are cancelled or repaid when a project hits financial ratios that make it bankable by commercial banks.

5.4.6 Market immaturity

The small heat network market in the UK has limited the development of the supply chain, leading to increased costs for projects and competition for components and skills.

5.4.7 Project economics

As evidenced by the substantial capital support programmes in the Germany, the Netherlands and the UK described above, the project economics of heat networks are both substantial and challenging. The market remains dependent on grant funding to be viable for commercial investors. The challenge for Governments is to design fiscal support mechanisms that make best use of available capital to deliver the 'Crowding-in' of private finance through informal or organised structures.

Case Study : UK Green Investment Bank

On its creation there was an interesting debate as to whether the UK GIB was better positioned to provide development funding to draw in other private finance as the development stage or alternatively if it would be more effective purchasing completed assets (and so giving developers confidence to fund development).

The bank leaned into development funding focus. The aim was to de-risk the earliest stages of project development by demonstrating an available source of capital on known terms. This was applied in UK offshore wind and is seen as having been successful. In general terms the GIB estimated that, whilst owned by the UK Government, it was involved in between 43% and 64% of the transactions in the UK offshore wind and waste and biomass sectors each year. (https://www.nao.org.uk/wp-content/uploads/2017/12/The-Green-Investment-Bank.pdf). It should be remembered that EIB funding was also available to the UK during this period. This demonstrates the potential importance of the availability of a knowledgeable nationally located public funder of net zero infrastructure if development of a particular sector, such as DH, is to be successful.

Whilst the UK made significant progress through the GIB in crowding in private finance into offshore wind, no such progress has been made in relation to DH. The UK Infrastructure

Bank (the UK's replacement to the EIB) is in the early stages of designing DH friendly public debt facilities, but this work does not yet extend to structures designed to crowd in private finance.

Case Study: Netherlands Heat Act
The Heat Act is updated in 2023 and the amended Act is in force since January 2024 (Wettenbank, 2024). The most recent information is that the Government may be pivoting away from private ownership to a majority share of ownership having to be public or state (51%). In the interviews set out in Objective 3 we find that private companies are now on standby to understand how such a position will impact them. New, public DH companies are also forming.

In 2020, both the HVC Group and Asper Investment Management received loan agreements with the EIB to support DH development ((EIB, 2020) (EIB, 2020)). Their commercial models rely on the acceptance of private ownership of private networks. For each of these projects, significant work has been undertaken to crowd in this private finance and through the establishment of those private entities, secure public infrastructure funding through the EIB.

It is unclear whether these arrangements would survive any change in the Heat Act, either in their current or a revised form. This emphasizes the importance of a stable and certain market framework where basic elements such as permitted ownership structures are carefully considered in advance.

5.4.8 Market Mechanisms

Renewable Heat Obligation - To support the need to decarbonise the heat sector, the Irish Government has stated an intention to the introduce a Renewable Heat Obligation (RHO)[14]. The RHO will support an increased use of renewable energy in the heat sector and contribute to a reduction in emissions in line with Ireland's climate ambitions.

The RHO is a mechanism that shows on the ground-level, tangible support for renewable heat delivery. To date, district energy has not been included in policies of this type. The Irish District Energy Association (IrDEA) has suggested that this poses a significant barrier to the rollout of DH at the scale needed ((IrDEA, u.d.). IrDEA is also concerned that the RHO largely overlooks waste heat as a source of sustainable energy that should be promoted in the Irish context. One way to do that is to allow district energy networks to sell RHO credits as an income source that could then be invested in the further growth of networks.

Key takeaways and areas for further evaluationon Funding

- **Returns profile:** Experience in other markets suggest that the return profiles for DH projects tend to be low. Funding mechanisms should be designed with this in mind, to ensure worthwhile projects are identified and supported, whilst less worthwhile projects might be considered less of a priority.

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[14] Gov.ie. Department of the Environment, Climate and Communications Renewable Heat Obligation. *https://www.gov.ie/en/publication/7a1f1-renewable-heat-obligation/*

- **Skills funding:** DH is a nascent market in Ireland. It may be appropriate for Government to work with potential DH developers and entrants to the market to identify how to deliver skilled professionals and contractors into the market. This is also an opportunity to increase employment in the sector.

- **Development and commercialisation funding:** Projects are likely to need significant development funding to develop early-stage concepts and move them through commercialisation to delivery. There are lessons to be learned from the experiences of publicly funded geographically proximate DH development funding programmes such as the Heat Network Development Unit (HNDU) in the UK.

  It is key to decide early which stakeholders policy wishes to support in leading development and implementation of projects and so receive development, commercialisation and capital funding. Government may also wish to consider aiming some funding at end users in relevant geographic areas to encourage connection to DH rather than retaining the status quo or connection to competing solutions that might be less desirable from an energy systems perspective e.g. heat pumps. It may be attractive to aim development funding at particular types of schemes that might be considered high priority because, for instance, they make good use of waste heat sources or serve a particularly suitable offtake profile.

- **Capital funding:** Due to a low returns profile, many schemes are likely to require capital funding support. This is particularly so in the early stages of market formation where some inefficiencies are inevitable. The Dutch grant support scheme describes this as the 'unprofitable top' (the difference between the eligible investment costs and the operating profit).

  As with development funding, it may be attractive to aim development funding at particular stakeholders and types of schemes that might be considered high priority because, for instance, they make good use of waste heat sources or serve a particularly suitable offtake profile.

  Any capital funding programme should be realistic and able to support the likely profile of a DH project. This involves development and capital spend over a number of years, with DH networks also being built out in phases. This favours a flexible capital funding model.

  Any funding model should also be designed to sit alongside other forms of finance considered attractive, for instance public debt or private finance.

- **Market mechanisms:** The Irish Government should consider whether it wishes to provide and amend proposed market mechanisms to include DH. For instance, the IrDEA has made representations that the DH should be included within the proposed Renewable Heat Obligation.

- **Availability of bespoke public debt products:** The Irish Government should consider whether it intends to make or work with the EIB to make public debt products available to DH. If so, such products should be carefully designed to ensure that they are likely to work in the context of the profile of a typical DH project.

- **Private Finance:** It is important to consider at an early stage of the development of the DH market whether private finance will be welcomed into projects. If private finance is considered to be attractive, careful consideration will need to be given as to how to design financing structures that allow private finance to sit alongside other forms of capital, including public grants and debt.

  Private finance providers will be focussed on permitted DH ownership structures. Clarity as to permitted DH ownership structures should be delivered early in the development of the market.

  It will also be necessary to establish a reasonable risk sharing profiles between project sponsors, DH asset owners, private finance and the public sector.

- **Fostering sector coupling private finance:** Ireland has an opportunity to develop DH in the context of the wider energy system. This may be critical as the viability of DH schemes without access to large amount of waste heat sources might be partly dependent on access to keenly priced electricity.

  Prioritising use of otherwise curtailed power into thermal storage at DH level is an example of the opportunity that may exist for intelligent sector coupling.

  Another possible source of income for DH is the ability to interact with the grid to provide grid flexibility services, known in Ireland as DS3 services. Codema is undertaking work to understand the potential benefit to the viability of DH economics of projects playing into such schemes.

  It is important to consider at an early stage of the development of the DH market whether private finance will be welcomed into projects. If private finance is considered to be attractive, careful consideration will need to be given as to how to design financing structures that allow private finance to sit alongside other forms of capital, including public grants and debt.

  Private finance providers will be focussed on permitted DH ownership structures. Clarity as to permitted DH ownership structures should be delivered early in the development of the market.

  It will also be necessary to establish a reasonable risk sharing profiles between project sponsors, DH asset owners, private finance and the public sector.

Objective 3

This section aims to review examples of the implementation of district heating networks in other jurisdictions from an end-user perspective, in terms of awareness raising and how the development of networks is communicated, how applications for connections are managed and interventions to boost uptake of district heating. This is based on expert interviews performed with DH companies and customers as part of this study.

6.1 The Respondents

The interview guide for this study for the DH companies was built around (1) awareness raising, (2) how to boost DH uptake and how development of networks is communicated to end customers and (3) how applications for DH connection are managed. The interview guide applied for the DH customers addresses the same questions but from the opposite perspective of the DH provider. In addition, each respondent was asked, at the end of the interview, if he/she would like to provide any advice to Irish policy makers. The interview guide is presented below (section-wise).

The results per each area of 'Awareness rising', 'Uptake of DH' and 'Management of DH applications' are presented according to the logic of Objective 1 based on the classification of mature, expanding and new markets. For the interviews, not all countries analysed for Objective 1 have been included but the countries that were targeted include: Denmark, Sweden, Finland, Germany, Spain and the Netherlands. Interviews were also performed with the DH company in Tallaght, Ireland and with a customer in that network.

In total, 22 interviews were conducted. More information on the study design is included in the footnote below[15].

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[15] The foreseen allocation of customers was 11 DH customers and 9 DH companies. There was, however, a problem encountered in reaching end customers in Spain, the Netherlands and Germany. As a result, DH companies rather than end customers were interviewed in Spain and the Netherlands. For Germany one customer was interviewed. In Finland, the dialogue with the interviewees resulted in the identification of a customer interested in participating in the study so there is an unforeseen, added Finnish DH customer to the dataset. Additionally, the Finnish DH companies were very happy to share contacts which resulted in three DH company interviews instead of the foreseen two. The final composition of respondents were 7 customers and 15 DH companies.

