District Heating Feasibility Study Standardised Template

A "How-To-Guide"

In Support of Conducting Standardised District Heating Feasibility Studies

District Heating Feasibility Study How-To Guide

Services in Support of Establishing, Conducting and Assessing Standardised National District Heating Feasibility Studies

June 2024

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Abbreviations

ASHP	Air Source Heat Pump
ATES	Aquifer Thermal Energy Storage
BAU	Business as Usual
BEC	Better Energy Communities
BEIS	Dept for Business, Energy & Industrial Strategy
BER	Building Energy Rating Certificate
BTES	Borehole Thermal Energy Storage
CAF	Climate Action Fund
CAP21	Climate Action Plan 2021
CAP23	Climate Action Plan 2023
CCGT	Combined Cycle Gas Turbine
CH4	Methane
CHP	Combined Heat & Power
CIBSE	Chartered Institution of Building Services Engineers
CO2	Carbon Dioxide
COP	Coefficient of Performance
CP1	Heat Networks Code of Practice for the UK
DBOM	Design Build Operate & Maintain
IrDEA	Irish District Energy Association
DECC	Department of Climate & Communication
DH	District Heating
DHCo	District Heating Company
DHW	Domestic Hot Water
DSM	Demand Side Management
DZ	Decarbonisation Zone
ESB	Electricity Supply Board
ESCO	Energy Service Company
ESG	Environmental Social & Governance
EU	European Union
GHG	Greenhouse Gas Emissions
GIS	Geographic Information System Mapping
GSHP	Ground Source Heat Pump
GSI	Geographical Survey Ireland
HeatNet	Interreg North-west Europe Project on 4th Generation District Heating
HP	Heat Pump
H2	Hydrogen
IRR	Internal Rate of Return
IT	Information Technology
JVCO	Joint Venture Company
KPI	Key Performance Indicator
kt	Kilo-tonnes (1 x 10^3 Tonnes)
LA	Local Authority
LESC	Local Energy Supply Contract
LOI	Letter of Intent
LPHW	Low Pressure Hot Water
MOU	Memorandum of Understanding
MWh	Mega-Watt Hour (1 x 106 Watt-Hours)
MWth	Mega-Watt Thermal
NHS	National Heat Study
NPV	Net Present Value
N2O	Nitrous Oxide
PHES	Pumped Hydro Energy Storage
RES-H	Renewable Heat
RHO	Renewable Heat Obligation
ROR	Rate of Return
RSES	Regional Spatial and Economic Strategy
SEAI	Sustainable Energy Authority of Ireland
SEZ	Strategic Energy Zone
SH	Space Heating
SOMS	Sales, Operations and Maintenance Set
SSRH	Support Scheme for Renewable Heat
TS	Thermal Storage
TJ	Terra Joule (1 x 10^9 Joules)
TWh	Terra-Watt Hour (1 x 10^9 Watt-Hours)
UK	United Kingdom
VAT	Value Added Tax
mWC	Millimetre Water Column
WP	Work Package

1 Introduction to the ‘How-to-Guide’

1.1 Purpose of this document

The purpose of this how-to guide is to set out the processes, key steps, considerations, and sources of information needed to deliver a high-quality district heating feasibility study and to successfully complete the accompanying template. It sets the boundaries on what is included within a feasibility study for district heating in an Irish context. It also provides supporting guidance, useful tools and reference materials on how to complete a high-quality feasibility study by populating the accompanying standardised feasibility study template.

This How-to Guide, along with the accompanying District Heating Feasibility Study Template, equips technical analysts with the tools necessary to develop their own District Heating Feasibility studies.

Additionally, post-completion of the feasibility study template, the accompanying Supplementary Guidance is intended to offer additional information on preparation for future following stages of the District Heating development process.

1.2 Audience for this document

The primary end-users of this district heating feasibility study how-to guide are professional technical staff, with experience in techno-economic analysis.

This how-to guide will contain information, guidance, support and references for the most important aspects of a district heating feasibility study. It is the responsibility of the document user to evaluate this information, and apply their knowledge, decision making, and technical judgement with reference to the specifics of each separate district heat feasibility study project.

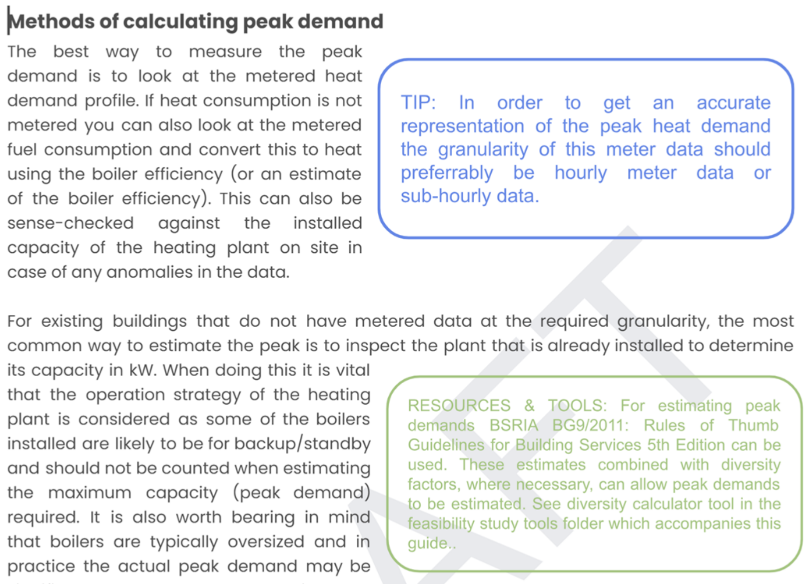
It is recognised that the how-to guide will outline and explain key considerations that must be included in a feasibility study analysis, however the final detail on how to include these considerations with reference to specific projects is the responsibility of the document user.

It is also recognised that this guidance document cannot be an exhaustive document for every scenario, however it will contain up-to-date knowledge and experience from the majority of district heating feasibility study projects carried out to date in Ireland, informed by international experience and comparison.

1.3 How to use this document

This document should be read in conjunction with the District Heating Feasibility Study Template. To help make this document easier to use, the following approach has been taken:

- For each section in the district heating feasibility study template, there is a corresponding section in this how to guide explaining the key elements typically included in that part of a district heating feasibility study analysis.
- The primary section numbering is consistent between the how to guide and the template for ease of reference.
- Useful tools and resources are highlighted in green boxes, as shown in Fig. 1 below.
- Design tips have also been highlighted in blue boxes.
- Key outputs are shown in grey boxes.
- The step-by-step process flow diagram in section 5.1 below provides an overview of the analysis conducted as part of a feasibility study.



Methods of calculating peak demand

The best way to measure the peak demand is to look at the metered heat demand profile. If heat consumption is not metered you can also look at the metered fuel consumption and convert this to heat using the boiler efficiency (or an estimate of the boiler efficiency). This can also be sense-checked against the installed capacity of the heating plant on site in case of any anomalies in the data.

TIP: In order to get an accurate representation of the peak heat demand the granularity of this meter data should preferrably be hourly meter data or sub-hourly data.

For existing buildings that do not have metered data at the required granularity, the most common way to estimate the peak is to inspect the plant that is already installed to determine its capacity in kW. When doing this it is vital that the operation strategy of the heating plant is considered as some of the boilers installed are likely to be for backup/standby and should not be counted when estimating the maximum capacity (peak demand) required. It is also worth bearing in mind that boilers are typically oversized and in practice the actual peak demand may be

RESOURCES & TOOLS: For estimating peak demands BSRIA BG9/2011: Rules of Thumb Guidelines for Building Services 5th Edition can be used. These estimates combined with diversity factors, where necessary, can allow peak demands to be estimated. See diversity calculator tool in the feasibility study tools folder which accompanies this guide..

Figure 1: Sample document layout, with useful tools and resources highlighted in green boxes and the design tips in blue boxes.

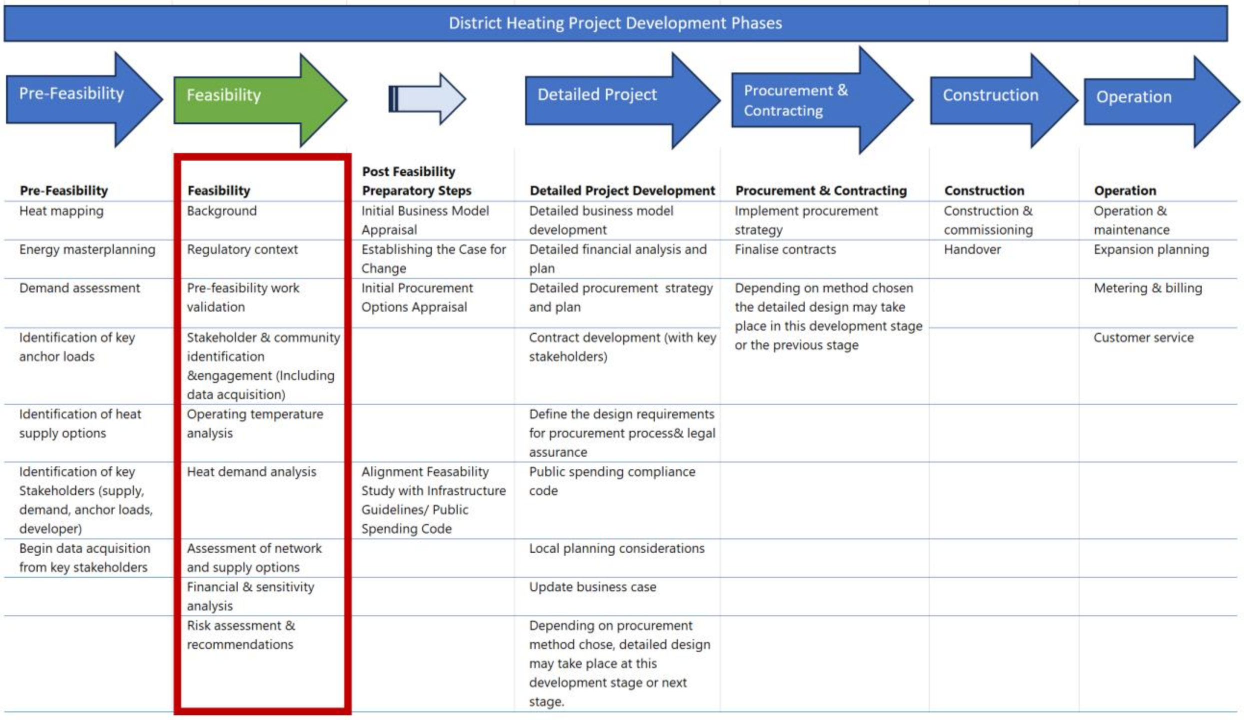
1.4 Need for this document

District heating (DH) represents a significant opportunity for Ireland to decarbonise its heat sector. The SEAI National Heat Study(2022) suggests that up to 54% of Ireland's heat could be most cost-effectively supplied through DH networks. This potential for DH has been recognised in policy with a target of 2.7TWh of Ireland's heat (approximately 10% of all residential and commercial heat demand) to be supplied through DH networks by 2030 under the Climate Action Plan 2023.

In order to achieve this ambitious target, it is vital that a pipeline of viable DH projects is identified and progressed across the country. In order to develop this pipeline of viable projects, Ireland needs greater capacity to produce high-quality DH feasibility studies. These studies are crucial to understanding a project's technical feasibility and financial viability and therefore will act as the main evidence base for informing the DH developers/decision makers to take proposed district heating projects forward for development.

1.5 District Heating Project Development Stages

District Heating project development consists of several stages (Figure 2). It is an iterative process, each stage refining and building on the previous stage. For the purposes of this how-to guide to district heating feasibility studies, the boundaries between project stages, and key considerations for each project stages are outlined in Figure 2.



Pre-Feasibility	**Feasibility**	**Post Feasibility Preparatory Steps**	**Detailed Project Development**	**Procurement & Contracting**	**Construction**	**Operation**
Heat mapping	Background	Initial Business Model Appraisal	Detailed business model development	Implement procurement strategy	Construction & commissioning	Operation & maintenance
Energy masterplanning	Regulatory context	Establishing the Case for Change	Detailed financial analysis and plan	Finalise contracts	Handover	Expansion planning
Demand assessment	Pre-feasibility work validation	Initial Procurement Options Appraisal	Detailed procurement strategy and plan	Depending on method chosen the detailed design may take place in this development stage or the previous stage		Metering & billing
Identification of key anchor loads	Stakeholder & community identification &engagement (Including data acquisition)		Contract development (with key stakeholders)			Customer service
Identification of heat supply options	Operating temperature analysis		Define the design requirements for procurement process& legal assurance			
Identification of key Stakeholders (supply, demand, anchor loads, developer)	Heat demand analysis	Alignment Feasability Study with Infrastructure Guidelines/ Public Spending Code	Public spending compliance code			
Begin data acquisition from key stakeholders	Assessment of network and supply options		Local planning considerations			
	Financial & sensitivity analysis		Update business case			
	Risk assessment & recommendations		Depending on procurement method chose, detailed design may take place at this development stage or next stage.			

Figure 2 District Heat Project Development Diagram.

This "How-to Guide is concerned with the contents of the 'Feasibility Stage', while the supplementary guidance offers support in preparation for the Detailed Project Development Stage.

1.6 Stakeholder input

SEAI gratefully acknowledge the participation of many stakeholders in the development of this how-to guide. Stakeholder participation was primarily gathered though stakeholder workshops.

Stakeholders were drawn from the following categories of organisation; local authorities, energy agencies, public sector policy and regulatory organisations, public sector bodies with heat decarbonisation mandates, energy services company (ESCOs), mechanical and electrical (M&E) consultants, district heat investment groups.

To avoid doubt, this acknowledgement does not imply endorsement by the stakeholders who participated.

1.7 Background

What is District Heating

A district heating scheme consists of an insulated pipe network, which allows heat generated from a single or several larger centralised source(s) (energy centres) to be delivered to multiple buildings to provide space heating and hot water (Figure 3).

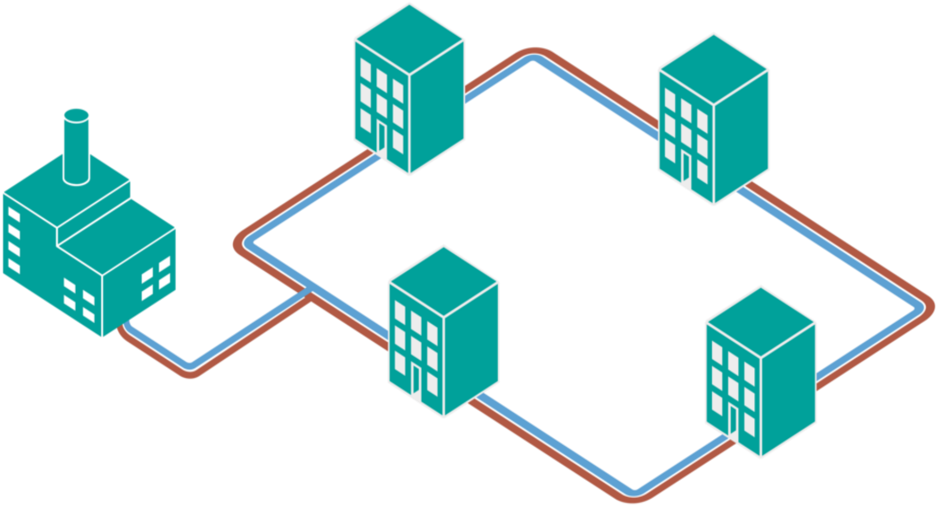


Figure 3: Indicative Diagram of a DH Scheme *(Source: https://withenergy.co.uk/districtheating-explained)*

What is District Heating

A district heating (DH) scheme involves a network of insulated pipes that distribute heat from one or several centralised sources (energy centres) to multiple buildings for space heating and hot water.