6.2 Awareness raising

Below, the responses on the topic of awareness rising about DH are provided from the point of view of DH companies and customers for mature (Sweden, Denmark, Finland), expanding (Germany) and new markets (Spain, Netherlands and Tallaght, Ireland). The six questions below were asked to the DH companies, three of the questions were asked to the customers, with a custom adjusted vocabulary (marked by italics). The question "other" was asked to both DH companies and customers.

Q1 What customers do you have? B2B? Private homeowners?

Q2 What is the distribution across customer segments? Industries, Official buildings? Residential buildings?

Q3 How do you find potential, new, customers?

How did you get in touch with your DH company? Did you contact them, or they contacted you?

Q4 How did you find the customers you have now?

Q5 What is the unique selling point you convey to customers?

What are the main advantages of DH according to the DH company? What do they sell to you?

Q6 Are the customers interested in how the technology works? Do you inform them about this? Do you compare the DH solution to other solutions (for example a HP or a gas boiler)?

Are you interested in how the technology works? Do you want a comparison to other heating alternatives?

Q7 Other

6.2.1 Mature markets (Denmark, Sweden and Finland)

Q1-Q2: Customer segments and their allocation

In all three countries, all DH company respondents say there is a mixture of customer segments where the largest heat supply volumes go to professional customers, but the number of private homeowners in terms of customer numbers is largest. One Danish and one Finnish DH company mentioned the market share of DH in their city (95% and 92% respectively).

Q3-Q4: How do you find new customers and how did you find the ones you have now?

To find new customers, being part of the city planning process is important, according to the Swedish DH companies interviewed. Based on connections made there, the customers contact the DH company. One of the companies tries to facilitate new customers by providing them with "one way in" offering water, heating and waste management as a single offer. This company is also preparing for the provision of DH to new areas. This involves some risk taking, because DH is not mandated for new areas but allows a first mover advantage.

Both the Danish DH companies interviewed are expanding their networks. In one of the companies, there has been an ongoing energy transition phasing out the current CHP boiler on the DH network (replaced by an electrical boiler in combination with an accumulator tank, waste heat recovery from a datacentre and heat pumps using ground water and sea water). An energy hub harvesting excess energy from solar and wind has also been developed. This company decided to expand its customer base 5 years ago, when there was an initial subsidy from the government to shift away from oil and gas. The company gets a subsidy for each new customer. This expansion was based on a map of the city to see where the network could be made denser. 25 areas around the city were identified as relevant, with a payback period of 25-30 years. Pipe cost and foreseen heat sales were used to calculate the business case for expansion.

One Danish company noted that industrial areas are often economically beneficial to connect. The sales process is such that a small survey is usually carried out to see if customers are interested in DH. If so, a meeting is held and then, if there is a will to get DH, a project proposal is provided by the DH company to the municipality. If the municipality agrees the project needs to be completed within 5 years, often construction starts within 6 months. The second, Danish DH company, expands its network by 20-25 kilometres per year. It goes into new areas, converts existing customers and connects new buildings part of urban change (for example the development of new office buildings).

In two of the Finnish DH companies, DH is the main alternative for heating and cooling in the city. One of the companies has made an active effort to sell DH for the last 10-15 years, taking an active role in city planning processes. 5 years ago the first customer disconnected from the network. Another Finnish DH respondent confirms that being part of city planning processes is key to success. The same company is actively creating awareness about DH not being identical in all places; it is a local, tailored product. The third Finnish DH respondent experiences a situation where customers are coming to the DH company, to connect there is however competition with heat pumps.

A common denominator amongst the DH company respondents across the three countries is that they are well-established DH companies that have been around for a long time. Hence, there is limited information on how the current customers were acquired. What is known is that many customers asked for DH after the oil crises in the 1970s and 80s.

One common denominator in the DH customer responses in the mature markets is that the buildings were already on DH when they were acquired or built. One Swedish DH customer also points out that they are part of the same group as the DH company and thereby DH is the given choice. The two Danish customers have a long tradition of resorting to DH.

Q5: What are the Unique Selling Points of DH?

The DH respondents have a very similar view. The USP is that DH is a sustainable solution, it is highly reliable and resilient, comes at a competitive price but is above all a carefree solution. One Swedish DH respondent identifies that the offer to provide a joint, one way in (water, energy, waste management) service, is also a competitive advantage. The other Swedish DH company representative stresses the possibility to work together with the customer, through motivational tariffs (aimed at reducing power) as a competitive advantage and one Finnish DH company respondent identifies that upcoming CO_2 free DH is a competitive offer (planned for 2029).

One DH customer in Sweden stresses that dialogue with the DH company is important as well as the possibility to get a premium, climate neutral product (the standard DH offer is not climate neutral, hence the customer is paying a premium for it). The other customer in Sweden confirms the perspective of comfort and climate being main values. One of the Danish customers points to the green value and the price as main values. The other Danish customer has educated its caretakers on DH and sees that the reliability of DH is a competitive advantage.

Q6: Are customers interested in technology?

The DH company respondents across the three countries have a very similar view. Business customers are more interested in the technology than private customers. The increase of the value of the building (mentioned by a Danish DH company) and green certificates of buildings (mentioned by a Finnish DH company) is also interesting for building owners.

The Swedish and Danish customer respondents are not interested in understanding the technology, as they already know it well.

Q7: Other

One of the Swedish customers experienced a 12% increase of the heat price in 2023 and took the DH company to arbitration with price transparency raised as an issue. The Finnish DH customer representative noted that an estimation was made to see if a heat pump would be cheaper, but it is assumed that the price of DH will come down soon (the war in Ukraine has increased DH prices by 30%) which should make an investment in a heat pump more expensive than keeping DH.

6.2.2 Expanding markets (Germany)

Q1-Q2: Customer segments and their allocation

One of the German DH company respondents represents a well-established DH company in Germany. The other DH company respondent is providing new DH solutions. For the former, the allocation is 80% residential and 20% non-residential customers. For the latter, the new solutions product portfolio is 65% residential and 35% non-residential customers.

Q3-Q4: How do you find new customers and how did you find the ones you have now?

The well-established DH company actively searches for new customers, but notes that it is important to be in dialogue with the city to understand where the network is expanding. It is also important to find an "anchor" customer, a large customer around which an expansion of the grid can be built. There is direct dialogue with potential customers and the company has a map on its webpage outlining where DH will be available next.

The other DH company notes that customers, mainly developers, contact them for support in designing their energy system which can take up to 4 years from initiation to completed projects.

The German DH customer respondent is a building association which also owns the local DH company. The DH grid is rather small, and the DH customer's buildings served as an anchor load to expand the network. An important reason for this setup is that, in Germany, the building owner has responsibility to ensure a certain proportion of renewable energy is supplied to the building stock. With DH this responsibility is now delegated from the building company to the DH company. Renewable integration and lower temperatures (for minimized distribution losses) were discussed before the arrangement was established.

Q5: What are the Unique Selling Points of DH?

The lower need for maintenance from a customer perspective was highlighted by the respondents, along with space saving compared to a gas boiler or heat pump and low operational costs. Other advantages highlighted include cost competitiveness (compared to alternatives), being a renewable alternative, engaging with a single solution provider (for heat, cooling, electricity, mobility) and sector coupling as the main selling points.

Both respondents also address the new building energy Act. According to the Act a new heating system has to have at least 65% renewables in it or there is a requirement to connect to a DHN (where the DH company is responsible for making a plan to meet renewable goals under the Act by 2045).

One of the DH company respondents said that the provision of support to customers to identify and access federal funding for projects is an additional selling point. The DH customer also expressed this point, the DH company fully supported them with the grid connection through a subsidy program and covered all costs. The DH customer paid for the adaptation of their home heating system to the transfer station. In return, the DH company accommodated the DH customer in terms of pricing to be able to comply with the legal requirements of price equality for old and new types of heating. At the time of the changeover, there was very strong price pressure due to extremely cheap natural gas. Furthermore, the buildings were prepared by the DH company for a supply of electricity from the combined heat and power plant, which will help the DH customer to further save costs in the future. In addition, the DH company provides the opportunity to prioritise the use of renewable heat generated in the house (solar thermal energy) and to supplement it with DH.

Q6: Are customers interested in technology?

On the matter of how interested in technology the customers are, one DH company does not feel this is the case. The other, mainly dealing with developers, finds that technology is interesting to the customers since new solutions need explanation.

6.2.3 New markets (Spain and Netherlands & Tallaght, Ireland)

Q1-Q2: Customer segments and their allocation

In Spain, one respondent identifies that most of the customers are residential (multi-family buildings with central heating) whereas the other two Spanish respondents say it depends on the area where the network is located. In the Netherlands, most customers are private homeowners, the number of professional customers is lower but in terms of supplied heat volumes the segments are of similar size.

In Tallaght, currently only public buildings are connected to the network but 133 private apartments are due to be connected (in 2024-25). The network is currently expanding and in the future a mix of public and private customers is foreseen, which is needed as heat demand should also be present over weekends (the currently connected public buildings close down during weekends).

Q3-Q4: How do you find new customers and how did you find the ones you have now?