Potential Benefits of District Heating relative to individual heating systems:

- **Economies of Scale:** DH networks reduce capacity requirements due to varied customer heat demands, increasing the efficiency of larger heat generation units compared to individual building-level systems. This results in lower operational costs and more efficient heat production.
- **Ease of Decarbonisation:** Fewer, larger generation units simplify the switch to lower carbon technologies, aiding long-term decarbonisation efforts without/ with less extensive retrofitting.
- **Flexibility and Reliability:** DH is technology-agnostic, capable of using various renewable, low-carbon and waste heat sources. This diversity ensures reliable heat supply and potentially lowers costs.
- **Enhanced Renewable Electricity Utilisation:** Incorporating heat pumps into DH networks allows electricity to be stored as thermal energy, balancing the electrical grid during low demand periods.

1.8 “How-to guide” and each of the Feasibility Study Chapters

The following chapters (2-13) explain in detail how to complete the sections outlined in the feasibility study template that accompanies this guide.

2 Executive Summary

This section of the report outlines the purpose of this report and summarises the key findings and conclusions based on the results of the feasibility study analysis. This executive summary also highlights the recommendations and next steps from this report.

AN EXECUTIVE SUMMARY SHOULD INCLUDE THE FOLLOWING:

- Restate the purpose of the report.
- Summarise the key points of the report.
- Describe any results and explain conclusions.
- Highlight any limitations of the analysis.
- Highlight recommendations and next steps identified.

3 Introduction

This section of the How-To Guide sets out what we might expect to see in the Introduction section of a feasibility study. This section of the feasibility study sets out the broader context around District Heating (DH) for the reader of the study who may not be familiar with the technology or the targets and policy objectives which support the role out of DH in Ireland.

This introduction section of the feasibility study could include:

- A brief description of what DH is.
- How DH aligns with Ireland's climate objectives and associated targets at a national/local level.
- Where this feasibility study sits within the broader project development phases (See Figure 2).

4 Background

This section sets the context for the feasibility study, introducing District Heating (DH) systems and exploring the policy landscape supporting their rollout in Ireland. A well-structured background section educates stakeholders about the importance and implications of the project, aligning with national climate goals.

4.1 Prompt for the Study

The feasibility study may be initiated due to various factors:

- **Local Policy Objectives:** As outlined in development plans or spatial and economic strategies.
- **Heat Resource Identification:** Through local heat planning efforts or discovery of significant untapped heat sources.
- **Energy Security and Emission Targets:** Driven by concerns over gas/oil supply security or mandates to meet specific emission reduction targets. Similarly a drive to meet renewable energy deployment targets.
- **Fuel Poverty and Decarbonisation Goals:** Exploring DH as a solution to fuel poverty within a broader decarbonisation strategy.

4.2 Current Heat Supply and Demand

Understanding the existing heat supply landscape (e.g. the prevalence of gas or oil boilers) and demand within the area helps in assessing the potential impact and feasibility of DH systems.

4.3 Study Area Definition

The feasibility study should clearly define the geographical scope, which might be based on:

- Local Area Plans
- Decarbonisation Zones
- Areas identified in pre-feasibility studies or heat master plans.

4.4 Regulatory and Legislative Context

This section offers an overview of the regulatory and legislative frameworks that influence DH projects, which is crucial for aligning the project with current laws and policies.

4.4.1 National Level Context

Recent strategic documents that shape the DH landscape in Ireland include:

- **Climate Action Plan 2024(CAP24)[1],(Govt. of Ireland, 2024):** Continues to build on CAP23's targets (Table1), emphasizing the increased integration of DH systems to achieve a 51% reduction in emissions by 2030. CAP24 introduces specific new high-impact actions aimed at boosting the deployment of renewable heat and enhancing the energy efficiency of buildings.
- **National Heat Study (SEAI,2022)[2]:** Offers insights into optimising heat supply systems across Ireland, underscoring the role of DH in transitioning to sustainable heating solutions.
- **District Heating Steering Group Report [3](DECC, 2023)** contains recommendations that set the foundation for the development of the district heating sector in Ireland.
- **40by30 Renewable Heat Plan[4](Renewable Energy Ireland, 2021):** Identifies the potential of DH in meeting Ireland's heating needs through renewable sources, particularly in urban settings where heat demand is dense.

The Climate Action Plans of 2023 and 2024 set out strategic initiatives for District Heating (DH) development, focusing on expanding infrastructure to meet heat demand targets and deploying systems in strategically identified areas. These plans aim to enhance the integration of renewable heat into the district heating mix and establish frameworks for planning, permitting, and regulation to ensure effective implementation and consumer protection. Up to 0.8 TWh of district heating is to be installed across both the residential, public and commercial building stock by 2025, and up to 2.7 TWh by 2030[5].

Target Description	2025 KPI	2030 Target	Notes
Total DH Heat Demand Coverage	0.8 TWh	2.7TWh	Targets by 2030 to cover 10% of commercial, public and residential building heat demand.
Strategic Deployment Areas	Identify areas	Implement DH systems	Prioritise areas with high heat demand and potential for heat recovery.

Table 1: Overview of latest DH Deployment Targets from CAP 2024 including 2025 and 2030 KPIs.

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[1] https://www.gov.ie/en/publication/79659-climate-action-plan-2024/

[2] https://www.seai.ie/data-and-insights/national-heat-study/

[3] https://www.gov.ie/en/publication/3f132-district-heating-steering-group/

[4] https://renewableenergyireland.ie/wp-content/uploads/2021/05/Renewable-Energy-Ireland_Renewable-Heat-Plan_-Final.pdf

[5] https://www.gov.ie/pdf/?file=https://assets.gov.ie/293730/00ee6688-fc2a-4897-8077-de73280ec7fc.pdf#page=null

4.4.2 Local Level Context

This section details the local context for the DH project site, incorporating relevant energy analyses and policies affecting heat and district heating:

Relevant Local Policy:

- **Development Plans:** For instance, the Dublin City Development Plan 2022 – 2028 and the South Dublin County Development Plan 2022 - 2028 emphasise low carbon district heating networks and the integration of district heating in new developments.

- **Regional Strategies:** The Regional Spatial and Economic Strategies (RSES) across different assemblies (Eastern & Midlands, Northern & Western, Southern) outline policies supporting district heating development, emphasizing energy recovery, efficiency, and low-carbon technologies.

These local insights and policy frameworks provide a robust foundation for assessing and advancing district heating initiatives tailored to specific regional needs and opportunities.

4.5 Pre-feasibility Study

This section outlines at a high level the initial analysis typically conducted in a pre-feasibility assessment.

What is a Pre-feasibility study?

Before starting a detailed feasibility study, what is called a pre-feasibility analysis is conducted. Pre-feasibility analyses are very high-level assessments, that can be conducted quickly to evaluate the projects with highest potential, that merit deeper analysis in a full feasibility study. Key elements of pre-feasibility analyses include:

- Heat mapping
- Energy master-planning
- High level demand assessment
- Identification of potential 'anchor loads'
- Early investigation of heat source options
- Stakeholder evaluation (demand, supply, scheme developer)
- Begin data acquisition process for key anchor loads (minimise delays in next stage)

Useful resources for pre-feasibility include:

- SEAI Heat Demand Map[6]
- SEAI District Heating Candidate Area Map[7]
- Dublin District Heating Viability Map[8]
- The Irish District Energy Association (IrDEA) Heat Atlas[9]

Use of maps and GIS mapping software is a best practice way to present information such as heat demand, heat supply, geographical constraints, and local energy infrastructure.

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[6] SEAI, 2022, Heat Demand Map

[7] SEAI, 2023, District Heating Map

[8] Codema, 2021, District Heating Viability - Dublin

[9] IrDEA, 2019, Irish Heat Atlas

5 Feasibility Process Overview

The feasibility study phase sits within an overall project development process before the detailed project development phase and after the pre-feasibility phase as outlined in Figure 2 in Section 1.5 - District Heating Project Development Stages.

- **Feasibility assessment steps**. This section of the guide provides an overview of the steps involved in completing a feasibility study (including key outputs) and builds upon the pre-feasibility work discussed in section 4.5.

- **Stakeholder engagement:** This section also outlines a framework for stakeholder engagement. This stakeholder engagement is an important process which underpins much of the feasibility analysis and ensures the best available information is used in the development of the study.

5.1 Step-by-Step Techno-Economic Feasibility Process

This section outlines the steps involved in developing the techno-economic feasibility analysis which provides the main evidence base for the development of a potential district heating network. This represents the bulk of the analysis that will inform the completed feasibility study report.

This stage does not discuss the steps involved the preceding or following project development stages, as shown in Figure 2 (pre-feasibility and detailed project development respectively).

The focus of this section:

- Outline the steps for developing the techno-economic feasibility analysis, to aid readers understanding of the overall analytic process.
- Highlight that the techno-economic analysis serves as the core evidence base informing the completed feasibility study report.
- Highlight that the stakeholder engagement process occurs concurrently with the development of the techno-economic feasibility analysis. It influences the analysis by sharing information and involves deeper engagement through workshops, especially regarding business models and procurement options.

The six stages to be included in the feasibility study are outlined below in both Table 2 and visually in Figure 4; 1) demand assessment, 2) initial assessment of energy supply options, 3) heat distribution systems, 4) multicriteria analysis of shortlisted options, 5) detailed energy supply options assessment and lastly, 6) recommendations and summary. Each of these stages is described in further detail in the subsequent chapters of the report. Figure 4 below graphically represents these stages, providing a visual overview of the entire feasibility process. It can be seen from this diagram that the stakeholder engagement process runs in parallel to this work and informs its development primarily through the sharing of information but also deeper engagement through workshops.

Main Stage and Chapter	Sub-Stages	
1. Demand Assessment	**1.1 Evaluation of thermal demand**	Building demand
Chapter 6		Operating temperatures analysis
2. Initial Assessment of Energy Supply Options	**2.1 Longlist of options**	Brainstorming potential options, typically 6 to 10.
Chapter 7	**2.2 Shortlist identification**	Qualitative evaluation to narrow down to 3 to 6 best options.
	2.2 Identification of alternative scenarios	Definition of 'business-as-usual' and counterfactual scenarios for comparison.
3. Heat Distribution Systems *Chapter 8*	**3.1 Network Route & Building connections**	Evaluation of feasible network routes and building connection types and constraints.
4. Summary of Energy Supply Options and Multicriteria Analysis of shortlisted options *Chapter 9*	**4. Description off all scenarios to be analysed**	Documenting all scenarios explored, including variations in network design and energy supply options.
		Identify the existing or typical solutions (business-as-usual) and alternative (counterfactual) scenarios to understand potential impacts and benefits.
Chapter 10	**4.1 Multicriteria analysis**	Applying an Integrated Risk Matrix (IRM) and conducting a high-level techno-economic analysis for each option.
5. Detailed Energy Supply Options Assessment *Chapter 11*	**5.1 Detailed Technical Economic Analysis**	Detailed financial assessment (40 years typically) Includes technical sizing, hydraulic modelling, pipe sizing, and energy system modelling. Includes sensitivity analysis
	5.2 Carbon performance evaluation	Assessment of CO2 emissions and savings
Chapter 12	**5.3 Risk assessment**	Evaluation of environmental and technical risks
6. Recommendations and Summary *Chapter 13*	**6.1 Feasibility Study Sections summary**	Detailing the preferred option recommendation

Table 2: Main stages and substages of the feasibility analysis explained in the following sections of this how-to guide.

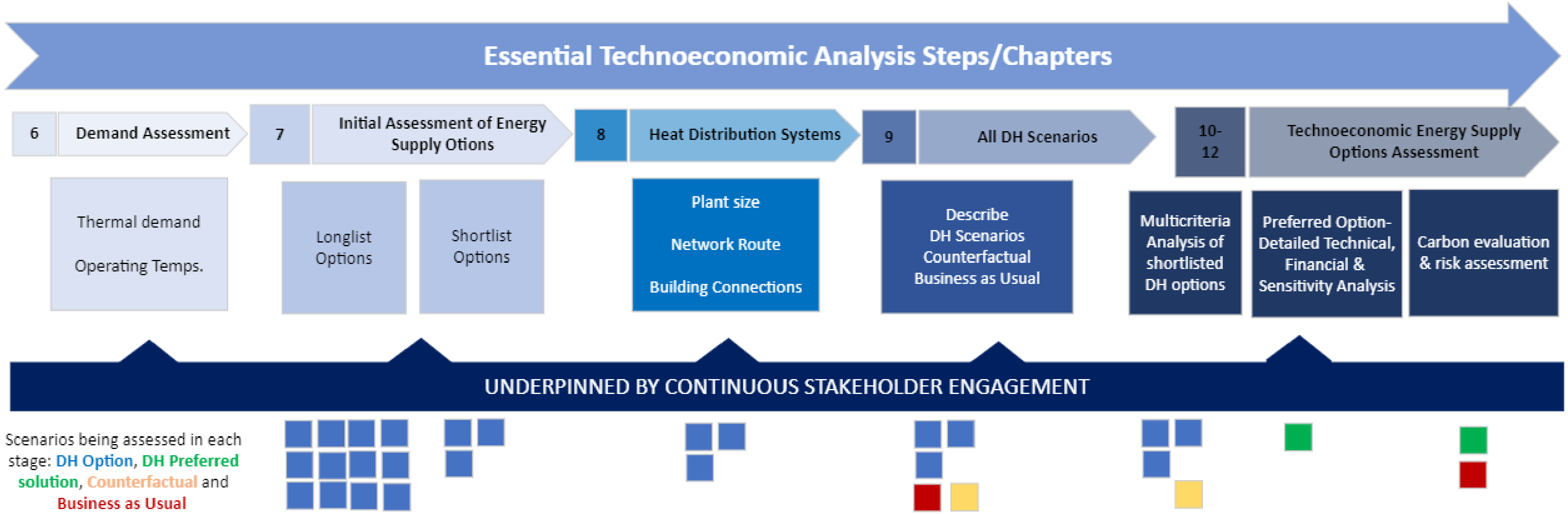


Figure 4: Key Steps and Outputs in the technoeconomic feasibility analysis as detailed in Table 2.

5.2 DH network Stakeholder Identification & Engagement

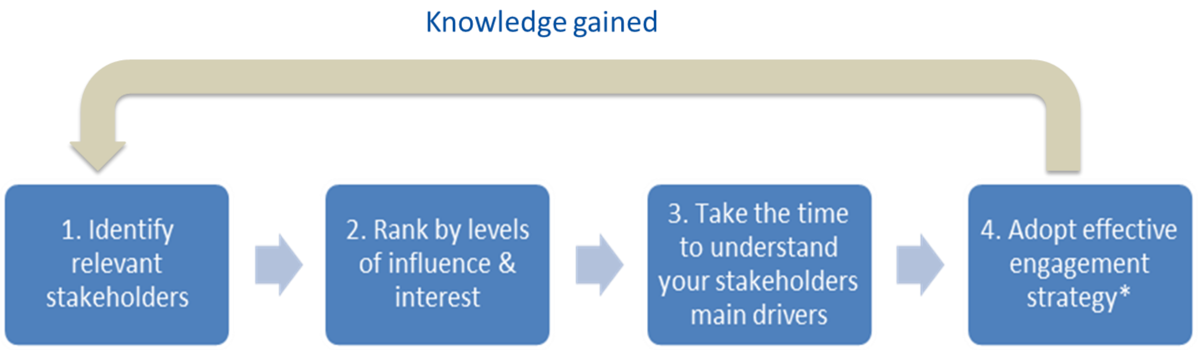
Stakeholder identification and engagement plays a vital role in the delivery of any district heating network. Stakeholder engagement can often be neglected, with priority being given to the technical aspects of a project. However, building relationships and engaging in an ongoing, open dialogue with potential customers and other key stakeholders is crucial when it comes to determining the viability and eventually delivering a DH project. This engagement process allows more accurate information to be obtained and as a result improves the quality of the final feasibility study. Some of the types of information obtained through this engagement are as follows:

- Heat loads
- Each party's key drivers (environmental, legal, economic, etc.)
- Opportunities to collaborate (e.g., trench sharing)
- Electrical grid connection capacity
- Customer heating systems details – temperature regimes, age, location of plant rooms, etc.
- Understanding the levels of interest / commitment to the project
- When customer is likely to connect to the network

5.2.1 Process for Effective Stakeholder Engagement

This section of the report sets out the steps to take in order to achieve effective stakeholder engagement. These steps include identifying the relevant stakeholders, prioritising your stakeholder list, understanding stakeholder drivers and barriers, and adopting the most effective methods and timing for engagement / collaboration. This stakeholder engagement process (Figure 5) runs in parallel to the feasibility study development process allowing for more accurate information from stakeholders to inform the development of the network. This process was developed by Codema as part of the South Dublin Transition Roadmap[10] which was delivered as part of the Interreg HeatNet NWE project.

TIP: It is important to engage with stakeholders as early as possible to allow time for the most suitable people within the organisation to be involved and to facilitate data sharing to create a more robust analysis where possible.



*The frequency, timing and type of communication will vary based on stakeholders' role and ranking

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[10] Codema, Transition Roadmap for Developing District Heating in South Dublin (2019): https://www.codema.ie/images/uploads/docs/HeatNet_NWE_Transition_Roadmap_Report_Final_-_Digital.pdf

Figure 5: Stakeholder Engagement Process Graph (Source: Codema)

5.2.2 Step 1 - Identifying Relevant Stakeholders

The first step is to identify the stakeholders relevant to your project. This will include anyone who might contribute to, has an interest in, or may be affected by the development of your DH scheme. This might include some of the following the local authority (e.g. city or county council), local energy agency, planning bodies, finance/investors, procurement, legal, analysts, environmental body, developer(s), project team, SEAI, highways, customers (businesses and residents), heat sources (Industrial, ESCo etc.), consultancy, ESCo, DHCo, media/communications.

It is important to note that you may not know all the relevant stakeholders from the start of the project and that this list is a live document, which will be updated throughout the project as more information becomes available and a greater understanding of the drivers and barriers is achieved. A good starting point for developing your initial list of stakeholders is to think about the roles that will need to be filled in order for your district heating scheme to be delivered and put relevant stakeholders' names against each role. These roles can be categorised as follows[11]:

1. Promotion (driving delivery of project)
2. Customer (purchasing heat or coolth from the network)
3. Governance (prescribing objectives, rules and policies)
4. Regulation (consumer protection, fair pricing)
5. Funding (arranging finance)
6. Asset Ownership (owns the physical assets such as generation assets, network, etc.)
7. Development of property (constructing and maintaining the buildings connected)
8. Land ownership (granting access for installation and maintenance)
9. Landlordship (landlord of connected buildings ensuring occupiers connected and secondary or tertiary heating system is maintained)
10. Installation (design and installation of Dh system, which may include the energy centre, network, heat substations or HIUs)
11. Operation (operates and maintains the DH system)
12. Heat sales (metering, billing and customer service)
13. Supplier of last resort (provides backup heat supply customers)

It is important to note that multiple stakeholders may fit into one role category (e.g. multiple stakeholders as customers) and also that one stakeholder may perform multiple roles (e.g. an ESCo might fund, install, operate and sell heat). In cases where you have internal stakeholders within your organisation or initial project team, it would be of benefit to sit down together to develop as broad a list of further stakeholders as possible and share any contact details you might have. Directly contacting stakeholders that you already know and have a good relationship with will generally result in a far greater degree of engagement.

5.2.3 Step 2 - Understanding Stakeholder Drivers and Barriers

Stakeholder drivers for developing a district heating scheme should be identified and recorded at an early stage in the process. These drivers will help shape the project objectives and can outline the role each party will need to play in delivering these key objectives. The list below (Table 3) provides an example of some of the main drivers behind connecting to and developing a DH scheme and how they might relate to certain stakeholders. It should be noted that these drivers can be seen as either having a positive or negative impact

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[11] BEIS Heat Network Detailed Project Development Resource: Guidance on Strategic and Commercial Case (2016)

by each stakeholder e.g. innovation might be seen as a positive for one stakeholder but seen as a risk by another.

Area	Drivers	Local Authority	Developer	Customer
Environmental	Carbon emissions reduction associated with heating and/or cooling	✓	✓	✓
	Increasing renewable energy share of the heating fuel mix	✓	✓	✓
	Air quality improvement	✓		
Economic and financial	Reducing local authority energy costs	✓		
	Job creation and stimulation of the local economy	✓		
	Sustainable source of revenue for the local authority	✓		
	Contract or service value for money	✓	✓	✓
	Space savings in connected buildings	✓	✓	✓
	Cost-effective compliance with building regulations	✓	✓	✓
	Increasing regional competitiveness – attracting industry with low-carbon, low-cost heat	✓		
	Energy tourism	✓		
	Trench sharing savings	✓	✓	
Technical	Resolving performance issues with existing building heating systems	✓	✓	✓
	Energy security and resilience	✓	✓	✓
	System reliability and maintainability	✓	✓	✓
	Innovation	✓	✓	✓
Social	Alleviating fuel poverty	✓		✓
	Reducing energy costs to customers	✓		✓
	Customer satisfaction (improved comfort, control, simple billing, customer service)	✓		✓
	Regeneration of housing stock	✓		✓
	Protection of vulnerable customers	✓		✓
Political	Local authority capacity and skills development	✓		
	Compliance with national or regional policies	✓	✓	✓

Area	Drivers	Local Authority	Developer	Customer
	Reputation	✓	✓	✓
	Requirement for buildings in designated DH area to connect	✓		
Legal	Compliance with regulations	✓	✓	✓
	Compliance with planning policy	✓	✓	✓
	Compliance with metering/billing regulations	✓	✓	✓
Circumstantial	Planned new development (identified as a potential anchor load for an area-wide network)	✓		
	Capital funding becomes available	✓	✓	✓
	Existing building or estate heating system reaching the end of its operational life	✓	✓	✓

Table 3: Example Stakeholder Drivers Table, highlighting potentially important drivers for key stakeholders.

To get a deeper understanding of the relative importance of these key drivers, ask the stakeholders to rank the above objectives on a scale of 1 to 10, with 10 being the highest priority. These scores can be represented visually in the form of a radar chart (Figure 6) to highlight the key objectives of the project for multiple stakeholders. This will help to communicate the most relevant information to each stakeholder. In the example in the figures below (Figs. 6,7), we can see that the main drivers for the local authority are in the environmental area, specifically the reduction of carbon emissions, improving air quality and increasing the use of renewable energy for heating and are shown in a more specific drivers overview radar chart in Figure 7.

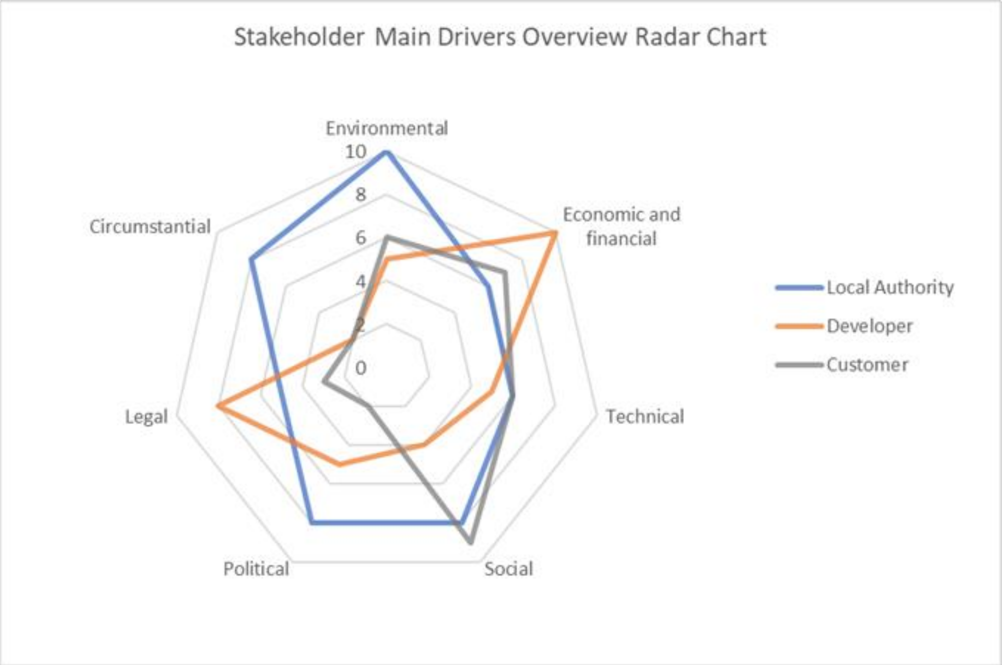

Figure 6: An example of a Stakeholder Main Driver Overview Radar Chart

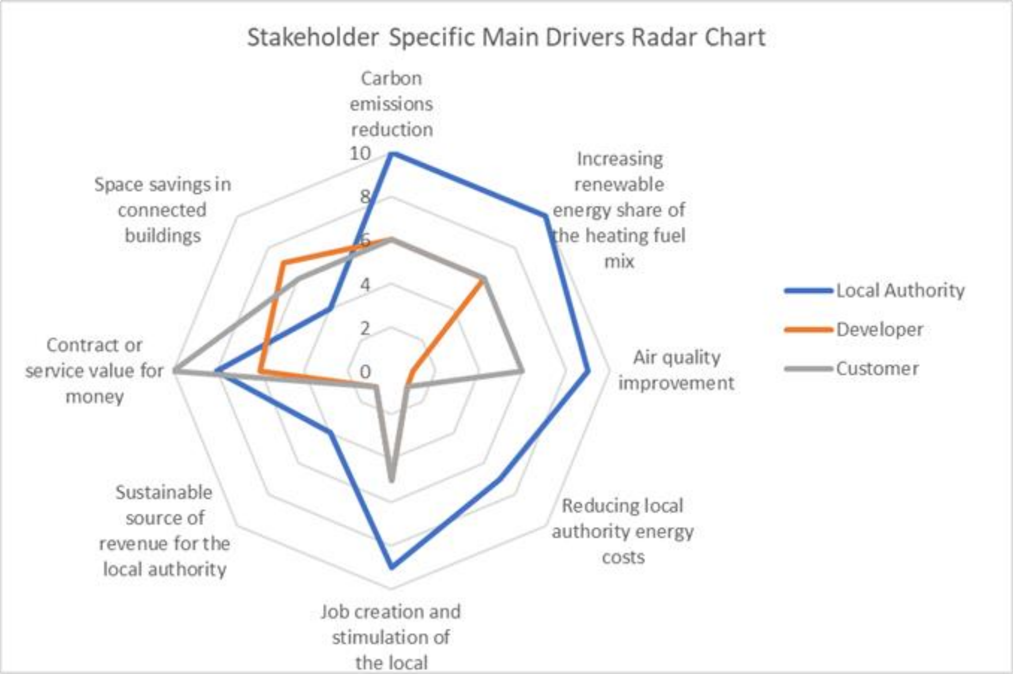

Figure 7: An example of a Stakeholder Specific Main Drivers Rader Chart

5.2.4 Step 3 - Prioritise Stakeholders

TOOL: An Interest-impact mapping tool similar to that shown in Figure 8 has been provided to support the feasibility study guide.

The prioritisation of stakeholders is important in order to identify where best to focus your engagement efforts. One way of prioritising stakeholders is to rank each one on the level of influence they could have on the project and also on the level of interest and enthusiasm they display for being involved; this will allow you to plot their position (in quadrant A, B, C or D) on an impact-interest grid (see example grid in Figure 8) and help determine the type and frequency of the ongoing engagement required based on this position. The initial ranking of stakeholders will be carried out based on your own knowledge and assumptions regarding heat demand estimates, waste heat availability, ownership (e.g. publicly owned) and proximity to the proposed network; this may be subject to change as more information becomes available following more in-depth discussions with each stakeholder.

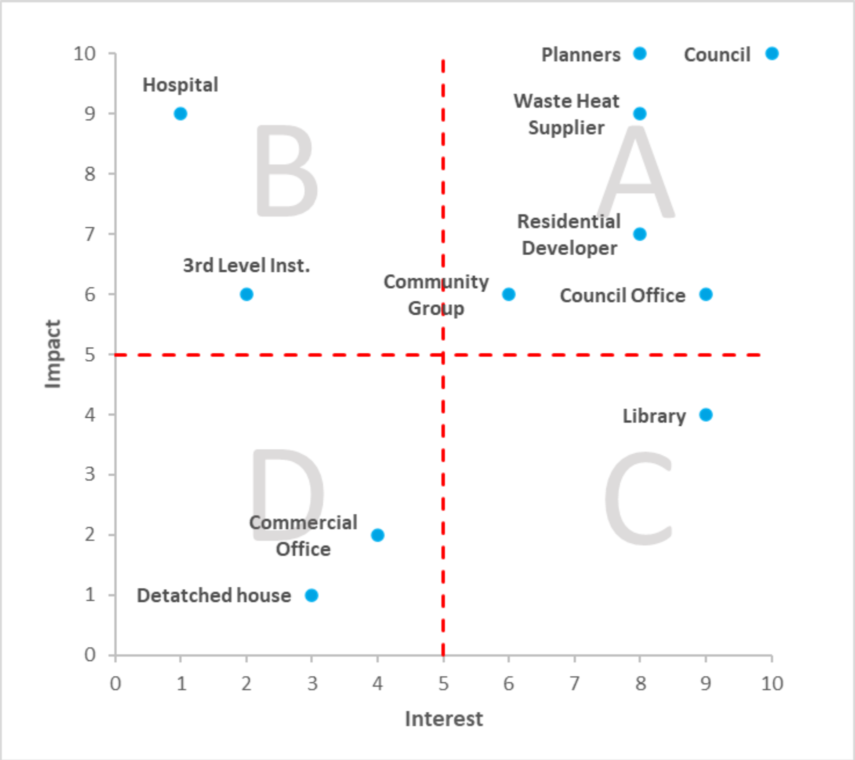

Figure 8: Example of a Stakeholder Impact and Interest Graph

Stakeholders that fall within the “A” section of the graph have both a significant interest and potential impact on the project, making them crucial to the success of the project. It is therefore key that they have a strong understanding of the project and can actively contribute to its development. This should involve two-way engagement (face-to-face meetings, emails, phone calls), joint learning, decision making and actions.

If a stakeholder falls within the “B” section of the graph, i.e. could have a high impact but has a lower interest in the project - perhaps a stakeholder who does not want to be actively involved in the project but may have access to information that could greatly impact the viability of your project – they should be encouraged to share their views. This can be done by sharing project progress updates and asking for comment. This will involve two-way engagement within a more limited area of responsibility.

Stakeholders which are positioned in section “C”, of the graph which have high levels of interest but a lower impact on the project may not initially have a key role in the project’s success but should be kept informed about the project as it progresses, as they could potentially have a larger impact at a later date (e.g. might be a customer who end up expanding their premises and significantly increase their heat demand which could act as an anchor load) and perform a key role within the project.

Stakeholders that fall within the “D” section of the graph, where they have low interest levels and low impact on the project, are the least critical group to the success of the project; however, it is still important to keep these stakeholders informed as there may be unknown or unexpected supporters within this group whose status may change as the project moves forward or may influence other stakeholders. This will primarily be done in the form of one-way engagement (e.g., brochures, webpage, email, open consultation).

5.2.5 Step 4 - Effective Engagement

It is important to tailor your engagement methods to communicate as effectively as possible with each stakeholder and provide the most relevant information to highlight the most applicable benefits, address any concerns and show your understanding of the stakeholders’ main drivers (motivators and barriers). This approach, along with ensuring the stakeholders have the opportunity to give their perspective in every interaction, will help keep levels of interest high and lines of communication open, leading to greater collaboration and cooperation.

Your first engagement with all stakeholders should give a brief description of what district heating is and a description of your project and its objectives; this will help to clarify your project and help clarify what district heating is and how it operates. Where possible, this initial engagement should be carried out by a team member who has an existing good relationship with the stakeholder in order to build trust in the project. The potential benefits to the stakeholder of connecting to the DH system should also be highlighted at this point; the advantage of DH in this regard is that it has a wide range of potential benefits that are applicable to many stakeholders. Choose the benefits that are most applicable to the stakeholder and how your project can address any perceived concerns the stakeholder may have.

TIP: It is recommended that stakeholders are contacted via both email (to give the brief description of the scheme which can be shared within their organisation) and phone. It is a lot easier to gauge interest and have a more in-depth discussion over the phone if the stakeholder has any questions regarding how the system works, its benefit to them, etc.