The answers to Q3 and Q4 are very similar for the new markets. In Spain, to contact new customers, one DH company establishes a local office to get in touch with the organizations managing buildings. Those organizations inform the residents about DH and if relevant a vote is made amongst the tenants. Another company also engages with the organizations managing buildings but also building owners and engineering companies when expanding into existing building stock. For new areas, a dialogue with the municipality is key as it can decide on DH expansion. One Spanish DH company interacts with a company providing the substations and heat to buildings, there is no direct sale to customers.

As a result of a review of the heat act in the Netherlands, which aims to de-privatize DH ownership (to at least 51% public ownership) there is a freeze on engaging new customers in the private DH company interviewed. In the municipal company, expansion is guided by municipal heat planning. Prior to the current situation, the private companies would enter new areas by municipal concession contracts (long term) or tendering processes (with private development companies). Expansion of DH was also carried out by directly contacting developers located in the proximity of the DH network.

For Tallaght, the city planning department informs project owners about DH and advises them to connect to the system, with demand to connect currently larger than supply. Initial customer contacts predated the creation of the DH company.

Q5: What are the Unique Selling Points of DH?

In both Spain and the Netherlands, similar selling points are presented: cost efficiency and a sustainable energy supply. One Spanish DH company also stresses the benefit of locally generated jobs. Another Spanish DH company says that the fact that DH gives a high energy classification of buildings (A) if DH is used is important. One Spanish DH company and one DH company from the Netherlands point to the benefit of the DH price fluctuating less than gas.

For Tallaght, decarbonization is an important selling point. The comfort of DH and price are also important aspects. The Tallaght customer points to the use of waste heat noting that DH is a cost competitive solution and that the hassle of accessing a competitive price for electricity supply for individual heat pumps is avoided.

Q6: Are customers interested in technology?

All respondents but one in Spain and the Netherlands say that the professional customers are interested in how the technology works. In Tallaght, there is a large interest for the technology. Many site visits have taken place to see the plant and how it works. The customers want to understand the interface with the buildings and substations. In Tallaght, the DH customer respondent is interested, especially in the future diversification of geothermal supply.

Summarizing the section, it is identified that:

- In terms of Unique Selling Points, the aspects of comfort, a resilient system, price competitiveness and a green solution are mentioned across countries.
- In all markets, new customers are often identified by being part of the city planning process and being synchronized to municipal development plans is critical. In the mature markets and Germany, the customers often contact the district heating company but there is also active outreach to interest new customers.
- In Germany, the new building code has been important for increased uptake of district heating. A similar situation is present in Spain where district heating improves the energy class of buildings.
- In Spain, outreach to customers is important. Interviewing district heating companies in Spain three different actions were identified. One company works closely with the municipality and its planning process, one establishes a local office in cities that the company wants to enter, and one company engages with the providers of substations to the building rather than the building owners themselves.

- In the Netherlands, a new heat bill is coming into force. According to the bill, private district heating companies need to become a public-private collaboration with at least 51% public ownership. This upcoming change has halted the expansion of existing, private district heating companies whereas new municipally owned ones are starting up.

6.3 Uptake of DH

Below, the responses on the topic of how to maximize the connection rate/ boost DH uptake/ develop the DH system are provided from the point of view of DH companies and customers for mature (Sweden, Denmark, Finland), expanding (Germany, France) and new markets (Spain, Netherlands & Tallaght, Ireland). The six questions below were asked to the DH companies, one of the questions was asked to the customers, with a custom adjusted vocabulary (marked by italics). The question "other" was asked to both DH companies and customers.

Q1 Do you have a lowest level of heat density for providing DH to an area? If so, what is it?

Q2 How do you engage customers to connect? Are there any incentives like:

Does the DH company support you to connect to the network?

Q3 How do you decide to provide DH to a new area?

Q4 How do you communicate to the customers that they will have the option of DH? What channels (direct contact, public information, campaigns, direct contacts etc.?)

Q5 Do you work differently with existing and new built areas?

Q6 Other?

6.3.1 Mature markets (Denmark, Sweden and Finland)

Q1/ Q3: Do you have a lowest level of heat density for providing DH to an area? How do you decide to provide DH to a new area?

None of the Danish company respondents apply a heat density number. Heat density is only one part of the assessment. A Swedish DH company lists the distance to the grid, access to residual energy, the expansion plans of the area as important factors of the assessment. One Finnish DH company respondent says that pay back is more important than heat density. Another Finnish DH representative points to the fact that it is important to size the system right: if you do not assume energy efficiency improvements over time your systems will be oversized and inefficient. Pre-contracts can be one efficient way to secure customers to a new area.

Q2: How do you engage customers to connect?

Incentives raised by respondents in previous interview questions were raised (including incentives for shifting away from gas in Denmark and direct electrification in Sweden for example). Both Danish DH companies address the point of offering energy as a service (with customers renting equipment) which can reduce barriers to uptake. Danish, Finnish and

Swedish DH companies also raise the potential for customers to be engaged to connect as prosumers through small scale generation in addition to connection to the DH system.

One Finnish company works with motivational tariffs that generates a win-win solution for the company and its customers. One of the Swedish DH customers identifies that motivational tariffs can be useful but often they only serve the interest of the DH company (like reducing demand). A Danish DH customer outlined the motivational tariff in place for their system while another Danish DH customer is interested in additional services from the DH company in order to reduce the workload of the local caretakers. One Swedish DH customer is engaged by the DH company to discuss future price models, the company is also engaged in a "price dialogue" with the DH company; an initiative where DH companies voluntarily invite customers to discuss price developments in the upcoming year.

One Swedish DH company acknowledges that upcoming CSRD reporting will lead to new customer demands on, for example emissions. One Swedish DH customer reflects on the fact that they needed emissions data for their own reporting for their company, then the DH company was supportive in generating the necessary information.

One Finnish DH company mentions that digitalization is coming, and in the future, the systems will be smart. It will engage customers that can follow their own energy use locally in their apartments.

Q4: How do you communicate to the customers that they will have the option of DH?

Information from responses to earlier questions is that direct customer dialogue, often from city planning processes, is prevalent all three countries.

Q5: Do you work differently with existing and new built areas?

In all three countries, the same kind of process exist for existing and new built areas.

6.3.2 Expanding markets (Germany)

Q1/ Q3: Do you have a lowest level of heat density for providing DH to an area? How do you decide to provide DH to a new area?

One of the German DH companies mentions the number of 415 MWh per hectare and year. This is not the sole number a decision is made upon; other aspects are considered too and can compensate if the heat density is not reached. The other DH company is working in metropolitan areas where the heat density is high, they do not focus on heat density. Instead, they have a minimum size (20 000m2 or 1GW of heat) of installations undertaken. Federal funding also drives a certain size (at least 17 substations and 100 apartments).

Q2: How do you engage customers to connect?

One of the DH companies offers energy performance contracts to large customers and then a stable price (with shifts possible every 6 month) is important. The company also has one prosumer.

The other DH company bases its new solutions on available waste heat sources, hence prosumers are more common. Both DH companies resort to public funding. One mentions, two funding mechanisms that exist: one is the CHP law (which provides for funding for expansion of networks operated by CHPs: 30% of pipe costs are returned) and then there is a funding program for individual customers for the building connection (whereby customers can get 40% funding for connection cost). Federal funding is also available for DH networks. These funds cover 40% the investment costs for new projects and 50% of the planning costs. There is also financing for existing projects (Building act).

Q4: How do you communicate to the customers that they will have the option of DH?

Interview respondents in Germany had similar answers to this question; they mainly have direct customer dialogue.

Q5: Do you work differently with existing and new built areas?

Interview respondents in Germany had similar answers to this question; in a new area the potential customer is different than in an existing area, hence the communication is tailored to the relevant customer category.

6.3.3 New markets (Spain, Netherlands & Tallaght)

Q1/ Q3: Do you have a lowest level of heat density for providing DH to an area? How do you decide to provide DH to a new area?

Two Spanish DH company respondents provide heat density indicators. These are 80 000 MWh/year and system and 2-3 MWh per meter of pipeline. Two other DH company respondents say it depends on the area, and that multi family buildings and large buildings are the ones where new investments are profitable.

One DH company from the Netherlands points to the municipal heat plan for guidance on where to invest. These elements will be decisive for entering an area or not. In Tallaght, Ireland, larger buildings are sought after to lower CAPEX costs.

Q2: How do you engage customers to connect?

One Spanish respondent mentions regional support for providing DH (support for the DH company), while another says that funds from the European Investment Bank (EIB) can be obtained for designing and installing DH in an area. The third Spanish respondent finds there are usually funds or subsidies for renewable energy installations. The state has also promised incentives for using waste heat, but this has not been realized as of yet.

One of the DH companies from the Netherlands says that there are incentives available for households shifting away from gas. The other DH company in the Netherlands says there is an incentive for both DH companies and customers to connect to DH. One Spanish and one DH company from the Netherlands have experience of waste heat recovery and prosumers (limited volumes). One Spanish DH company provides initial customers with the connection line for free, along with renovations of old substations. All respondents but one says that old equipment (such as a boiler) is sometimes removed (by the DH company) when DH is installed. Often, the customer wants to keep the old boiler for a few years to see that the new system works.

In Tallaght, potential customers compare the CAPEX cost of DH with alternative heating technologies. Currently a datacentre is providing waste heat. The university (TUD) is also doing geothermal tests and could be a prosumer in the future by providing geothermal heat to the system. The Tallaght customer also points out that it is helpful to have the DH company's support in collecting data needed for required GHG reporting.