It is also important that you state how the stakeholders can get involved in the project and the role they could play in developing the project (e.g. by providing information such as heat demand data or providing support for the project via a written statement of support) that would allow a greater understanding of the feasibility of the proposed scheme. It is important to organise further follow-up meetings with key stakeholders in order to keep the project details up-to-date and to share how the project is progressing.

Table 4 below gives an example of some of the useful information that may be provided by certain stakeholders to help progress the DH project. Note that this is not an exhaustive list and there may be other information that may also contribute towards the project.

Table 4: Useful Information to Request from Stakeholders in order to progress the study.

Stakeholder	Useful Information
Local Authority	• Local area plan and location of development zones • Details of planning policy and how it facilitates district heating • Drawings or GIS files showing barriers to DH installation (existing utilities, infrastructure, environmentally sensitive areas, heritage sites) • Location, type and floor area of existing buildings • Location of publicly-owned sites and/or land • Details of recent (protected period – see guidelines for managing openings in public roads) or planned roadworks (opportunity for shared civils costs)
Developer	• Details of planning permission • Development phasing schedule (development quantum and timescale) • Development massing – location within the site of various buildings of different use type • Heating system details (planned system type and design temperatures) • Heat demand figures (BER, benchmarked, thermo-dynamic models) • Letter of support • Site investigation report – detailing ground conditions

Stakeholder	Useful Information
Potential Customer	• Heating plant details (size, age, location, fuel used, etc.) • Energy bills and metered readings if available • Heating system details (system type and operating temperatures) • Details of planned on-site works (boiler replacement, fabric upgrades, installation of other infrastructure, planned extensions, etc.) • Letter of support - see template letter in Appendix A

5.2.6 When to Involve the Relevant Stakeholders

Different stakeholders will have varying levels of input at different stages of the project. Figure 9 below gives a general outline of the level of input from the main stakeholder groups through the seven main project stages used in the CIBSE heat networks code of practice [12]. This will help guide the level of communication required from each stakeholder at each stage of the project.

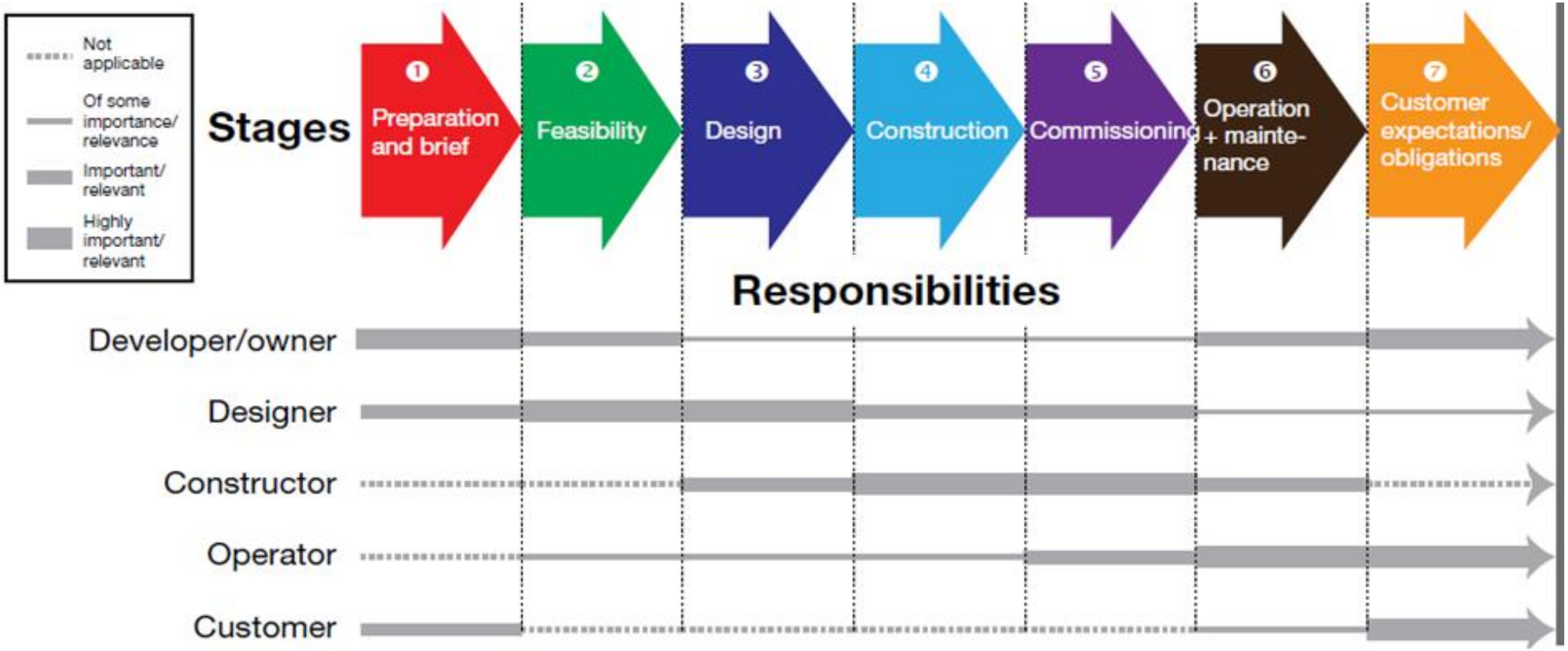

Figure 9: Stakeholder Input Graph, (source: CIBSE CP1 Heat Networks Code of Practice)

Figure 9 highlights indicative responsibilities and relevance to different stages of the DH Project development. For the purposes of this guide, the Feasibility Stage 2 correlates with the contents of this feasibility study template.

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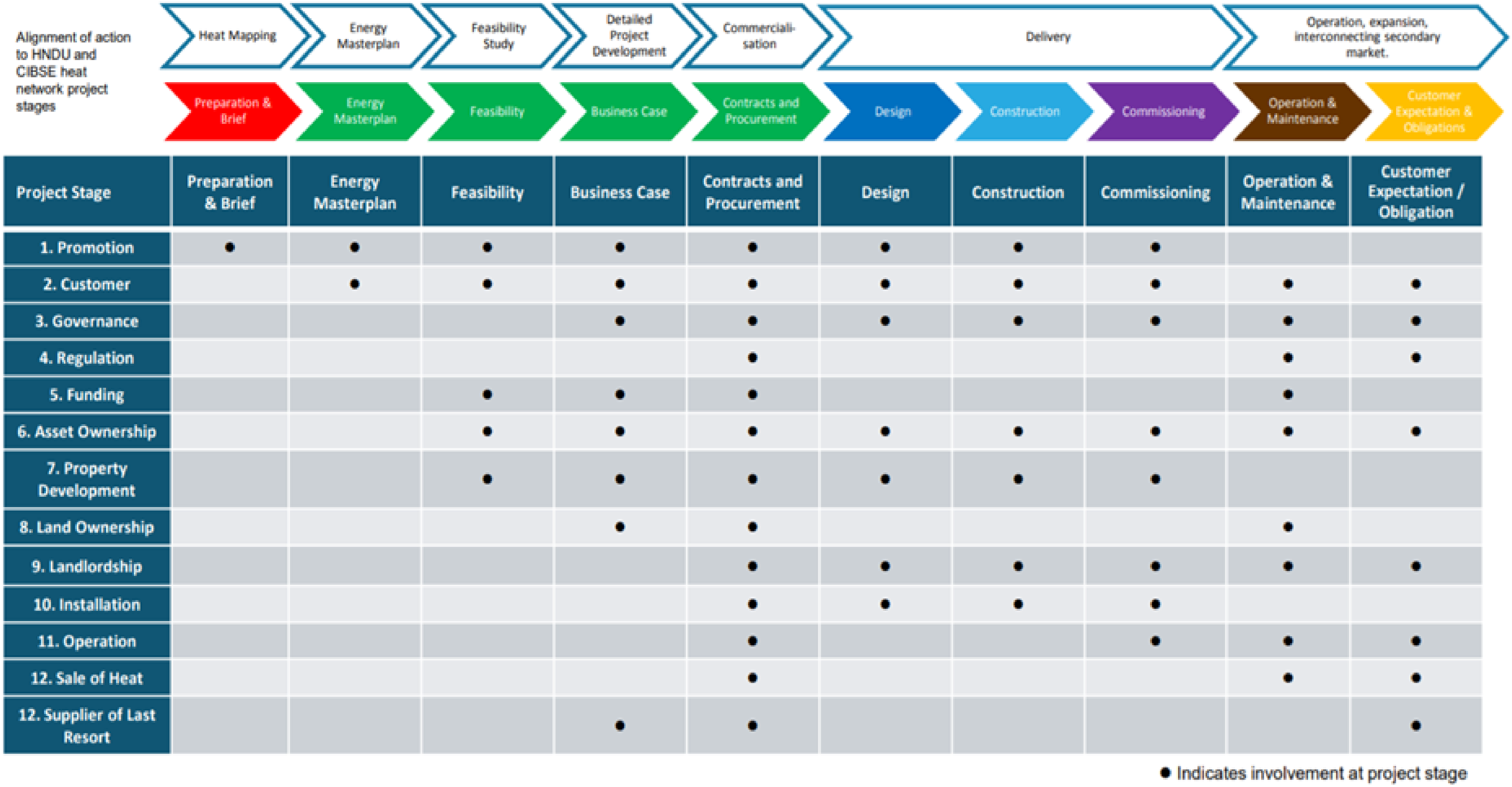
[12] CIBSE (2020), *"CP1 Heat networks: Code of Practice for the UK"*



Project Stage	Preparation & Brief	Energy Masterplan	Feasibility	Business Case	Contracts and Procurement	Design	Construction	Commissioning	Operation & Maintenance	Customer Expectation / Obligation
1. Promotion	●	●	●	●	●	●	●	●		
2. Customer		●	●	●	●	●	●	●	●	●
3. Governance				●	●	●	●	●	●	●
4. Regulation					●				●	●
5. Funding			●	●	●				●	
6. Asset Ownership			●	●	●	●	●	●	●	●
7. Property Development			●	●	●	●	●	●		
8. Land Ownership				●	●				●	
9. Landlordship					●	●	●	●	●	●
10. Installation					●	●	●	●		
11. Operation					●			●	●	●
12. Sale of Heat					●				●	●
12. Supplier of Last Resort				●	●					●

● Indicates involvement at project stage

Figure 10: Stakeholder Involvement at Project Stage Graph; Source BEIS 2016

Figure highlights at what stage of a project different stakeholders may becoming involved. This feasibility study refers to the ‘Feasibility’ Stage here., Source: BEIS Heat Network Detailed Project Development Resource: Guidance on Strategic and Commercial Case (2016)

6 Demand Assessment

This chapter outlines the steps to be undertaken in order to analyse and assess the heat demands to be met by the potential DH scheme and its operating temperatures. It is a first step that underpins the technoeconomic analysis that follows in terms of peak heat demand, operating temperatures, heat supply options and the resulting financial analysis.

6.1 Heat Demand

This section provides guidance on how to estimate heat demands and discusses important considerations when using these demands for sizing network pipelines and sizing heat generating plant.

Assessing the heat demand is the cornerstone of any DH feasibility analysis. It is therefore crucial that the heat demand assessment of any feasibility analysis is carried out using the best available data. The hierarchy of heat demand data shown in Figure 11 indicates which data is the best to use in this regard and sections 6.1.2 and 6.1.6 give advice on converting fuel demand to heat demand and calculating peak demand. Strong engagement with stakeholders can greatly increase the quality of the heat demand assessment.

Heat demand outputs:

- Annual heat demand for each connection (both existing and future demands in MWh)
- Phasing of demands - what year will heat demand connect to the network.
- Peak heat demand (MW) for each connection (including for diversity of demand where relevant) – Important for network and plant sizing (heat production and substations particularly).
- Location of demands (to be mapped) – To facilitate the development of potential pipe network routes.
- Customer building use types and ownership – informing the likelihood of connecting to the network.
- Customer heating system & operating temperatures – Informing network temperature requirements and likelihood of connection (operating temperatures discussed in greater detail in section 6.2)

The majority of this information will be captured in the feasibility study report, (Feasibility Study Table 3) using tables similar to Table 5 and Table 6 shown below, relating to connection likelihood and more specific heat demand.

Table 5: Connection Likelihood Assessment

Connection Likelihood	Description (e.g. Ownership, Supporting Regulations/Policy, Existing/Planned, etc.)	Buildings
High	Publicly owned buildings, high certainty of connection	• University Building
Medium	Buildings with energy efficiency obligations and new developments that must meet new building energy regulations, increased likelihood of connection	• Office 1
Low	Private buildings/rentals, limited ability to influence connection. Buildings with heating systems that are less compatible with DH i.e. systems that are not water based and/or are not	• Existing Residential Apartment Block

Connection Likelihood	Description (e.g. Ownership, Supporting Regulations/Policy, Existing/Planned, etc.)	Buildings
	centralised.	

It is suggested to include quantitative measures such as scoring systems that factor in multiple dimensions like financial feasibility, technical viability, and regulatory compliance to objectively assess connection likelihood.

TIP: CIBSE CP1 Section 2.4 provides indicative temperatures regimes for existing building heating systems once rebalanced (80° C flow and 60° C return) and for new or replacement heating systems. This discussed in greater detail in section **6.2** of this guide.

Key heat demand information when it comes to sizing the DH network it outlined in Table 6. This includes the peak demands at the connections point (i.e. this would include application of diversity factors for multi-unit residential developments) and at the Energy Centre, where a further diversity factor would be applied (this factor is typically in the 70-80% range[13] for large networks with diverse building types) and assumed operating temperatures based on the current heating system installed.

Table 6: Typical Summary Table of Heat Demand Information

Phase	Heat On Date	Buildings	Heat Demand (MWh)	Peak Heat Demand @ Connection (MW)	Peak Heat Demand @ EC (MW)	Assumed Allowable Temperature Regime (°C)	Likelihood of Connecting	Comments
1	2025	Office				80/60	Medium	
		Existing Residential Apartment Block				80/60	Low	Uses electric storage heaters
2	2028	University Building				80/60	High	
		Hotel				80/60	High	
Total								

6.1.1 Phasing of Heat Demand

Phasing of the demand is an important consideration when performing a techno-economic analysis as the load connected to the network in a given will have a direct impact on the cashflow for that year and therefore impact the key viability metrics from the financial analysis. There are a number of important things to consider when it comes the phasing or connections for both new and existing buildings which are set out in Table 7 below. The decision on phasing would typically be informed through strong engagement with the building owner/developer.

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[13] Range for networks with diverse heat demands from CIBSE CP1 and AM12 respectively.

Table 7: Heat Load Phasing Considerations Table

Type	Phasing Considerations
Existing Buildings	• Remaining lifespan of current heating plant (what year was current plant installed) – building owner may want to realise the full life of this asset or may not. • Dates of planned renovation works (possible coordination to minimise disruption to occupants). • Policy or regulatory changes which need to be met by a certain date (e.g. mandate for certain building to reduce emissions by a given date).
Future Buildings	• Construction timelines – which may include a certain contingency for planning or construction delays and to account for when building will finally be occupied. • If initial decision to use alternative low-carbon heat when do these reach end of life.
Other Considerations	• May be areas where pipe cannot be laid for a number of years due protected periods (newly installed paving, road surfaces, etc.) and where circumnavigating this area would be prohibitively expensive. This will be informed by the proposed pipe network route. • Similarly pipe may not be laid for a number of years in order to coordinate with other works (lay pipes when road is being opened, when a bridge is being built, etc.).

6.1.2 How to Calculate Annual Heat Demand

TIP: When using heat meter data that measures at intervals smaller than 1 hour, it is important to consider that there may be inertia in the system which would result in an artificially high peak demand (particularly on start-up). This is due to the return water on start up being the water that has been sitting in the secondary system cooling while the heating system has been off.

When it comes to calculating heat demands it is important to use the best available information in order to reduce potential for inaccuracies in your calculations. The hierarchy of data which can be used to determine the heat demand of potential customers is show in Figure 11. Where possible it is best to use data that is higher up this hierarchy (metered data being the best quality data).

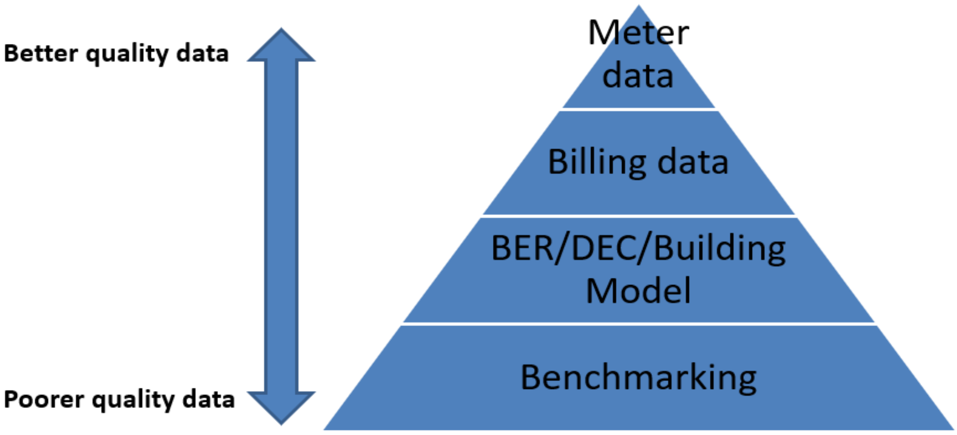

Figure 11: Hierarchy of Heat Demand Data

It is important to note at this point that fuel demand (e.g., gas, oil, electricity demand) is not the same as heat demand. Therefore, if the data available is fuel consumption data this will need to be converted into heat demand using the efficiency of the heat generating plant e.g., the boiler. The equation used for doing this can be seen below.

$$\textbf{\textit{Heat Demand}} = \textbf{\textit{Fuel Demand}} \times \textbf{\textit{Net Efficiency of Boiler}}$$

Methods of estimating the boiler efficiency used in this equation are discussed in greater detail in the following sections.

TIP: Gas consumption data for the previous 24 months can be requested from Gas Networks Ireland. This can be used to calculate annual heat demand if meter or billing information is not available. Request form available from Gas Networks Ireland.

6.1.2.1 Converting Fuel Consumption to Heat Consumption

In order to convert fuel demand into heat demand the efficiency of the boilers will need to be considered.

6.1.2.1.1 Estimating Boiler Efficiencies

When it comes to estimating efficiencies of boilers there are a number of elements to consider. These include a) the operating temperature, b) the boiler age and c) type of boiler:

- The operating temperature of the heating system - the return temperature of the heating system has a direct impact on the efficiency of condensing boilers (see Figure 12 below)
- The age of the boiler - over time the efficiency of a boiler will tend to reduce. The figures below provide an indication of the efficiency reduction with the age of boiler[14]:
  - Over 25 years old: 60-70% efficient
  - 20 years old: 75% efficient
  - 15 years old 80-85% efficient
  - 10+ years old 80-85% efficient

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[14] The heatinghub, Boiler efficiency calculator: https://www.theheatinghub.co.uk/boiler-efficiency-guide-and-energy-saving-tips#:~:text=Over%2025%20years%20old%3A%2060,years%20old%2080%2D85%25%20efficient

- Type of boiler - the fuel it burns and whether it is a condensing boiler. Typical efficiencies for boilers using different fuels are shown below:
    - Gas boiler 75%
    - Condensing Gas Boiler 85%
    - Oil boiler 75%
    - Electric boiler 100%
    - Biomass boiler 75%

Figure 12 below outlines how the efficiency of a condensing boiler reduces with increasing return temperature. The majority of existing heating systems in Ireland have a return temperature in excess of 54°C resulting in a theoretical maximum efficiency that will not exceed 87%.

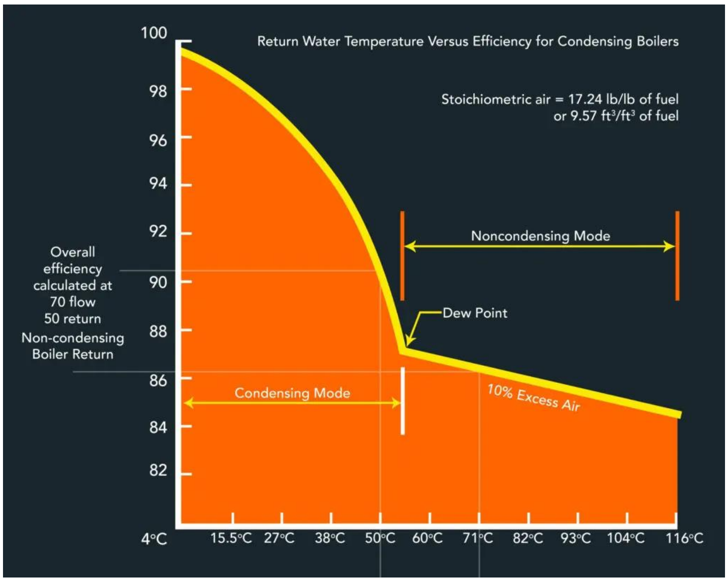

Figure 12: Condensing Boiler Efficiency vs Return Water Temperature (Source: HeatGeek)

6.1.2.1.2 Boiler Efficiencies from Data Sheets

If using boiler efficiency figures from the boiler's data sheet to calculate heat demands, it is worth noting that these efficiency figures typically provide the net efficiency (assumes that the latent heat energy in the flue gas cannot be captured). As the fuel used for the boiler is quantified/billed based on the gross calorific value it is important to use the gross boiler efficiency when converting the fuel demand into a heat demand. To calculate the gross efficiency, you would typically multiply the net efficiency by 0.9 for gas or oil.

$$\boldsymbol{Gross\ Boiler\ Efficiency = Net\ Boiler\ Efficiency \times 0.9}$$

$$\boldsymbol{Heat\ Demand = Fuel\ Demand \times Gross\ Boiler\ Efficiency}$$

6.1.2.2 Heat Demands from Modelling

In the absence of metered consumption or billing data, it is common practice to use building models (developed to indicate compliance with Part L of the building regulations e.g. DEAP or NEAP based models) to estimate heat demand. It is worth noting that the demands calculated using these models are theoretical and may not match the buildings actual heat consumption. It is also worth noting that these models calculate the heat demand rather than the fuel demand so there is no need to convert these demand figures using boiler efficiency.

6.1.3 Heat Demands of Existing Buildings in the Future

The difference between theoretical demand and actual demand (commonly referred to as the performance gap) is a phenomenon that is worth bearing in mind when considering the use of demands developed from building energy models in DEAP and NEAP. Analysis of the performance gap in residential dwellings, Aydin et al[15] compared theoretical consumption (based on that expected from the Building Energy Rating certificate) to actual consumption (based on metered gas consumption) for 710,000 buildings in the Netherlands. The results of this study show that expected demand reductions from retrofitting dwellings were 26.7 % less than expected among homeowners, and 41.3 % among tenants.

A study conducted in the Netherlands by Visscher, H., & Meijer, F. (2016)[16], which compared metered gas consumption with Energy Performance Certificates' (EPCs) theoretical consumption shows that buildings with higher ratings typically consume more energy for heating than expected and those with poorer rating typically consume less. This analysis is shown in Figure 13 below. Further research by University of Cambridge[17] that demand reductions made by upgrading insulation in walls and roofs generally last only for 2-4 years before changes in occupant behaviour etc. brings heat demand back to its original levels. This rebound effect could be considered when assessing future heat demands.

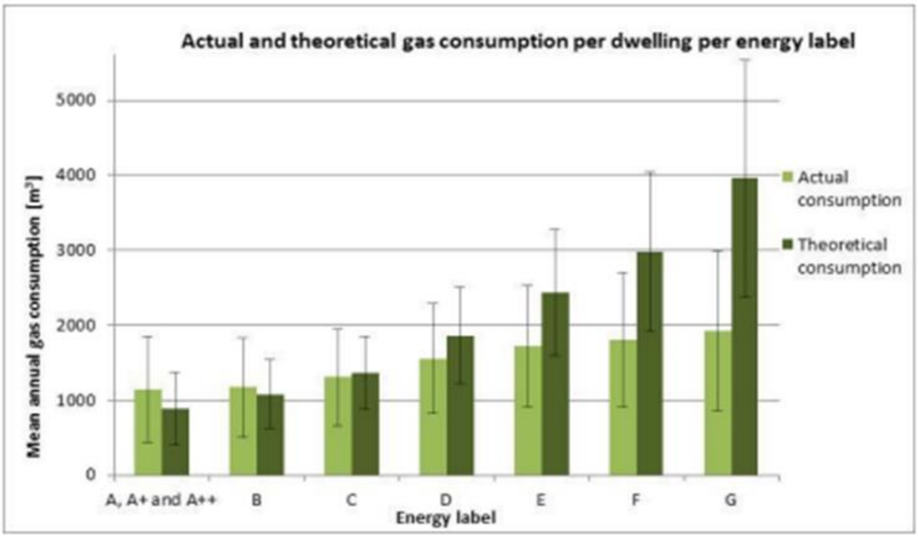

Figure 13: Performance Gap Between Theoretical and Actual Heat Demand[18]

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[15] Aydin, E., Brounen, D. and Kok, N., 2013. The Rebound Effect in Residential Heating. https://www.tilburguniversity.edu/sites/tiu/files/download/The%20Rebound%20Effect_EA300813.pdf

[16] Visscher, H., & Meijer, F. (2016). Energy regulations for housing and the performance gap. In K. Kähkönen, & M. Keinänen (Eds.), Proceedings of the CIB World Building Congress 2016: Volume I - Creating built environments of new opportunities (pp. 795-805). (Tampere University of Technology. Department of Civil Engineering. Construction Management and Economics. Report). Tampere University of Technology.

[17] University of Cambridge, Insulation only provides short-term reduction in household gas consumption (2023): https://www.cam.ac.uk/research/news/insulation-only-provides-short-term-reduction-in-household-gas-consumption-study-of-uk-housing

[18] Visscher, H., & Meijer, F. (2016). Energy regulations for housing and the performance gap. In K. Kähkönen, & M. Keinänen (Eds.), Proceedings of the CIB World Building Congress 2016: Volume I - Creating built environments of new opportunities (pp. 795-805). (Tampere University of Technology. Department of Civil Engineering. Construction Management and Economics. Report). Tampere University of Technology.

6.1.4 Heat Demand from Benchmarks

In some cases, you may only have floor areas from which to calculate a heat demand from. In this instance the floor area can be multiplied by fuel consumption benchmarks to estimate fuel demand. This can then be converted to heat demand using an assumed boiler efficiency. There are several documents developed by CIBSE which can be used to calculate the annual heat demand. As these guides generally normalised for UK climate these will need to be degree-day corrected using local degree day figures (using 15.5 degrees Celsius reference temperature).

RESOURCES & TOOLS:
The following documents can used for calculating fuel consumption from floor area:

- CIBSE TM46
- CIBSE Guide F
- CIBSE Energy Benchmarking Dashboard

To convert the fuel demands into heat demands you will need to apply an efficiency as stated in the sections above.

These benchmarks are UK benchmarks (assuming an average of 2021 degree days in the case of TM46) and therefore the space heating proportion of the demand (referred to as the dependent fraction) will need to be degree day corrected for the location of the building. Local degree days can be found at https://www.degreedays.net/. A tool to help with degree day correction can be found in the feasibility study tools folder which accompanies this guide.

The CSO have also recently linked domestic BER data with actual gas consumption data from GNI to develop indicative gas consumption benchmarks by type of dwelling and by BER rating. As these benchmarks are based on actual gas demand it could be considered a higher quality resource than the DEAP models (as it includes for any performance gap as discussed in section 6.1.3), however, the fact that this information does not consider the specifics of an individual building means that this assumption is not definitive.

RESOURCES & TOOLS:
The CSO have linked domestic BER data with actual gas consumption data from GNI to develop indicative gas consumption benchmarks by type of dwelling and by BER rating. These can be found here https://www.cso.ie/en/releasesandpublications/ep/p-dberngs/householdgasconsumptionbybuildingenergyratings2022/

6.1.5 Heat Demands for Future Planned Developments

For new developments heat demands can be estimated using typical estimated demands from similar DEAP or NEAP models or using metered data for similar buildings (same type and construction – relating to the same iteration of Part L of the Building regulations. Table 8 below provides a description of the possible methods to use for future residential and commercial buildings along with some indicative figures to indicate the order of magnitude of heat demand we might expect from such developments.

Table 8: Indicative Heat Demand for Planned Buildings

Building Type & Unit	Possible Methods for Estimating Future Heat Demand	Sense-check Metric
Residential	DEAP calculations for specific development – required for Part L compliance and considering the possible performance gap Metered or DEAP analysis of similar (same type and subject to the same building regs) existing buildings	nZEB apartments of average size are generally in the region of 3.5MWh/annum per apartment. This could be slightly higher when considering the possible performance gap
Commercial Buildings	Benchmarks demand with an assumed reduction due to greater efficiency standards and considering the possible performance gap where possible. NEAP modelled heat demand and considering the possible performance gap	

6.1.6 How to Calculate Peak Heat Demand

Calculating the peak demand is a very important step as this is what will be used to calculate the required capacity for the customer substation and the size of the network (which is a function of the peak demand and temperature difference between the flow and return, known as the ΔT). It also allows for an estimate of the peak demand for the whole network which is used for determining the size/capacity of the heating plant required in the energy centre.

6.1.6.1 Methods of calculating peak demand

The best way to measure the peak demand is to look at the metered heat demand profile. If heat consumption is not metered you can also look at the metered fuel consumption and convert this to heat using the boiler efficiency (or an estimate of the boiler efficiency). This can also be sense-checked against the installed capacity of the heating plant on site in case of any anomalies in the data.

TIP: In order to get an accurate representation of the peak heat demand the granularity of this meter data should preferably be hourly meter data or sub-hourly data. However sub-hourly data can sometimes give artificially high peaks during start-up periods due to inertia in the secondary system (where return temperatures remain low as the heat works its way around the circuit)

For existing buildings that do not have metered data at the required granularity, the most common way to estimate the peak is to inspect the plant that is already installed to determine its capacity in kW. When doing this it is vital that the operation strategy of the heating plant is considered as some of the boilers installed are likely to be for backup/standby and should not be counted when estimating the maximum capacity (peak demand) required. It is also worth bearing in mind that boilers are typically oversized and in practice the actual peak demand may be significantly lower than the installed capacity. This is why metered data is a preferred option, whenever available.

RESOURCES & TOOLS:
For estimating peak demands BSRIA BG9/2011: Rules of Thumb Guidelines for Building Services 5th Edition can be used. These estimates combined with diversity factors, where necessary, can allow peak demands to be estimated. See diversity calculator tool in the feasibility study tools folder which accompanies this guide.

A rule-of-thumb method for quickly estimating the peak demand of a building when other methods are not possible is to convert the annual heat demand (MWh) into a peak using assumed typical full load equivalent hours (FLEQ). These equivalent hours represent the relationship between the peak and the annual demand for different types of buildings. The table 9 below sets out some typical values to help estimate peaks. For building types not shown in the table it may be reasonable to assume that the FLEQ of 2,000 hours can be used.

Table 9: Example Full Load Equivalent (FLEQ) Hours Used for Estimating Peak Demand

Building Type	Typical Full Load Equivalent Hours
Residential	2000
Commercial	1800
Hospital	3000
Hotel	2800

To estimate the peak demand the annual heat consumption can be divided by the full load equivalent hours (FLEQ). The table above provides indicative FLEQ figures. If the annual consumption is in MWh, then the resulting peak will be in MW. If the annual consumption is in kWh, then the resulting peak will be in kW.