Q4: How do you communicate to the customers that they will have the option of DH?

The respondents have similar answers, they have direct customer dialogue. In Tallaght, customers contact the DH company.

Q5: Do you work differently with existing and new built areas?

The respondents have similar answers; in a new area the potential customer is different than in an existing area, hence the communication is tailored to the relevant customer category. In Tallaght as most areas are new, a three-year plan for expansion is under development.

Summarizing the section, it is identified that:

- In the mature markets, none of the district heating companies resorts to heat density as a main indicator when deciding to invest in district heating expansion or not. In Germany, one of the companies addresses heat density as one of several measures considered. The same applies to two of the Spanish district heating companies. More important than one, key parameter, is the overall analysis of the neighbourhood. The composition of buildings, if there are large buildings in the area that can serve as "anchor" customers and future development plans of the city must be considered.

- In the mature markets, energy as a service is discussed, which increases the overall system efficiency and generates a gain for the customer (win-win arrangements). Again, in the mature markets, motivational tariffs are applied to some extent. In Germany, Spain, the Netherlands and Denmark there is support for district heating expansion.

6.4 Management of DH applications

Below, the responses on the topic of how to manage DH applications are provided from the point of view of DH companies and customers for mature (Sweden, Denmark, Finland), expanding (Germany, France) and new markets (Spain, Netherlands & Tallaght, Ireland). The four questions below were asked to the DH companies, while questions asked to the customers are highlighted with a custom adjusted vocabulary (marked by italics). The question "other" was asked to both DH companies and customers.

<u>Section 4. How do you manage applications for DH?</u>

Q1 Do you have any que system where customers inform you if they are interested in DH? If so, how long is the waiting line?

Did you have to wait for the DH? How long? Was there a que system?

Q2 Does the customer building have to be at a specific energy efficiency level?

Did your building have to be at a certain energy efficiency level to get DH?

Q3 Can customers with other heat systems (like HP) be connected to DH as well?

Do you have double systems (HP and DH or other)?

Q4 Other?

6.4.1 Mature markets (Denmark, Sweden and Finland)

Q1: Do you have any que system where customers inform you if they are interested in DH?

One of the Danish DH respondents say they have a waiting list until 2036 for potential DH customers (for conversion from gas customers). The other respondents refer to early dialogues with customers that remove the need for a queuing system.

Q2: Does the customer building have to be at a specific energy efficiency level?

None of the DH company respondents say that the buildings connecting to the system need to be at a certain energy efficiency level. The risk of oversizing the system if the customers undertake energy efficiency investments over time is not seen as a problem. Instead, it will allow the DH system to provide more customers with heat without any additional production unit. One Danish DH respondent says that you must make a smaller dimensioning of the system than you initially think to keep the system efficient over time.

Q3: Can customers with other heat systems (like HP) be connected to DH as well?

All DH companies but one (in Denmark) are experiencing this problem as it can reduce the overall business case and efficiency of a DH network. In order to address this issue in some cases it has been met with a special tariff. One of the DH customers has this kind of solution in place (a Swedish customer), while the Finnish DH customer interviewed sees that it would be cheaper to completely disconnect from the DH system than to have a double system.

6.4.2 Expanding markets (Germany)

Q1:Do you have any que system where customers inform you if they are interested in DH?

None of the respondents say they have a queuing system for potential DH customers to connect. The DH customer interviewed in Germany outlined that planning and implementation of the new DH network was carried out jointly from 2014 to 2017. From 2018, the construction of the new network began, which was completed in 2021. During this period, a total of 22 apartment buildings of their company were connected to the new DH network.

Q2:Does the customer building have to be at a specific energy efficiency level?

The oversizing of system is addressed by one customer in Germany. As oversizing was previously common practice, it now allows for expansion of the DH system.

One of the German DH companies identifies that for low temperature systems energy efficiency measures need to be performed first. However, in newly built areas the energy efficiency of buildings is high. In Germany the "primärenergifaktor (PE)" encompasses both building and energy systems: so there can be a very efficient building or a very efficient energy plant or a combination of both. The PE is a very important metric in Germany, you need to be below 0.35, at that level you can make savings on the building side.

Q3: Can customers with other heat systems (like HP) be connected to DH as well?

Such a solution is too expensive for customers in one of the locations. For the other DH company, in new areas this is not a problem, at least not initially (the operation contract is 10 years).

6.4.3 New markets (Spain, Netherlands & Tallaght)

Q1: Do you have any que system where customers inform you if they are interested in DH?

None of the respondents say they have a queuing system for DH customers to connect. One respondent says there is a first come, first served system and that early dialogue with customers removes the need for a queuing system.

The Tallaght customer says that they were engaged in connecting to the network before it was built so had to wait for construction to be completed, but there was no additional wait.

Q2: Does the customer building have to be at a specific energy efficiency level?

None of the respondents say that the buildings need to be at a certain energy efficiency level (unless if it is a low temperature system, then it is important; mentioned by one DH company from the Netherlands). It is, however, good if information about energy efficiency measures in brownfield areas or ongoing developments is known as it will impact on how to size the system overall.

Q3: Can customers with other heat systems (like HP) be connected to DH as well?

One of the respondents has experience from double systems (HP and DH) being installed. It is news and difficult to manage (cannot be managed on the tariff).

Summarizing the section, it is identified that:

- All respondents, across markets, say they do not have a queuing system for connection to a network. Close and long-term customer dialogue appears to make such a system redundant.

- No district heating company necessitates the buildings to be connected to be at a specific energy efficiency level. Only if a low temperature system is installed the energy efficiency of the building must be known. In the mature markets, the oversizing of the systems that occurs as energy efficiency measures are undertaken over time, has freed capacity up to expand the grid. Hence, in retrospect, the oversizing of systems fitted to energy inefficient buildings, has been an efficient way to expand district heating over time.

- In the mature markets, customers that combine district heating with individual heat pumps exist. This can be troublesome because the building owner will use the heat pump when electricity is cheap and district heating is reduced to a peak load. In the mature markets the price model has been adjusted to manage this kind of customer. In Germany and the new markets customers combining the two systems are not common.

6.5 Advice for the expansion of DH in Ireland

At the end of the interviews, the respondents were asked if they wanted to stress any point of importance for a successful expansion of DH in Ireland. Below, the responses are provided without any specific order.

- To establish DH the following should be considered: mandating could be an option for some customers or areas, as it makes it easier to get an efficient business case. Look into the potential geographic areas and consider if there are energy intensive clusters, like datacentres etc. Harvest locally available heat. Establish win-wins. Be part of the city planning process to get in early in new developments.
- You need people to be present when you sell DH to new areas to explain the technology to different neighbourhoods.
- Think about low temperature networks. The energy efficiency of buildings should be improved first, then you can rollout low temperature networks.
- Think about making a holistic study of DH. What problems will you solve with DH? Think about sector coupling aspects. Also study the existing infrastructure, what is under the street? What do you risk disrupting when you dig in the streets? Make a long-term plan and make realistic assumptions. Identify the relevant dimensions and the timeline when the system will be fully utilized. Do not regulate the market, keep it open. Competition should be fair and transparent.

- Private ownership is preferable, then competition will be based on market prices. Then there is a real incentive for competition. Government owned DH can reduce the incentives to create shareholder value and can lead to inefficient investments that in turn create higher district heating costs. With efficient investments the end price will also be low.
- Datacentres should be an important heat source in Ireland.
- DHN is the most investment heavy (30% of investments in new DH or more), how can you create a quick and easy way at city level to build a network? A standardized system or process should be applied across Ireland.
- Customer support is needed for the installation stage, a transparent price structure is important, peak load DH can be expensive if you combine HP and DH. Reason with the DH company about a relevant price (avoid penalty pricing).
- Information flows well with key account customers, invite larger customers so they are part of new developments.
- Resort to DH experts so known problems can be avoided. For example, expertise around pressures, correct dimensioning and pressure differences exists in mature markets. Purchase good heat exchangers so you do not loose pressure between them. Purchase high quality vents to avoid corrosion.
- Historically in Denmark, DH was built for heat sparse areas, this was not successful.
- The main driver in Denmark was legislation. You need to acquire a critical mass to make sense of the investment. So, it must be mandatory to connect to the system at least initially. It has to be a government decision to kick the expansion off.
- When you do not have any DHN yet think about if it is relevant to have low temperature networks locally. They are energy efficient and can use local waste heat sources (supermarket with cooling devices etc.). The use of this kind of heat has not been studied enough. Consider making smaller islands with a pipeline connecting them (if connection is relevant). For example, this is relevant where there are datacentres. Build in a number of heat sources to the network.
- It is important to support the building owners in understanding the technology when it is rolled out in Ireland.
- Take the substation into your control. Integrate smart meters into the DH legislation so you can have live monitoring of the system and can use it for optimization. Think about the network temperature in the very beginning: what do the buildings need? Think about what kind of pipes you should have; dimension them wisely and with a long-term plan.
- Think about the responsibilities: the issue of building owners delegating the responsibility of renewable energy supply to the DH companies. This can be a pull factor.
- Make the dimensioning thinking about what the network will look like in 20 years from now.
- Be careful of the use of air source heat pumps in DHNs, it is not necessarily improving the system (you need space and the COP is poor).
- Ireland should have a look at the local energies available, like datacentres, water from the sea and rivers. This scope should be investigated.
- The most important thing is to have a discussion on what heat sources are sustainable in the long term. For example, waste incineration: is it sustainable or not?
- A DH system has the same level of complexity as the entire electricity grid but must be balanced locally; and the costs have to be borne by the local customers. So, for each DH system think about the heat sources you introduce into it. When DH systems are made in locations where there is no locally available, sustainable heat source, it can be challenging.

- One of the main recommendations for Ireland are to explain to homeowners that DH is the way forward; based on sustainability reasons and electricity demand associated with connecting large volumes of HPs.
- A law on thermal energy is needed, it will be a door opener for district energy investments in Ireland.

References

Aecom. (2017). *Reducing the capital cost of district heat network infrastructure.* Energy Technologies Institute LLP.

Averfalk, H. D. (2018). *Analysis of 4th Generation District Heating Technology Compared to 3rd Generation* . Energiforsk.

Aydin, & et.al. (2013). *The rebound effect in residential heating.* Tillburg University.

Boldrini, A. J.-G. (2022). The role of district heating systems to provide balancing services in the European Union. *Renewable and Sustainable Energy Reviews,*, 154.

Boverket. (2023, September 13). *https://www.boverket.se/sv/PBL-kunskapsbanken/*. Retrieved from www.boverket.se: https://www.boverket.se/sv/PBL-kunskapsbanken/regler-om-byggande/boverkets-byggregler/vatten-och-avlopp/legionella-i-vatten/

Buffa, & et.al. (2019). 5th generation district heating and cooling systems: A review of existing cases in Europe. *Renewable and Sustainable Energy Reviews*, Vol. 104, 504-522 .

Bundesamt fur Wirstschaft und Ausfuhtkontrolle. (n.d.). *Energie*. Retrieved March 2024, from https://www.bafa.de/DE/Energie/Energieeffizienz/Waermenetze/Waermenetzsysteme_bis_2022/waermenetzsysteme_bis_2022_node.html

Bundesgesetzblatt. (2002, March 22). *Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung (Kraft-Wärme-Kopplungsgesetz - KWKG) (Law for the Maintenance, Modernization and Expansion of Combined Heat and Power (Combined Heat and Power Act - KWKG)).* Retrieved from https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl102s1092.pdf

Bundesministerium des Innern und für Heimat. (2020). *The new Buildings Energy Act*. Retrieved from https://www.bmi.bund.de/EN/topics/building-housing/building/energy-efficient-construction-renovation/buildings-energy-act/buildings-energy-act-node.html

Bundesministeriums der Justiz. (2022, December). *Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung.* Retrieved from https://www.clearingstelle-eeg-kwkg.de/sites/default/files/2023-01/KWKG_221220.pdf

CEE Bankwatch Network. (2021). *How can the EIB and the EU financial mechanisms support the decarbonisation of district heating?* . CEE Bankwatch Network.

Codema. (2020, December 15). *Contract Awarded for Ireland's First Large-Scale District Heating Scheme.* Retrieved from https://www.codema.ie/media/news/contract-awarded-for-irelands-first-large-scale-district-heating-scheme

Codema. (2021). *Dublin Region Energy Masterplan.* Retrieved from https://www.codema.ie/images/uploads/docs/Full_Report_-_Dublin_Region_Energy_Master_Plan.pdf

Collins. (1959). The history of district heating. *District Heating*, Vol. 44(4), 154-161.

Collins, J. T. (1959). *The History of District Heating, District Heating.*

Comission: EU. (2023). *Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast).*

Danish Energy Agency. (2015). *Regulation and planning of district heating in Denmark.*

Danish Energy Agency. (2022). *Technology data.* Retrieved 2021, from https://ens.dk/en/our-services/projections-and-models/technology-data/technology-data-generation-electricity-and

de Boer, S. (2023). *Effects of the New Collective Heat Supply Act Determine Investment Climate for District Heating Sector.* Rabobank.

DECC. (2015). *Asessment of the costs, performance, and characteristics of UK Heat Networks.* Department of Energy and Climate Change.

Deloitte. (2018). *Infrastructure finance review, Insights for district heat network investment in the UK.* Deloitte.

Department for Energy Security and Net Zero. (2023, December). *Heat Network Zoning.* Retrieved from https://assets.publishing.service.gov.uk/media/65b3c38c0c75e30012d8012f/heat-network-zoning-consultation-2023.pdf)

Dublin City Council. (2021, May 5). Retrieved from https://www.dublincity.ie/sites/default/files/2021-05/spc-update-05-may-2021.pdf

EC. (2022). *Recovery of Urban Excess Heat*. Retrieved from https://cordis.europa.eu/project/id/767429

EC. (2023). *Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast).* Retrieved from Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast)

EC. (n.d.). *Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC.* Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32004L0008

EC. (n.d.). *National energy and climate plans*. Retrieved from https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

EGEN. (n.d.). *Heat networks Investment Grant (WIS).* Retrieved from EGEN: https://www.egen.green/grants/wis-grant/

EIB. (2020). *Netherlands: Dutch district heating gets green acceleration*. Retrieved from https://www.eib.org/en/press/all/2020-386-dutch-district-heating-gets-green-acceleration#:~:text=HVC%20Groep%2C%20a%20sustainable%20energy%20and%20waste%20company,Investments%20%28EFSI%29%20of%20the%20Investment%20Plan%20for%20Europe.

EIB. (2020). *Netherlands: EU support for Dutch district heating projects*. Retrieved from https://www.eib.org/en/press/all/2020-269-eu-support-for-dutch-district-heating-projects

Elgocell. (2023, December 20). *Värmekulvert.* Retrieved from www.elgocell.se.

European Bank of Reconstruction and Development . (2021, 12 24). *EBRD and donors support new district heating upgrades in Balti* . Retrieved from https://www.ebrd.com/news/2021/ebrd-and-donors-support-new-district-heating-upgrades-in-balti.html

Federal Ministry of Economic Affairs and Climate Action. (2022). *Boost for green district heating: Federal funding for efficient heat networks (BEW) begins Introduction* . Retrieved from Federal Ministry of Economic Affairs and Climate Action: https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/09/20220915-boost-for-green-district-heating-federal-funding-for-efficient-heat-networks-bew-begins.html

Fjärrvärmelag (2008:263). (2008, May 15). Retrieved from https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/fjarrvarmelag-2008263_sfs-2008-263/

Fransson, & et.al. (2022). *Business models at REWARDHEAT demonstrators.* European Commission.

Fredriksen, W. &. (2017). *District heating and cooling.* Lund : Studentlitteratur .

Frontier Economics Limited. (2015). *Research on district heating and local approaches to heat decarbonisation Annex 1: Overcoming barriers to district heating.* Frontier Economics Limited.

GOV.UK. (2022). *GREEN HEAT NETWORK FUND Scheme Overview* . UK Department of Energy Security and Net Zero. Retrieved from https://www.gov.uk/government/publications/green-heat-network-fund-ghnf

GOV.UK. (2024). *Heat networks*. Retrieved from https://www.gov.uk/government/collections/heat-networks

Green Investment Group. (2016, 3 2). Retrieved from GIB and Equitix commit £10m to expansion of Wick district heating scheme: https://www.greeninvestmentgroup.com/en/news/2016/gib-and-equitix-commit-p10m-to-expansion-of-wick-district-heatin.html

Gullev, L., & Duedahl, M. (2019). Internal rate of return and how it affects development of DH projects. *Hot Cool*, pp. 7-12.

HeatNet NWE. (2018). *HeatNet NWE: Transition strategies for delivering low carbon district heat*. Retrieved from https://vb.nweurope.eu/projects/project-search/heatnet-transition-strategies-for-delivering-low-carbon-district-heat/

Holton, & et.al. (2023, 12 6). *Vast village heat pump tests one route to net zero for rural Britain*. Retrieved from https://uk.news.yahoo.com/vast-village-heat-pump-tests-070429571.html.

IEA. (2016). [5] International Energy Agency. *World energy balances until 2014*.

IrDEA. (2023). *Developing an Electricity Storage Policy Framework for Ireland - Consultation Response.* Retrieved from https://districtenergy.ie/resources/Documents/IrDEA%20Electricity%20Storage%20P olicy%20Framework%20Consultation%20Submission%20Jan%202023%20-%20Final%20(1).pdf

IrDEA. (n.d.). *Irish District Energy Association*. Retrieved from https://districtenergy.ie/

Ireland, S. E. (2023). *Poolbeg Sector Integration, Investigating Synergies between the electricity, heat and hydrogen sectors*. Sustainable Energy Authority of Ireland.

IVL. (2022). *Flexi-Sync*. Retrieved from https://www.flexisync.eu/

KFW IPEX Bank. (2023, 5 2). *KfW IPEX-Bank: Financing for the expansion of the district heating network in Hamburg*. Retrieved from https://www.kfw-ipex-bank.de/Presse/News/Pressemitteilungsdetails_761216-2.html

Kommuninvest. (n.d.). *Eligible projects & sustainability criteria* . Retrieved from https://kommuninvest.se/en/eligible-projects-sustainability-criteria/

Lund, & et.al. (2014). 4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems. *Energy*, Vol. 68, 1-11.