6.1.6.2 Diversification

Diversity (a.k.a. Coincidence) factor result from customers not requiring their respective maximum capacity heat demands at the same time. Each consumer's use of heat is partially random, and this particularly manifests in the use of hot water (DHW). Space heat demands on the other hand are related to the physical heat flows in buildings which change due to outdoor temperature variation. Space heat demands are not always synchronised and there are random deviations, but there is higher coincidence since cold spells will affect all consumers at the same time and systems run for longer durations increasing the likelihood of overlap. The coincidence factor for domestic space heating is therefore a lot larger than for domestic hot water. Diversity (coincidence) factors for domestic DHW and SH can be seen in Figure 14. The diversity factor associated with DHW (blue line) comes from the Danish standard DS439. The diversity factor associated with the space heating demand comes from CIBSE CP1 2020 (District Heating Code of Practice).

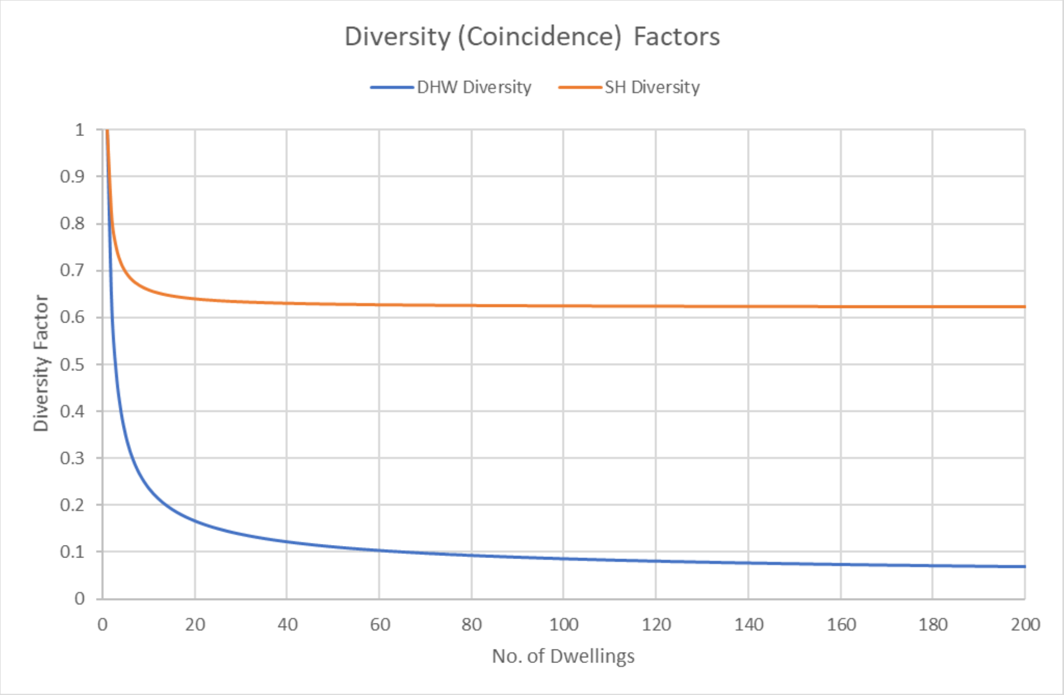

Figure 14: DHW and Space Heating Diversity Factors per No. of Dwellings (Source: Codema Image based on methodology from Danish Standard DS439 and CIBSE CP1 2020)

The resulting peak SH demand per flat should be sense-checked against the figure of approximately 3kW per flat for a scheme of more than 200 dwellings as assumed for peak space heating in the Code of Practice. The BSRIA Bluebook also provides some rules of thumb for peak heat demands prior to applying diversification.

RESOURCES & TOOLS: The tools which accompany this report provide an automated calculation of diversified peak demand based on number of apartments using the curves outlined in Figure 14.

6.1.7 Mapping Heat Demands & Anchor Loads

These heat demands can be added to a Geographic Information System (GIS) map to visualise their location and relative size (MWh per annum). GIS maps can also allow the proposed pipe network routes to be drawn to help with stakeholder engagement and also to allow the lengths of pipe required to be calculated automatically (see Figure 15 for example).

RESOURCES & TOOLS: Certain organisations may already have access to GIS software such as ArcGIS which can be used for mapping purposes. If this is not available free open-source GIS software is also available. One of the most popular open-source GIS tools is Quantum GIS (also known as QGIS). This can be downloaded for free from the following website https://www.qgis.org/en/site/forusers/download.html

During this mapping process it is also important to identify anchor loads. These are loads that are of significant size (The general threshold is often considered to be between 100MWh and 300MWh heat demand per annum) and generally have a high likelihood of connection (due to them being public sector buildings with decarbonisation objectives or through displaying a clear intent to connect to the network during stakeholder engagement meetings – preferably supported through a signed letter of intent[19]) will help inform your network route.

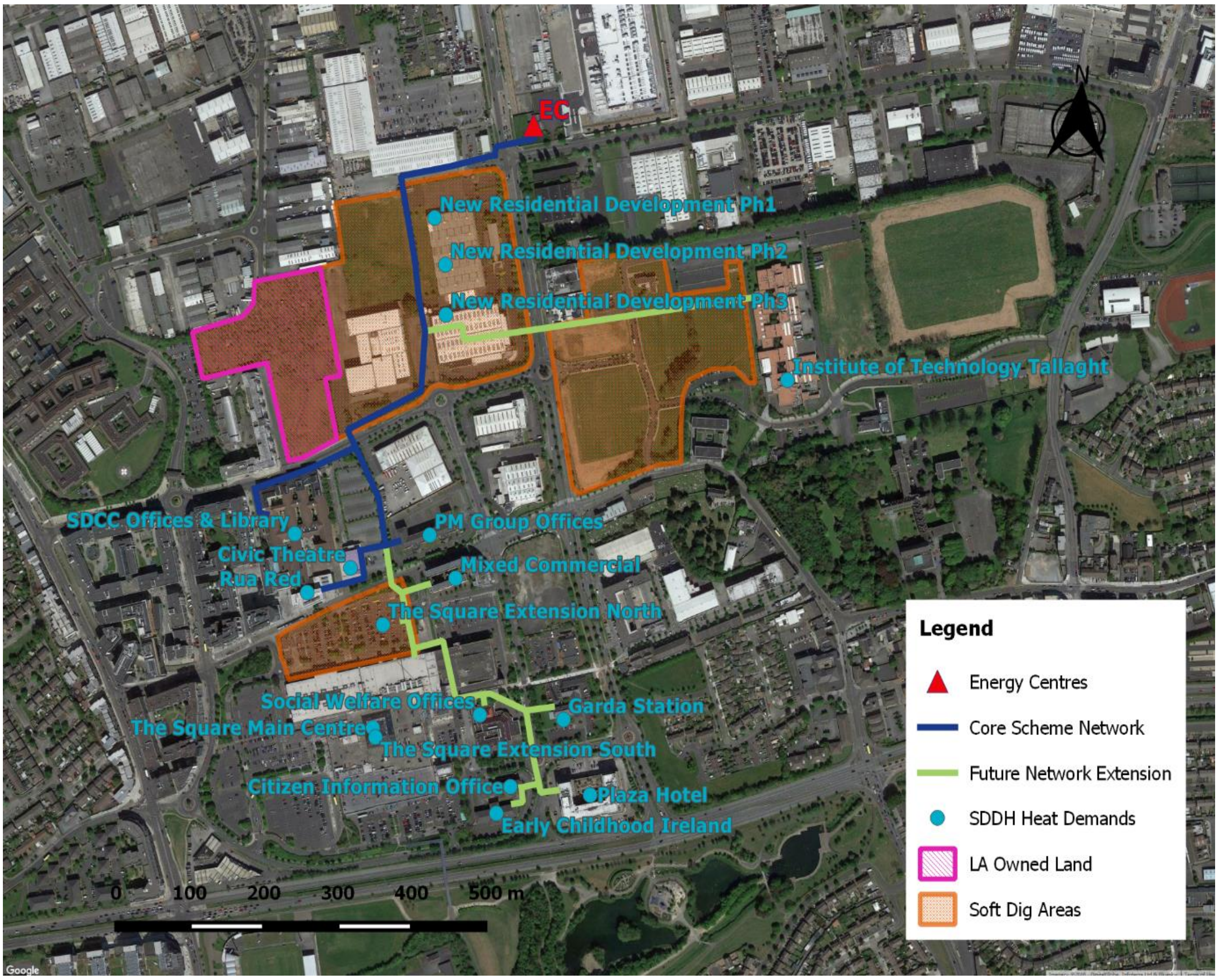

Figure 15: Example Heat Demand and Network Route Map from the Tallaght District Heating Scheme (Source: Codema)

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[19] See draft letter of intent in Appendix B

TIP: These maps are also a useful resource when it comes to sharing details (within the project team) of buildings which might potentially connect to the network. Where available, this may include useful information such as:

- Name - Name of company or organisation
- Annual demand (MWh/a)
- Peak demand (MW)
- Basis for peak demand estimate (e.g. capacity of boilers assuming duty stand-by, assuming equivalent run hours of 2,000 per annum, etc.)
- Use Type (e.g. residential, office, etc.)
- Public/Private building?
- Heating System (e.g. gas boiler with radiators and hot water tank, electric storage heating, etc.)
- Year Current Heating System was Installed (if known)
- Building Heating System Design Flow and Return Temperatures (e.g. 82/71°C)
- Level of Interest/Engagement (rate from 1 to 5, with 5 being highly interested)
- Assumed year of connection to DH
- Hyperlink to stakeholder folder where further building data and meeting notes are saved
- Decision maker contact details (Name, role, email address of person who has the power to decide to connect to the network)
- Technical data supplier contact details (name, role, email address of person who has access/knowledge of the current heating system and billing/metering information)
- Date info last updated.

6.1.1 Impact from Future Policies/Heat Demands Decreasing in Time.

The thermal demand evaluation should also consider future heat demands, incorporating effects of urban development, policy changes, or technology advances.

6.1.2 Renewable Energy Integration

The thermal demand evaluation should also consider potential integration of renewable energy sources into heat demand calculations, including potential impacts on reducing peak loads and overall energy demand. For example, the inclusion of the impact of solar water panels in dwellings decreasing the domestic solar water load.

6.1.3 Sensitivity Analysis

It may be advisable to conduct sensitivity analyses to validate heat demand forecasts, including variable considerations to ensure robust network design.

6.2 Operating Temperature Analysis

Operating temperature outputs:

- Assumed operating temperatures for proposed DH network – which will inform the pipe network sizing, thermal store volume and the network efficiency assumptions.
- Description of reasoning for this – temperature requirement of heating systems connecting, impact of temperatures on DH system efficiency, etc.
- Optional - Commentary on potential savings from optimising operating temperatures.

Operating temperatures are an important consideration when carrying out the network design for the techno-economic analysis as these have an impact on the size of pipes required to serve the heat demand as well as heat losses and pumping requirements. The temperature requirement (max flow temperature) for the DH network will be set by the building connecting to the network that has the highest temperature requirement for its secondary heating system, unless localised boosting of the temperature is envisaged. There will be further opportunity to optimise the temperature regime at detailed design stage and indeed over the operational life of the network but certain reasonable assumptions need to be made at this point in order to size pipes and equipment, and make reasonable efficiency assumptions for heat production (particularly if using heat pumps).

It should be noted that typically an additional 3-5°C would be added on top of the customers secondary heating system temperature requirement for the DH network where an indirect configuration (i.e. a hydraulic break between the water in the DH network and the water in the buildings own secondary heating system, in the form of a heat exchanger/substation) is expected due to the temperature drop across this hydraulic break. For example, if the max temperature requirement for all buildings connecting to the network is 80°C then the DH network flow temperature would need to be 85°C. Similarly, the return temperatures in the DH network would also be 3-5°C higher than those of the buildings secondary system.

6.2.1 Typical Design Temperature for Building Types

Most space heating systems in existing buildings (which traditionally would have operated using an 82/71 temperature regime, see Table 10) can be rebalanced to operate on a 80°C flow and 60°C return temperature regime. When the network is planned to serve such buildings, it is reasonable to assume a DH network flow temperature of 85°C and return temp of 65°C for the pipework serving these connections. For network pipes that serve multiple buildings the weighted average return temperatures (VWART) (average return temperature weighted by volume of water going to each connection) are used to inform pipe capacities/sizing and efficiency assumptions.

Table 10: Preferred Design Temperatures for New and Replacement Secondary Heating Systems[20]

Building /System Type	Max Building Secondary System Flow/Return Temps (° C)	Comment
Rebalanced Traditional 82/71 Systems	80/60	Change if operating temps possible due to general oversizing of rads and especially where fabric upgrades have occurred since heating system install
Radiators	70/40	For direct connections to DH network. In operation higher flow temp may be used once radiator return is

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[20] From CIBSE CP1 (2020), *"CP1 Heat networks: Code of Practice for the UK"*

Building /System Type	Max Building Secondary System Flow/Return Temps (° C)	Comment
		less than 40C
Fann Coil Units	60/40	
Air Handling Units	60/40	
Instantaneous DHW (DH side of HEX)	70/25	Please note that DHW low-volume instantaneous systems (less than 15 litres from HIU to Kitchen tap) can supply at a temperature of 55°C without concerns over legionella[21]
DHW Cylinder with Coil (DH side)	70/45	Return temperatures will be greater than 45° C most of the time as heating up from cold rarely occurs
DHW Calorifier with External Plate HEX (DH side)	70/25	Centralised calorifier generally designed to store water at 60°C with min recirc temp of 55°C. Typically 70°C flow temp needed
Underfloor Heating	45/35	

6.2.2 Operating Temperature Optimisation

While not being a firm requirement during the feasibility stage, it may provide further value to the feasibility report to include some analysis on optimal operating temperatures for the network. This would consider the life cycle cost of changing the operating temperatures within the allowable range whilst maintaining a good level of service to all customers. Such an analysis could consider the following over the life cycle of the network and compare the potential savings against the cost of making changes to facilitate using a lower normal operating supply temperatures or higher peak demand flow temperatures to ensure a well-functioning system:

- Heat losses
- Pipes size/insulation/suitable construction and associated costs (CAPEX, OPEX)
- System efficiency (on heat production depending on source and on pumping)
- Additional capacity to connect further demand through same pipe in the future

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[21] - https://www.cibse.org/knowledge-research/knowledge-portal/guidance-note-domestic-hot-water-temperatures-from-instantaneous-heat-interface-units

7 Initial Assessment of Energy Supply options (network and plant options).

This section guides the process of identifying and evaluating potential energy sources for the district heating network, ensuring a strategic approach to sustainable and efficient energy management.

From a longlisting of options identify a short listing of best options: The steps described begin with a comprehensive list of viable heat sources based on proximity, capacity, and other essential factors. These sources are then methodically shortlisted through a rigorous assessment of their feasibility, cost-effectiveness, and alignment with environmental and operational criteria. The objective is to select the most promising options that not only meet the current energy demands but are also adaptable to future expansions and changes, thereby ensuring long-term sustainability and efficiency of the network.

This initial shortlisting assessment of DH options paves the way for a detailed techno-economic analysis, described in the following chapters. This analysis ensures that the chosen solutions are practical and beneficial for both the community and the environment.

The process of identifying a preferred heat source from the different supply options is performed using the steps set out in Figure 16 below.

Figure 16: Outline Process to identify 1) an initial long list of options, perform a qualitative analysis on the longlist and b) identify as a result, a shortlist of heat sources.

7.1 Identification of a Long list of Supply Options

Long List of Energy Supply Options outputs:

- Longlist completed in Table 5 of template (Completed example shown below in Table 11).

As district heating networks are technology agnostic there are many ways in which heat can be supplied to the network. Figure 17 below outlines some of the heat sources available within the Irish context that can be utilised by DH networks.

This graph also indicates the typical temperature range these heat sources could be available at (on the left-hand side of the graph) and whether or not a heat pump might be required to raise their temperature to serve different customer temperature requirements (shown on the right-hand side of the graph). On the left-hand side of the graph the heat pump efficiency (coefficient of performance) is shown when raising the source temperature to either 60°C or 80°C, which are common supply temperature ranges for DH networks which utilise heat pumps. This supply temperature will be driven by the end use temperature requirements of the DH customers. It should also be noted that the temperature requirement for each end use will have to be increased by typically 3 - 5°C for every hydraulic break between the source and the end use (e.g. heat exchangers, HIUs). Temperature requirements are discussed in greater detail in Section 6.2.