Lund, H. W. (2014). 4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems. *Energy*, 1-11. doi:https://doi.org/10.1016/j.energy.2014.02.089

Lygnerud, & et.al. (2021). Business models combining heat pumps and district heating in buildings generate cost and emission savings. *Energy*.

Lygnerud, & et.al. (2021). *Low temperature district heating implementation guidebook.* Kassel: Fraunhofer Verlag.

Lygnerud, & et.al. (2023). A study on how efficient measures for secondary district heating system performance can be encouraged by motivational tariffs. *Energy, Sustainability and Society*, vol. 13:38.

Lygnerud, & et.al. (2022). *handbook for increased recovery of urban waste heat.* European Commission.

Lygnerud, K. (2018). Challenges for business change in district heating. *Energ Sustain Soc* , 20.

Minister for Justice, Equality and Law Reform. (2011, January 24). Retrieved from https://www.oireachtas.ie/en/bills/bill/2009/32/

Ministers, N. C. (2017). *Nordic approach to EU's Heating and Cooling Strategy.* Nordic Council of Ministers.

Ministry of Climate, Energy and Supply. (2022). *Lov om ændring af lov om varmeforsyning og lov om planlægning.*

Nordic Investment Bank. (2024, 1 13). *NIB finances investments in electricity distribution and district heating in Finland*. Retrieved from https://www.nib.int/releases/nib-finances-investments-in-electricity-distribution-and-district-heating-in-finland

Ochs, & etal. (2022). Integration of heat pumps in buildings and district heating systems-evaluation on building and energy system level. *Energies*, Vol. 15.

Person, & et.al. (2019). Heat Roadmap Europe: Heat Distribution Costs. *Energy*, vol 176, 604-622.

REI. (2021). *40 By 30.* Retrieved from https://renewableenergyireland.ie/wp-content/uploads/2023/08/Renewable-Energy-Ireland_Renewable-Heat-Plan_-Final.pdf

REWARDHeat. (n.d.). Retrieved from https://www.rewardheat.eu/en/

Ruth E. Bush, C. S. (2016). Realising local government visions for developing district heating: Experiences from a learning country. *Energy Policy*, Pages 84-96.

Scotland, H. N. (2017). *District Heating Strategy Factsheet.* Heat Network Partnership for Scotland .

SEAI. (2022). *District heating and cooling: spatial analysis of infrastructure costs and potential in Ireland.* Dublin: Sustainable Energy Authority of Ireland.

SEAI. (2022). *National Heat Study.* Retrieved from https:www.seai.ie/data-and-insights/dublin-region-energy-master-plan/

SEAI;b. (2022). *Heating and Cooling in Ireland today.* Sustainable Energy Authority of Ireland.

SEAIc. (2022). *Low carbon heating and cooling technologies.* Sustainable Energy Authority of Ireland.

sEEnergies. (2019). *Construction costs of new district heating networks in France.* EU Commission.

Sneum, D. M. (2018). Economic incentives for felxible district heating in the Nordic countries. *International Journal of Sustainable Energy Planning and Management*, 27-44. Retrieved from https://doi.org/10.5278/ijsepm.2018.16.3

Spain NAPCP 2020. (2022). Retrieved from https://circabc.europa.eu/ui/group/cd69a4b9-1a68-4d6c-9c48-77c0399f225d/library/76448740-48f1-428d-b626-6a0e4386468e/details

Steininger, & et.al. (2021). *The economic effects of achieving the 2030 EU climate targets in the context of the corona crisis- an Austrian perspective.* University of Graz, Austria.

Sustainable Energy Authority of Ireland. (2022). *National Heat Study Report 2, District Heating and Cooling Spatial Analysis of Infrastructure Costs and Potential in Ireland.* Retrieved February 25, 2024, from https://www.seai.ie/publications/District-Heating-and-Cooling.pdf

SvenskFjärrvärme. (2007). *Kulvertkostnadskatalog.* Stockhlm: Svensk Fjärrvärme.

UK Infrastructure Bank. (n.d.).

UK Infrastructure Bank. (2023). *Strategy Update , Heat Networks.* UK Infrastructure Bank.

Visscher, & Meijer. (2016). Energy regulations for housing and the performance gap. *CIB World Building Congress.*

Werner. (2017). International review of district heating and cooling. *Energy*, Vol. 137, 617-631.

Werner, S. (2013). Chalmers EC.

Werner, S. (2017). District heating and cooling in Sweden. *Energy*, 419-429. doi:https://doi.org/10.1016/j.energy.2017.03.052

Wettenbank. (2024, 01 01). *Warmtewet.* Retrieved from https://wetten.overheid.nl/BWBR0033729/2024-01-01

Wettenbank. (2024, January 1). *Warmtewet*. Retrieved from https://wetten.overheid.nl/BWBR0033729/2024-01-01

www.gavleenergi.se. (2023).

www.hassleholmmiljo.se. (2023).

www.malarenergi.se. (2023).

www.tekniskaverken.se. (2023, 12 20). Retrieved from www.tekniskaverken.se.

Zero, U. D. (2023). *Energy Bill Policy Statement.* UK Department of Energy Security and Net Zero.

Østergaard, D. S. (2018). *Heating of existing buildings by low-temperature district heating.* Technical University of Denmark, Department of Civil Engineering.

Annexes

Annex 1: Identified information on existing ideas, current and planned DH policy in Ireland

Annex 2: An outlook: policy implementation in the UK

Annex 1: Identified information on existing ideas, current and planned DH policy in Ireland

A1.1 Existing Ideas for Policy for DH Implementation in Ireland

Working with Codema we have identified a body of work that has already been undertaken to establish potential policy positions within Ireland. This includes both new enabling policy and amendment to existing policies that have potential to interact with the DH market.

The following Government sponsored work has been undertaken to identify and assess the potential for implementation of DH in Ireland.

- National Heat Study – up to 54% of heat demand could be served by DH - https://www.seai.ie/data-and-insights/national-heat-study/district-heating-and-cool/
- Assessment of Geothermal Dh in Ireland - https://secure.dccae.gov.ie/GSI_DOWNLOAD/Geoenergy/Reports/GSI_Assessment_of_GeoDH_for_Ireland_Nov2020_v2.pdf

In addition, work has been undertaken by DH stakeholders as follows:

- Dublin Heat Transition Roadmap (Action specific to heat transition)) - https://decarbcitypipes2050.eu/wp-content/uploads/2023/09/D4.4_Transition-Roadmaps-Dublin.pdf
- Dublin regional Energy Masterplan - https://www.codema.ie/images/uploads/docs/Full_Report_-_Dublin_Region_Energy_Master_Plan.pdf
- Heat Roadmap Europe Study – up to 54% of heat demand could be served by DH - https://districtenergy.ie/heatatlas
- 40by30 report - https://renewableenergyireland.ie/wp-content/uploads/2021/05/Renewable-Energy-Ireland_Renewable-Heat-Plan_-Final.pdf
- IrDEA Policy Positions - https://districtenergy.ie/policy
- Codema Policy Positions - https://www.codema.ie/services/energy-policy-and-planning/codemas-submissions-to-national-energy-consultations/
- DH Steering Group – https://www.gov.ie/pdf/?file=https://assets.gov.ie/265549/487f6e25-427d-4ba3-acc8-d3b5e6272b46.pdf#page=null

- Policy Recommendations Also Included in 40by30 Report produce by Renewable Energy Ireland – https://renewableenergyireland.ie/wp-content/uploads/2021/05/Renewable-Energy-Ireland_Renewable-Heat-Plan_-Final.pdf
- IrDEA Policy Objectives – https://districtenergy.ie/policy

A1.2 Current DH Policy Development in Ireland

Working with Codema, we have identified the following documents which set out current thinking on DH policy in Ireland:

- Climate Action Plan 2024 (national Targets & refences to required frameworks) - https://www.gov.ie/en/publication/79659-climate-action-plan-2024/
- DH Steering group report 2023 (national working group on DH led by DECC). This page also includes steering group meeting minutes which gives an indication of the conversation at national government level - https://www.gov.ie/en/publication/3f132-district-heating-steering-group/

A1.3 Planned DH Policy Development

A Heat Bill is due in 2024 and Codema understands that this will likely have mandated for public building connections in designated DH areas.

Codema also understands that a Centre of Excellence is being set up in Ireland that will be similar to the Heat Network Development Unit (HNDU) in the UK.

A1.4 Feedback on Existing Policy that impedes development of DH

Working with Codema, we have identified the following existing potential brakes on DH development and implementation within existing policy.

- Part L updates – default carbon and primary energy factors are conservative and only exist for two types of heat source. More fundamentally there are three thresholds that that need to be met for compliance, this should be simplified to focus on carbon
- Funding – lack of clarity about funding how can it be accessed or how much is available? Dedicated fund could also help stimulate the DHC market
- MUD Act limiting contract durations – increasing project risk (Minister for Justice, Equality and Law Reform, 2011)

Annex 2: An outlook - policy implementation in the UK

A2.1 The UK

The UK is an equivalent market to Ireland with a similar existing provision (natural gas dominated) and similar building stock. Its DH policy journey may therefore be instructive. However, in terms of market framework, Ireland may consider itself more aligned with the

Netherlands which tends towards public ownership of utilities. Relevant considerations from both markets are discussed.

Policy level

To date, UK policy has tended towards local authority led development of DH projects. Planning obligations in some cities have also mandated DH on large-scale new-build development sites.

A lack of national legislation specific to heat networks has been considered unhelpful by stakeholders, leading to the recent development of a national policy framework for DH. This policy is contained within the UK Government's Energy Security Bill, introduced in 2022, which came into force as the Energy Act 2023.

A key feature within the Act is Heat network zoning. Heat network zoning will provide clarity on the roles and responsibilities of organisations at the national and local level. It establishes new zoning bodies and clarifies the process for engaging stakeholders, allowing for better long-term planning and coordination, faster roll-out of networks, and lower costs.

Planning and Zoning

The Energy Act, which received Royal Assent in October 2023, establishes the regulatory framework for heat networks in Great Britain and grants the Secretary of State the powers to introduce heat network zoning in England through secondary legislation ("zoning regulations").

It is intended that the designation of a heat network zone will have two primary effects.

(i) Signaling the appropriateness of heat networks for that area. The designation of a heat network zone will provide a strong signal to building owners, businesses, public organisations, and other organisations that heat networks are expected to provide the lowest cost solution to decarbonising heat in that area. This will influence decisions made at the local government, organisational, and individual level.

(ii) Placing requirements on certain bodies and organisations within the area. The main requirements placed on different bodies are as follows:

- A requirement to provide information for the purposes of heat network zone identification.
- A requirement for some buildings to connect to a heat network.
- Requirements on heat sources which could connect to a heat network in a zone.
- Monitoring and reporting requirements.
- Initiating processes to develop the zone to its full potential.

The designation of a heat network zone will require the zoning bodies to start the development of one or more heat networks in that zone. Deciding who can construct networks in a heat network zone, and where, is one example. This will include wider work to understand commercial opportunities for networks in a heat network zone.

Heat network zoning aims to mitigate existing risks related to the construction and operation of new or expanded heat networks. The UK market considers that these risks currently make it harder and more expensive to invest in heat networks. This results in smaller, less cost-effective heat networks with limited potential for growth. The UK Government hopes that zoning will make it quicker, easier and less risky to build city scale heat networks will enable the sector to grow rapidly and deliver our energy security and net zero commitments affordably.

The UK Government is developing a standardised national methodology – "the zoning methodology" – to help identify areas which can be designated as heat network zones. These will be areas where heat networks are expected to be the lowest cost low-carbon heating solution. The aim is to provide local stakeholders, developers, and investors with greater clarity and confidence about where building heat networks are the best choice to decarbonise heating.

The regulations will enable the government to create two new zoning bodies: the heat network zoning authority – shortened to "the Central Authority" – and Zone Coordinators.

Zone Coordinators will have roles related to zone identification, delivery, operation and review. Including:

1. Identifying, designating and reviewing zones:

a. Collecting local data and intelligence to assist in identifying zones.

b. Refining indicative heat network zones using the zoning methodology.

c. Carrying out a formal consultation of the heat network zone boundary before designating the zone.

d. Designating heat network zones by registering them with the Central Authority. e. Identifying, assessing and implementing the outcome of zone reviews.

2. Zone delivery:

a. Develop a Zonal Market Prospectus, including information about the preferred delivery model and a report regarding heat sources in the zone.

b. Publishing the Zonal Market Prospectus.

c. Running any competition or process for appointing a heat network zone developer or developers.

d. Depending on appointment process, reviewing prospective zone developers' Zone Development Plans.

e. Choosing the standard conditions which apply in their zone from a standardised list. f. Finalising contractual agreements or otherwise with the zone developers.

3. Zone operation:

a. Monitoring the performance of zone developers against the contractual conditions.

b. Reporting data to the Central Authority.

c. Enforcing zone requirements by issuing penalty notices or equivalent.

d. Considering appeals against exemption decisions or enforcement actions and escalating to the Central Authority when necessary.

Under the emerging secondary legislation, the Central Authority may choose to carry out some Zone Coordinator functions in some or all zones if circumstances require it, for instance due a lack of willing local public body or function.

Mandation
Another key feature of the UK's Energy Act is introduction of mandation of connection for some types of building (public sector and large commercial). The heat demand risk for networks can create uncertainty which hampers investment. Due to this perceived risk,

projects need to achieve higher rates of return than similar infrastructure to attract investors. The UK Government hopes that requiring certain buildings in heat network zones to connect to a heat network – where it is cost effective for them to do so – will help unlock scale, increase the number of viable opportunities, and drive the pace of deployment.

The Act also includes powers to make regulations to set requirements that apply in zones. This includes:

- Which buildings can be required to connect to a heat network, and when and how such buildings may seek an exemption from this requirement?
- Which types of building in zones, such as new buildings, can be required to install communal heat networks?
- Requiring operators/owners of sources of heat to provide information, and/or to connect to a heat network.
- The rules around terms for supplying heat to a heat network, including prices.
- Introducing limits on greenhouse gas emissions from heat networks in zones.
- Specifying what data may be collected by the zoning bodies, and from whom, to support the identification and designation of heat network zones.
- Ongoing monitoring and reporting requirements.
- How the above requirements will be enforced and the appeals process?

Interaction between Zoning and Planning
The UK Government has acknowledged that there will be a potential interaction between Zoning and Planning. The UK Department for Levelling Up, Housing and Communities and the Department for Energy Security and Net Zero are working together to ensure a joined-up approach between heat network zoning and local plans.

Building Regulations and Standards
In the UK's Future Homes and Building Standard consultation, the government is proposing a 'sleeving' system. Sleeving will permit all heat networks, including those within zones, to continue to connect to new dwellings and buildings if they can demonstrate they have sufficient low carbon generation capacity necessary to meet the demand of the new buildings. Only the carbon emissions of this spare generation will need to be equal to or lower than the heat network notional standard set out in the Future Homes and Building Standard consultation.

Energy Systems Planning
The UK Government wants to make it easier for consumers to make the switch to green products by 'rebalancing' prices between electricity and gas to remove existing price distortions. The rebalancing of gas and electricity prices is important for heat network zoning, as it will encourage the transition from existing heat-generating technologies, such as gas-powered combined heat and power (gas CHP), to low-carbon technologies. This includes using heat from large rivers, geothermal and waste heat from businesses. Large commercial heat pumps will be used to access heat from these sources, but the current electricity pricing structure means that heat pumps often remain more expensive to run than gas boilers.

Rebalancing will generate the clear short-term price signal necessary to shift both households and businesses to lower-carbon, more energy efficient technologies and help accelerate the roll-out of low-carbon heat networks.

Innovation and Research Support

The UK's Energy Systems Catapult has been funded by the UK Government to identify a range of options for reducing the capital costs of rolling out DH across the UK, laid out in a report for the Energy Technologies Institute. It suggested eight cost-saving route maps:

1. **Knowledge Management Research and Training** – Establish a District Heating Knowledge Centre to share learning and increase the impact of all other innovations. This knowledge centre would disseminate current best practice and outputs of other innovations, bringing together a wide group of stakeholders.
2. **Low Flow Rate Design** – Develop tools to help increase the accuracy of heat demand estimates and maximise the difference between temperatures entering and leaving the building.
3. **Radical Routes** – Reduce costs of civil engineering by running distribution pipes along the buildings themselves; either in the eaves or on the front. This is most effective in terraced housing but can be implemented cost-effectively in semi-detached areas.
4. **Trenchless Technologies** – Drill tunnels underneath the surface, removing the need for trenching. The technology for this already exists but key products need development to make it more cost effective.
5. **Improved Front End Design and Planning** – Demonstrate and quantify the positive impact of improved design work and surveying. This includes undertaking detailed survey and design work early, focussing on the activities that realise the greatest cost savings as well as adopting alternative contract frameworks to minimise the pricing of risk.
6. **Shared Civil Engineering Costs** – Share the costs of civil engineering between utilities working in the same region. This solution includes aligned planning cycles, developing a Streetworks Partnership, and joint ventures between district heating and utility companies.
7. **Direct Heat Interface Unit System and Existing Hot Water Storage** – Demonstrate the potential cost savings of replacing indirect with direct Heat Interface Units (HIUs) whilst making use of existing hot water tanks.
8. **Heat Interface Unit Optimisation** – Innovate to reduce the cost of HIUs for retrofit schemes from approximately £1,500 to £200.

Market Framework

The Energy Act 2023 lays the foundations for the market framework, with delegated powers that will lead via secondary legislation to come into force in 2024/2025 to:

- Regulation of the market, including consumer protections for consumers and carbon emissions limits and technical standards on networks.
- The appointment of a heat networks regulator to enforce regulatory requirements.
- The creation of rights and powers for licensed heat network developers to make constructing and maintaining heat networks easier.
- The introduction of step-in arrangements in the event of heat network insolvency, ensuring consumers continue to receive supply of heat.

These delegated powers will be conferred on the relevant Secretary of State with equivalent powers for the Department for the Economy in relation to Northern Ireland.

Key questions remain unanswered within the development of the UK's Market Framework. In particular what the permitted Routes to Market will be. In its December 2023 consultation the UK Government suggests it may pursue a model whereby a competition is run for the allocation of zones (Department for Energy Security and Net Zero, 2023). This competition may be designed to sit outside the normal procurement regime. Bidders would be required to apply to the Zone Coordinator in accordance with an approved underlying commercial model, which might be:

1. Authorisation only:

- The Zone Coordinator decides that any Heat Network developer authorised by Ofgem will (upon application to the zone) be granted the right to design, construct, operate and maintain heat networks within said zone. Applications can be on an ad-hoc basis.
- The Zone Coordinator does not require commitments about how and when heat network developers will deliver heat networks in the relevant zone.
- The zone rights granted to heat network developers in said zone may be time limited but will not be exclusive. This means that multiple heat network developers may have permission to operate within the zone.