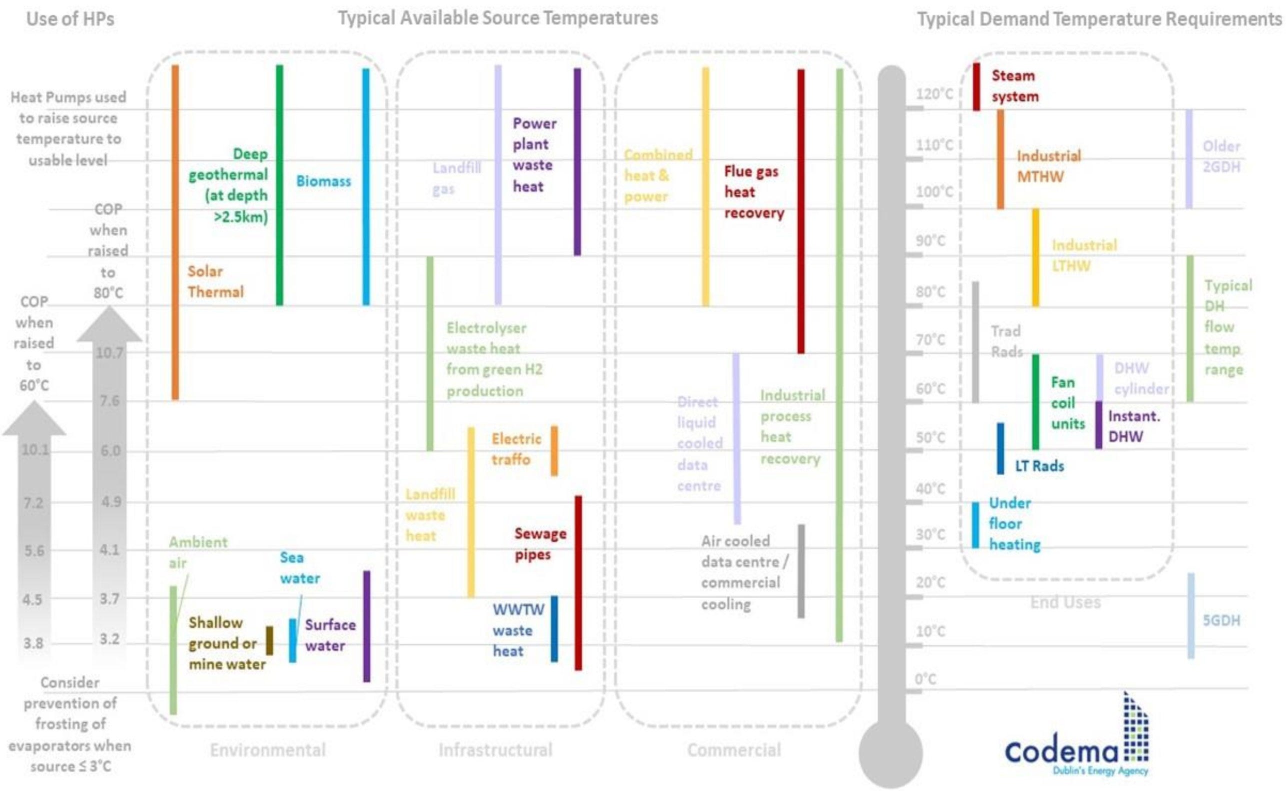

Figure 17: Typical Temperature Ranges for Heat Sources and Temperature Requirements for End Use

It is recommended that where possible local knowledge is used to determine whether there is space available for new heat production plant (ASHPs, solar thermal, etc.) within existing buildings or on existing sites or if waste heat sources (data centres, industrial sites, power plants, wastewater, etc.) exist or are planned to exist in the vicinity of the proposed DH network. The heat production cost data which supports this guide also includes indicative space requirements for different types of plant.

The first step is to identify a longlist of heat sources. This step mainly focuses on the proximity of the heat source to the network (typically within 2-5km but could be further away when supplying at high temperature or high volumes of heat) but where possible may also consider the capacity of the heat source.

Capacity will also be important if this source is to be the primary means of supplying heat to your proposed network. Typically, a heat source that has high availability (is available to offtake heat for most of the year) can have a capacity that is approximately 25-30% of the peak demand and still provide the majority of the heat demand when used in conjunction with thermal storage.

Therefore, any heat source above this capacity level should not be excluded from the long list. In case where there is an abundance of heat sources or plans for future network expansion, heat sources with higher capacities should be prioritised. The temperature of the heat source is the third factor which may be used for limiting the list of heat sources. In this case the higher the temperature the existing heat source the better as this means higher efficiency of heat production for the network.

Summary of long list of supply options selection criteria

Table 11: Longlist Criteria and Method of Assessment (See Table 12 for a completed example).

Criteria	Description	Method of Assessment
Proximity to Network	Distance from the heat source to the network. Preferably close proximity of the network (2-5km),	Mapping tools, GIS data
Heat Capacity (MW)	Capacity of the source to meet network demands	Calculation based on network load profiles
Source Temperature (°C)	Operational temperature range of the source	Technical data from source providers
Regulatory Compliance	Compliance with environmental and energy regulations	Review of local and national regulations
Infrastructure Retrofitting	Feasibility of integrating with existing infrastructure	Technical feasibility studies
Scalability	Potential to increase capacity to meet future demands	Forecasting models, growth scenarios
Climatic Suitability	Efficiency under local weather conditions	Historical climate data analysis
Space Required for Installation	Assesses feasibility within the available space.	
Socio-economic Impact	Effects on local job creation, energy costs, community acceptance	Socio-economic impact assessments

7.1.1 Identifying Local Heat Sources

This section of the guide sets out how one might go about identifying local heat sources for a proposed DH network.

7.1.1.1 Online Maps Identifying Heat Sources in Ireland

Some online heat source maps already exist and can quantify some of the heat sources already identified in an area. These include:

- SEAI District Heating Candidate Area Map - https://gis.seai.ie/districtheating/
- IrDEA Heat Atlas - https://districtenergy.ie/HeatAtlas
- Codema Dublin Heat Source Map - https://codema-dev.github.io/map/heat-source-map/
- The European Waste Heat Map (REUse Heat[22] and sEEnergies[23] Combined Map) - https://aau.maps.arcgis.com/apps/webappviewer/index.html?id=789b7faef30148bda20d320de9455919

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[22] https://www.euroheat.org/dhc/eu-projects/re-use-heat

[23] https://www.seenergies.eu/

- GSI Geothermal Suitability Map - https://www.gsi.ie/en-ie/programmes-and-projects/geothermal/projects/Pages/Shallow-geothermal-energy.aspx

Possible Heat Source Types Which May Not be Included in Existing Online Maps

The heat source maps above do not provide an exhaustive list of heat source across the country so therefore it may be necessary to identify and quantify local heat sources based on local knowledge and data. The list of possible sources outlined below can be used as a checklist to help identify these possible local heat sources. Further information on what each of these sources are and how they can be quantified can be found in Appendix B of the Appendices accompanying this How to Guide.

Commercial Sources:

- Flue gas heat recovery
- Industrial process heat recovery
- Commercial CHP excess heat
- Excess heat from existing biomass installations
- Commercial building cooling system waste heat (e.g. data centres, cold storage facilities, supermarkets)

Infrastructural Sources:

- Power plant waste heat (EfW and conventional power stations)
- Electrical transformer waste heat
- Landfill waste heat
- Landfill biogas
- WWTW waste heat
- WWTW biogas/sludge incineration
- Sewage pipe waste heat
- Waste heat from metro line

Environmental Sources:

- Air-source heat pumps
- Surface water (rivers, lakes, canals)
- Seawater
- Ground source heat pumps (shallow)
- Deep geothermal
- Mine water
- Solar Thermal

Table 12: An example of a completed Supply Option Longlist Comparison Table.

Criteria	Option 1	Option 2	…	Option n (*)
Description	Geothermal resource @2km depth using electric heat pumps	Waste heat taken from waste water		Heat pump using ambient air
Proximity to Network	0km	2km		0km
Heat Capacity	6.5MW	30MW		15MW due to space constraints
Source Temperature	60 °C	10-20°C		~10°C
Regulatory Compliance	High (meets all local environmental standards)	Moderate (some issues with waste management)		High (low emissions and energy efficient)
Infrastructure Retrofitting	Minimal (existing infrastructure supports integration)	Significant (requires new pipelines and pumps)		Moderate (some adjustments to existing systems)
Scalability	High (potential for expansion with more pumps)	Low (limited by availability of wastewater)		High (easily scaled with additional heat pumps)
Climatic Suitability	Excellent (consistent performance year-round)	Good (performance varies with wastewater flow)		Fair (efficiency drops in colder temperatures)
Socio-economic Impact	Positive (creates jobs in maintenance and monitoring)	Mixed (low job creation, but benefits waste management)		Positive (reduces energy costs, popular in community)

(*) n number of options, typically 6 to 10
Table 6 in the Feasibility Study Template needs to be completed similarly. (See Table 11 for a description)

7.1.2 Determining Heat Capacity

The first question this section aims to address is; is this heat source big enough to build a heat network around? Typically, new DH networks would look for a primary heat source that could cover a significant proportion of the heat demand, generally a heat source that has a heat supply to the network that equates to more than 25-30% of the peak demand would be able to supply a significant proportion of the heat demand.

The fundamental equation used for calculating the capacity of a heat source is Q=m.Cp.dT. Where Q is the capacity in kW, 'm' is the mass flow rate in kilograms per second (kg/s), Cp is the specific heat capacity of the liquid (typically water or air) in kJ/kg° C, and dT is the temperature difference in degrees Celsius (° C) of the heat source before and after the heat is extracted from it.

It is important to note that in the case of heat pumps this heat supply capacity would be the heat available from the heat source plus that from the electricity supply e.g. with a CoP of 3 the total heat supply to the network would be 3/2 or 1.5 times that of the heat source capacity. This is illustrated in Figure 18 below.

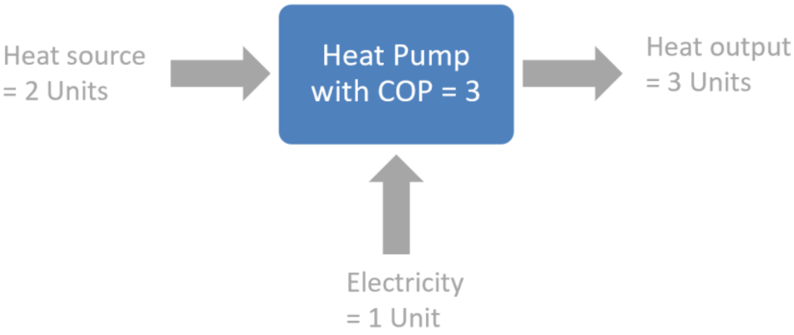

Figure 18: Illustration of Increase of Heat Output Capacity vs Heat Source Capacity when using Heat Pumps.

7.1.3 Heat Source Proximity to the Network

Another key question is in relation to proximity, how close does a heat source have to be to be viable? The viable distance will vary by the cost of heat production (generally a function of source temperature/efficiency of production and heat capture/recovery cost), and the quantity of heat that will be utilised in the network (i.e. how much heat is available from the source and how much demand will be connected to the heat network). As this is the early stage of the DH project there is uncertainty about the final quantity of heat that would be transported and therefore, we are assuming that any heat source that is within 5km of the study area could be considered in this analysis. The optimal heat source location would be in the centre of the heat network as this would reduce the size of pipework needed and pumping required to bring the heat from one side of the area to the other. It should also be noted that heat sources that are greater than 5km from the network may also be viable particularly if supplying at high temperature or supplying high volumes of heat.

7.1.4 Heat Source Temperature

This is the main indicator of the quality of the heat source and has a direct impact on heat production cost. Figure 17 provides indicative heat source temperature for various types of heat source. In the case of deep geothermal the temperature available will depend on the depth from which the heat is extracted. The deep geothermal source temperature would typically increase by somewhere in the region of 30° C per km depth.

7.1.5 Regulatory Compliance

This analysis aims to understand and adhere to environmental and energy regulations that impact project feasibility. A review of compliance issues and regulatory requirements should be conducted to ensure that any proposed heat sources meet current standards and contribute positively to sustainability goals.

7.1.6 Infrastructure Retrofitting

If current systems are in situ and require retrofitting, this section evaluates the feasibility of retrofitting those to accommodate new DH technologies. Case studies and practical guidelines can help illustrate how to effectively integrate new heat sources, while addressing potential obstacles.

7.1.7 Scalability

Scalability is important for the long-term success of district heating networks. As demand grows or changes, the system should have the capacity to expand and adapt without significant disruptions. Planning for scalability involves assessing potential future needs and ensuring that the network can be modified or enlarged to meet these demands efficiently.

7.1.8 Climatic Suitability

This analysis considers how different heat sources perform under various climatic scenarios to ensure efficient operation. Factors such as temperature variability, humidity levels, and seasonal changes need to be considered to select the most effective and reliable heat source for the area. For example, in Ireland the moderate climate with relatively mild winters and lack of extreme cold makes some types of district heating systems climatically suitable, especially in urban areas where the heat demand is concentrated.

7.1.9 Space required for installation.

To assess the space required for an energy centre, start by inventorying necessary equipment and determining their specifications and layout needs. Evaluate current and future heating demands, allowing for scalability and redundancy. Ensure compliance with local building codes, safety regulations, and zoning laws, and consider utility connections and ventilation requirements. Plan for operational efficiency by ensuring sufficient space for maintenance and workflow, and account for environmental impacts like noise and emissions. Finally, assess the available land and its suitability for the energy centre.

7.1.10 Socio-economic Impact

Selecting a heat source goes beyond technical and environmental considerations; it also has broad socio-economic implications. The impact on local job creation, energy costs, and public perception could also be valued at this stage. An assessment could be conducted to understand how different heat sources can affect the local economy and community, providing a comprehensive view of the potential benefits and challenges associated with each option.

7.2 Identifying a Shortlist of Potential Heat Sources (from the long list of options)

This second phase refines the selection of potential heat sources by narrowing down the initial long list of potentially 5 to 15 options to a more focused shortlist of 3-6 candidates. This selection is guided by specific criteria outlined in Table 6 of the DH Feasibility Template report, aiming to meet the complex requirements of a modern District Heating (DH) system effectively. The input to this analysis is the longlist table (e.g Table 12) and the outputs are a shortlist (eg. Table 13)

Shortlist of Energy Supply Options outputs:

- Shortlist of potential options identified from Table 6 in template.

7.2.1 Explanation of Qualitative Criteria for Shortlisting

The following sections provide a brief explanation of the qualitive criteria to be assessed in the supply options shortlist comparison table (Table 7 of the accompanying template).

7.2.1.1 Type of Heat Source & Carbon Content of the Heat

A key criterion for shortlisting heat sources is their alignment with the definitions of an 'Efficient District Heating and Cooling System' as per Article 26 of the Energy Efficiency Directive. This involves assessing whether the heat source primarily utilizes renewable or waste heat and evaluating its carbon intensity (gCO2/kWh). The evaluation also considers prospective changes in the carbon content of the energy mix to ensure future compliance with environmental standards.

7.2.1.2 Cost of Heat Production

The economic feasibility of each heat source is assessed by examining the costs associated with heat production, including fuel prices, operational timing influenced by energy models, system efficiency, carbon taxation, and available financial aids like grants. These assessments utilize both financial modelling (e.g, NPV) and life-cycle cost analyses to ensure thorough cost-effectiveness evaluation.

7.2.1.3 Heat Source Capital Cost

Capital cost considerations are crucial as they can pose significant barriers to project development. The analysis includes reviewing potential grants and funding opportunities that can mitigate initial financial burdens, such as those provided by the Support Scheme for Renewable Heat (SSRH).

RESOURCES & TOOLS: Space requirements, expected lifespans and costs for different technologies can be found in the latest technology catalogue for district heating from the Danish Energy Agency: https://ens.dk/en/our-services/projections-and-models/technology-data/technology-data-generation-electricity-and

7.2.1.4 Lifespan of the Heat Source & Associated Equipment

Evaluating the operational longevity of both the heat source and its related equipment is vital. This criterion considers the expected operational duration relative to the potential return on investment, particularly for heat sources that may not be viable long-term due to operational or industrial changes.