2. Authorisation and Consent (Reactive)

- Heat Network Developers authorised by Ofgem can apply to the Zone Coordinator for exclusive rights to design, construct, operate and maintain heat networks within a Zone Delivery Area. The developer sets out the borders of this area in its application.
- The Zone Coordinator grants exclusive rights to a successful applicant, with conditions, regulating the scope and extent of the applicable heat network. The form and content of the documents by which the rights are granted is to be developed.
- Rights may be conditional on satisfactory performance by the Heat Network Developer, related to developer commitments on how and when they deliver heat networks in the zone. The zone rights may be time limited.
- To note, applications and the granting of rights are on ad-hoc basis – a Zone Delivery Area is only developed when an applicant is successful. There is no set period of inviting applications, to assign a developer to all Areas, rather the process is on-going, as Developers apply to Areas.

3. Authorisation and Consent (Proactive)

   This model is identical to Authorisation and Consent (Reactive) above, save for the following important differences:

- The Zone Coordinator pre-determines the borders of the Zone Delivery Areas, not the Heat Network Developers in their applications.
- Applications are accepted as part of a competed process to assign rights to all Areas, rather than being accepted on an ad-hoc basis.

4. Local Authority Delivered

- A Heat Network Developer, owned wholly by the local authority, is created. The Zone Coordinator grants the exclusive right to design, construct, operate and maintain heat networks to this Developer. Rights may be conditional on satisfactory performance by the Heat Network Developer, on how and when heat networks are delivered in the zone.
- The local authority agrees a Shareholder Agreement with the Heat Network Developer. This allows the local authority to set responsibilities, provide a robust governance structure and establish clear lines of communication. The Shareholder Agreement is

indefinite, however the zone rights granted by the Zone Coordinator may be time limited.

5. Local Authority Joint Venture
- Heat Network Developers compete to develop an entire zone. This process is run by the local authority. The winning Developer enters into a corporate joint venture with the local authority.
- The Zone Coordinator then grants an exclusive right, to design, construct, operate and maintain heat networks within the entire zone, to this joint venture. Rights may be conditional on satisfactory performance by the joint venture, on how and when heat networks are delivered in the zone, based on commitments made by the Heat Network Developer in the initial competed process.
- The local authority agrees a Shareholders' Agreement with the Heat Network Developer. This Agreement determines the degree of influence and control the local authority and Developer, respectively, have over the joint venture entity. Influence and control would likely reflect the level of investment each party has made. The Shareholders' Agreement is indefinite, however the zone rights granted by the Zone Coordinator may be time limited.

6. 'Time limited' concession Heat Network Zoning consultation 2023 74
- This model is identical to Local Authority Joint Venture above, except for the difference in agreement form used to govern the collaboration between the local authority and the Heat Network Developer. In this model, the parties enter into a time-limited concession agreement, rather than an indefinite shareholder agreement (join venture). On conclusion of the concession agreement assets developed transfer to the Zone Coordinator or pass to newly procured zone developer or operator.

7. 'Evergreen' concession This model is like both the 'Time limited' concession and Local Authority Joint Venture, with the following differences:
- In this model the parties enter into a Corporate Concession Agreement, rather than a time-limited concession agreement or an indefinite shareholder agreement.
- A special purpose vehicle is used, instead of a joint venture. The principal shareholder is the Heat Network Developer, with the local authority holding a special share. This means the Heat Network Developer has day-to-day control. The local authority will only exert influence and control on the special purpose vehicle where it, and therefore the Developer, is failing to deliver. The Corporate Concession Agreement is indefinite, however the zone rights granted by the Zone Coordinator may be time limited. 'Evergreen' refers to the treatment of heat network assets developed and owned by the Zone Developer: such assets under this model would never transfer to the Zone Coordinator. 'Evergreen' does not refer to the relationship between the concession and buildings connected where supply contracts would need to be renewed on an agreed frequency.

Heat Sources

For low or no carbon networks, it is critical that heat sources are encouraged to provide heat to networks on a consistent basis and ideally at a low cost. New markets may wish to develop policy in this area to maximise the likelihood that valuable (and otherwise wasted) heat will become available to DH.

It is intended that Zone Coordinators will finance and enable the investigation of the potential for recovering heat from local sources in the local refinement phase of zone development. They will subsequently produce a heat source report to include in the Zonal Market Prospectus.

The heat source report will include, at a minimum, expected delivery temperatures, delivery profiles (a reliability assessment), likely or confirmed investments costs, operation and maintenance costs, administration costs and the expected lifetime of delivery for each heat source investigated.

The UK's Central Authority will provide support to Zone Coordinators to make these assessments, including guidance on the typical costs for many common heat sources that can be used for different costings.

During the heat source investigation, the Zone Coordinator will inform heat sources that they may be required to connect or give access at a later stage.

Zone developers may start negotiations with heat source owners ahead of the Zone Coordinator assessing bids as part of the zone delivery process.

Zone Coordinators will have the powers to ultimately require heat sources to connect or give access if negotiations fail. The Zone Coordinator can do so if, in their view, there is a sufficient case for the heat source to provide heat to the heat network at a price beneficial to both sides and without significant risk to the business interests of the heat source.

The Central Authority will publish national guidance on the acceptable price settlements for a variety of different heat sources.

The UK Government proposes that the negotiations between heat source owners and a heat network developer should be based on whether there is a difference between the 'marginal heat price' and the 'substitution price'. The marginal heat price is the cost to a heat producer of producing the heat before profit. The substitution price (counterfactual price) is the price at which a district heat network operator can produce the same amount of heat by themselves with whatever technologies the heat network is using.

Where the difference is positive this indicates that both the heat source owner and the heat network could financially gain from the sale of heat. The heat network can pay a price that is more than the cost of the heat source producing the heat but which is lower than the cost of the heat network producing the heat themselves. It is proposed that if this value is zero or negative heat delivery cannot be required. The Central Authority will support Zone Coordinators to assess these values through the provision of technical expertise and standard national guidance documents.

Regulation

The UK's Energy Act 2023 provides powers in relation to the regulation of the heat networks sector and appoints Ofgem as heat networks regulator in Great Britain with regulation scheduled to start from Spring 2025.

The Act gives the government powers to introduce consumer protection rules and carbon emissions limits on all heat networks. It also introduces an authorisation and licensing regime, to be administered by UK energy regulator Ofgem, with the latter granting heat network developers the same statutory development powers enjoyed by other utilities. In addition, the measures will ensure that heat network customers pay a fair price for their heat and that heat networks conform to minimum technical standards. Finally, Ofgem regulation will also protect consumers if their supplier goes out of business, and ensure their heat supply is maintained.

Table 11 Summary of proposed UK regulatory model for heat network regulation (subject to ongoing consultation)

	Domestic	Micro-business	Larger non-domestic
Price of heat benchmarking regulation [24]	Yes	Yes	No
Quality of service standards	Yes	Yes	No
Protections for vulnerable consumers	Yes	No	No
Transparency of information (including pricing information)	Yes	Yes	No
Connection cost protection	No	No	No
Guaranteed standards of performance	Yes	Yes	No

Pricing

The original UK heat network zoning consultation exercise confirmed the intention to extend Ofgem's price protection duties to cover all consumers within zones who are subject to the requirement to connect, including non-domestic consumers.

Having considered the issue further, however, the UK Government is now proposing a different approach whereby Zone Coordinators will be permitted, but not required, to set pricing conditions on the award of zoning rights to a heat network developer. Initially, the Central Authority will develop and oversee guidelines concerning these conditions but the ambition is that Ofgem will take this on in future as part of its general pricing regulation role.

Emissions

The UK Government proposes that the Central Authority will set maximum gCO2e/kWh limits for new heat networks in zones and new connections of existing heat networks in zones. These limits will apply from 2030. Zone developers will need to demonstrate compliance with this limit via Ofgem administered authorisation and consequently via emissions reporting on an ongoing basis. Ofgem, as well as the Zone Coordinators, will be able to take enforcement actions and impose penalties against heat networks that do not comply with these limits.

In summary, the UK's consumer protection proposals are as follows:

- All consumers within heat network zones, including larger non-domestic consumers, should have access to transparent pricing information. This will be delivered via a national standard condition relating to heat prices that all heat network developers or operators within heat network zones must meet.
- Zone Coordinators will be permitted, but not required, to set unit of heat pricing conditions on the award of a zone to a heat network developer.
- Mandatory national standard conditions will apply to heat network developers regarding the allowable costs of connections for communally heated domestic premises and new developments that will include one or more domestic dwellings. Zone Coordinators will be responsible for enforcing these requirements. These conditions will not apply to buildings that are occupied by microbusiness or other non-domestic consumers only, as we expect these consumers have greater incentives and capability to negotiate on connection costs.

- Measures relating to quality-of-service standards are not extended to larger nondomestic consumers in zones, and protection for vulnerable consumers are not extended to microbusinesses or larger non-domestic consumers