7.2.1.5 Availability of Heat Source

The availability of the heat source throughout the year and its reliability during peak times are assessed to ensure consistent heat supply. This is especially critical for sources that depend on fluctuating industrial activities or intermittent processes.

7.2.1.6 Price Stability

Market fluctuations in fuel prices can impact the long-term viability of heat sources. This criterion examines the historical and projected stability of fuel prices to mitigate financial risks associated with volatile energy markets.

7.2.1.7 Heat Owner Engagement

Engagement levels of the heat source owners are evaluated early in the process to determine their willingness and ability to contribute to the DH network, which is crucial for ensuring project feasibility and timeline adherence.

7.2.1.8 Planning and Environmental Considerations

Planning permissions and environmental impacts are assessed to identify potential project barriers. This includes evaluating the environmental credentials of each heat source and their compatibility with local planning regulations.

7.2.1.9 Technology Readiness Level (TRL)

The maturity and reliability of the technology used for each heat source are scrutinized to ensure they are proven and dependable for sustainable DH operations.

7.2.1.10 Assessing Potential Energy Centre Locations

The feasibility of potential locations for energy centres is analysed based on their proximity to the heat sources and the logistical and infrastructural capabilities of these sites. This assessment also considers the land availability, accessibility for construction, operational maintenance, and the potential for future expansions.

This comprehensive evaluation ensures that the selected heat sources not only meet technical and economic standards but are also capable of integrating seamlessly into the planned DH infrastructure while aligning with broader environmental and regulatory frameworks.

RESOURCES & TOOLS: A desktop analysis of publicly owned land can be performed using online state land database maps https://lda.ie/public-lands/register-of-relevant-lands/map

RESOURCES & TOOLS: Space requirements, expected lifespans and costs for different technologies can be found in the latest technology catalogue for district heating from the Danish Energy Agency: https://ens.dk/en/our-services/projections-and-models/technology-data/technology-data-generation-electricity-and

7.2.2 Shortlisting Example

This section outlines how to apply the previously outlined criteria (Section 7.2.1) to the longlist in order to create a shortlist of potential heat sources for a theoretical District Heating (DH) network. An example is shown which evaluates three initial options identified from a long list of DH heat supply option (example shown in Table 12): geothermal, waste heat, and solar thermal. Typically, a long list of options may include more options but for simplicity this example only shows three options.

Table 13, referred to as the **Heat Source Shortlisted Appraisal Example**, presents a comparative analysis based on the criteria from Section 7.2.1. Mirroring Table 7 of the feasibility study template, it assesses the characteristics and suitability of various heat sources for inclusion in a district heating network. As a result of this appraisal, two options were shortlisted, the rationale is provided in the following section.

Table 13: Example of a completed Heat Source Short Listed Appraisal from a long list of options

Criteria	Description	Long list option 1 Geothermal	Long list option 2 Waste Heat	Long list options 3 Solar Thermal	Long list option n
General Description	Brief overview of each option	Deep geothermal energy from natural reservoirs	Recovered heat from local industrial processes	Solar collectors converting sunlight to heat	
Proximity to Network (m)	Distance from the energy source to the network	500m	300m	1000m	

Criteria	Description	Long list option 1 Geothermal	Long list option 2 Waste Heat	Long list options 3 Solar Thermal	Long list option n
Heat Capacity Available (MW)	Capacity to meet DH needs	20 MW	15 MW	10 MW	
Installation Cost (€/MW)	Initial setup cost	High cost due to drilling and infrastructure	Medium, utilizing existing industrial setups	High, requires large area for solar collectors	
Proportion of Heat Covered	Percentage of annual demand fulfilled	60%	50%	30%	
Availability & Access	Ease of accessing the heat source	High, consistent availability	Medium, depends on industrial activity	Low, weather-dependent	
Security of Supply	Reliability of heat source supply	High, stable source	Medium, depends on industrial production	Low, varies with solar availability	
Price Stability/Reliability	Economic stability of heat supply	High, geothermal energy is generally stable	Medium, can vary with industrial output	High, primarily initial investment then low operational cost	
Expected Lifespan	Operational lifespan of the heat source	30+ years	20+ years depending on the industry	25+ years	
Renewable/Waste Heat Source	Compliance with sustainability criteria	Yes, completely renewable	Yes, utilizes waste heat	Yes, entirely renewable	
Space Required for Installation	Space needed for setup	Medium, requires access to geothermal wells	Low, integrates with existing facilities	High, extensive area needed for panels	
Heat Owner Engagement	Willingness of heat source owner to cooperate	High, typically managed by energy companies	Variable, depends on industrial partners	High, generally positive public reception	
Adaptability to Local Conditions	Suitability to local geographic and climatic conditions	Good, especially in geothermally active areas	Good, if industrial heat is abundantly available	Moderate, best in areas with high solar incidence	
Flexibility for Future Expansion	Potential to scale the solution	Moderate, depends on geothermal potential	High, if additional industrial heat becomes available	High, additional panels can be installed	
Environmental Considerations	Impact on CO2 emissions, air quality, etc.	Low emissions, very environmentally friendly	Low if capturing otherwise wasted heat	None, clean energy source	
Planning Considerations	Land availability, permissions, grid connection requirements	Requires permissions for land use and drilling	Requires coordination with industries	Requires substantial land and solar rights	
Technology Readiness Level	Maturity of the technology used	Fully proven & operational	Fully proven & operational	Fully proven & operational	

7.2.2.1 Example Shortlisting of Preferred Options Following Qualitative Evaluation.

The selection of preferred options for the district heating system, as detailed in Table 13, can be finalised during a stakeholder meeting. Based on the appraisal previously discussed, this meeting facilitates a consensus on the best options to shortlist. For illustrative purposes, this section presents **two preferred options** selected from the initial list:

- **Geothermal**: This option is favoured for its reliability and minimal infrastructural impact. It offers a consistent heat supply and can utilise existing geothermal wells, which enhances stability in heat provision.
- **Waste Heat from Industrial Processes**: This option capitalises on the potential of industrial waste heat. It maximises resource efficiency and provides a sustainable heating solution.

These two shortlisted options have been chosen from the initial set of three (long-list) as examples of potential evaluations. It is important to note that different scenarios may present a more extensive list of long list (up to 10) narrowing to possibly 3 to 5 short list options.

8 Heat Distribution Systems

This section analyses the various route options for the shortlisted options (Chapter 7), to identify the preferred pipe network route for each option. The distribution network typically represents the largest capital cost for a DH project. It is therefore important to try and minimise this cost to ensure greater project viability. The main factors which influence the capital cost of the network are a) network route, b) type of pipework and c) size of pipework. A primary output of this section is a completed Table 15 (which corresponds to Table 8 in the template)

8.1 Pipe Network Route & Construction Assessment

Pipe Network Assessment Outputs:

- GIS maps of proposed routes analysed showing phasing where applicable.
- Table of loads connected to the network under each phase – please consider future expansion of network when sizing network where applicable.
- Assumptions around diversity applied to pipe network branches (serving multiple connections)
- Total trench length for each phase of network
- Required size of each length of network pipe to inform network costs – based on peak heat demand and network temperatures (max flow temp determined by highest temp requirement of building connecting unless being boosted locally – see operating temperature analysis in section 6.2.
- Preferred pipe network route – considering least cost and other practical considerations like recent road reinstatement, land ownership, etc.
- Preferred pipe construction based on lowest life cycle costs (capex, heat losses)
- Associated pumping requirement (pump head and flowrate required) and cost of pump set for preferred network route option.

RESOURCES & TOOLS:
GIS layers showing location of underground utilities is available from ESB and GNI using the following contact details.

- ESB - dig@esb.ie
- GNI - dig@gasnetworks.ie or register for a dial before you dig account here

- **The network route** - adopting the shortest possible route between anchor loads, minimising infrastructure crossings (with large roads, rivers, rail lines, etc.), minimising installation in areas congested with other underground utilities (GIS layers showing location of these are available from ESB, GNI, etc.), and making use of soft dig areas (green field and brown field) particularly on publicly-owned land (to reduce civils costs and minimise traffic disruption from laying pipes in roads)

TIP: It is recommended there where possible the DH development team should collaborate with other utility providers (water, gas, electricity, fibre-optic cables, etc.) to avail of any trench sharing opportunities.

- **The type of pipework** - material (steel, PE-X, etc. which also takes into account maximum available temperature and pressure rating of pipework), construction (single pairs, twin pipes, etc. which have different maximum diameters available), and level of insulation (series 1, 2 or 3 polyurethane insulation) all affect the cost of the pipework.
- **The size of pipework -** the larger the diameter of the pipe, the larger the pipe cost and the wider the trench required and the greater the likelihood of needing bends to avoid obstacles. However, some pipes may be oversized in the initial phase to accommodate future expansion and connection of further heat loads.

RESOURCES & TOOLS:
Certain organisations may already have access to GIS software such as ArcGIS which can be used for mapping purposes. If this is not available free open-source GIS software is also available. One of the most popular open-source GIS tools is Quantum GIS (also known as QGIS). This can be downloaded for free from the following website https://www.qgis.org/en/site/forusers/download.html

A number of different route options would typically be assessed to find a preferred route based on the lowest combined cost (including both capital cost and life-cycle costs such as heat losses). Engagement with local stakeholders such as the highways teams, planners or those responsible for installing other underground infrastructure can be very beneficial during this process, to avoid instances where roads would have to be dug up shortly after being reinstated[24], reduce the need for wayleaves on privately owned land (for installation & maintenance), minimise traffic disruption, minimising complex crossings of other existing or planned infrastructure and taking advantage of trench sharing opportunities, avoiding areas congested with other utilities or underground culverts. GIS mapping can be very useful for communicating the route options investigated to help gain feedback from key local stakeholders and can also allow the trench length of the network to be calculated automatically. The online state lands database map[25] is a useful resource for identifying publicly owned land. The use of publicly owned land for trenching reduces the need for wayleaves on private land. Knowing the publicly owned land in the area can also be useful for identifying potential energy centre locations as discussed in the heat source options appraisal.

8.1.1 Network Diversity Factors

It is also important to consider diversity when it comes to sizing pipes, particularly in larger networks. For very large networks the diversity seen at various point throughout the network and at the energy centre (this is in addition to the diversity at the connection point discussed in the heat demand section) will need to be considered. For large networks with diverse demands this additional diversity factor can be taken as being in the 70-80% range based on guidance from CIBSE CP1 and AM12 respectively. The hourly demand profiles from the energy model can also potentially be used to determine more network-specific diversity factors.

8.1.2 Sizing Pipes

A hydraulic analysis of each pipe in the network is undertaken to determine the size of pipe required for each length of pipe in the network. The purpose of this analysis is to ensure that the heat demand can be served and that limiting velocities (or pressure drops) are not exceeded while also keeping the pipes as small as

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[24] The Guidelines for Managing Openings in Public Roads (A.K.A. the Purple Book) provides guidance on Protected Periods for roadways - https://www.rmo.ie/uploads/8/2/1/0/821068/guidelines_for_managing_openings_in_public_roads_apr._2017.pdf

[25] LDA, Report on Relevant Public Lands: https://lda.ie/public-lands/register-of-relevant-lands/map

possible to reduce capital cost, reduce heat losses and help maintain the required pressures. Keeping velocities (or pressure drops) below these limiting values ensures:

- The dynamic head losses (pressure drop) are minimised reducing the need for excessive pumping energy as well as the increase in pump capital costs that come with a need to be able to supply at higher pressure.
- The need to carry out a transient pressure surge analysis is avoided. Pressure surges also known as water hammer can cause severe damage to the pipes.
- Mitigate against flow induced movement of the pipework.

RESOURCES & TOOLS: The tools excel spreadsheet which accompanies this report provides an automated calculation of max allowable capacity for selected pipe diameters using selected operating temperatures (flow & return temperatures)

The fundamental equation used for calculating the capacity of a DHC pipe is Q=m.Cp.dT. Where Q is the capacity in kW, ‘m’ is the mass flow rate in kilograms per second (kg/s), Cp is the specific heat capacity of water in kJ/kg° C (approximately 4.2kJ/kg° C but will vary slightly with temperature), and dT is the temperature, and the temperature difference in degrees Celsius (° C) between the flow and return.

The max allowable mass flow rate for a given pipe diameter is a function of the max allowable velocity (or pressure drop depending on the method being used) for the given diameter, the operating temperatures and the density of the water (at a temperature taken to be the average between the flow and return temperatures). The table below provides some typical allowable velocities for different pipe diameters for steel carrier pipes which can be used to determine suitable pipe sizes.

Table 14: Typical Allowable Max Flow Rates for Steel DH Pipes of Different Diameters

Nominal Pipe Diameter (mm)	Typical Max Allowable Flow Velocity (m/s)
20	0.65
25	0.7
32	0.75
40	0.85
50	0.95
65	1.1
80	1.25
100	1.5
125	1.75
150	2
200	2.5
250	2.5
300	3

Nominal Pipe Diameter (mm)	Typical Max Allowable Flow Velocity (m/s)
350	3
400	3
450 or greater	3.5

Generally pipes are sized to serve the diversified heat load downstream of that pipe, however, sometimes main pipe runs can be sized the maximise the use of a heat source in the future i.e. a view is taken that this network will expand in a certain direction to serve a larger future load outside the current study area and that there is enough remaining capacity from the heat source to serve part or all of this load.

8.1.3 Determining Pumping Requirement

The pumps in the network allow the hot water carrying the heat to reach each demand at the required flow rate and differential pressure. These pumps need to provide the required head to overcome the friction losses within the network and account for changes in elevation in the network, where relevant. These pumps should also keep the static head high enough to prevent cavitation. Cavitation is when steam bubbles form and are pressed together causing them to implode. This can cause damage to the network, especially valves and pumps. Cavitation is prevented when the pressure in the network is kept above the saturation vapour pressure of the liquid. The key parameters in selecting the right pump set and determining its cost are the pumping head required, and the flowrate required.

Below sets out some assumption that can be used to help determine the pumping requirement, where more accurate information is not available:

- Differential pressure of 10 mWC (1 Bar) across all substations (conservative estimate)
- Pumps and substations are located at ground level
- The max pipe elevations above the pump set along the network route can be estimated using Google Earth.
- An extra 10 mWC (1 Bar) was added to account for static losses at the EC and ensure that the pressure in the network does not drop below the vapour pressure (vapour pressure of 0.7 Bar for water at 90° C) causing cavitation.

  For calculating the energy consumption the following assumption can be used, where more accurate information is not available:
    - Pumping efficiency (pump + motor + frequency converter) of 60%
    - The minimum turndown rate of the pumps is 10%

8.1.4 Heat Losses

The cost of the heat losses will be dependent on the heat source being used and the associated cost of producing the heat for the network. As a result DH networks which have a higher cost of heat production will tend to favour the type of network with higher levels of insulations to minimise the amount of expensive heat being lost. There is also a difference in heat losses when considering twin vs single (pair) networks however twin pipes are only available in limited sizes. Networks with lower operating temperatures will also experience lower heat losses which may favour pipes with lower levels of insulation.

RESOURCES & TOOLS:
Calculating the heat losses of the network is an important of determining the life-cycle cost. This can be done using tools such as the Logstor Heat Loss calculator tool which is available online http://calc.logstor.com/en/energitab/

Heat losses are important as they having an ongoing impact on the margin earned by the network as a result of paying to produce heat which ultimately does not make it to the customer to earn a revenue for the project. Online tools such as the Logstor Heat Loss tool can be used to calculate heat losses. Alternatively, these can be calculated in a spreadsheet using the thermal conductivity of the insulated pipe. As a general rule of thumb, the heat losses in a well performing network should not exceed 10% of the heat supplied to the network unless network is in a low heat density area, or the pipework is sized for some large heat loads that are not connected in this feasibility study.

8.1.5 Comparing Network Route Options

In the life cycle cost it is also important to consider the lifespan of different pipe constructions. For example, it is important to consider that networks which use steel carrier pipes have a longer lifespan than those with plastic carrier pipes. There are also operational considerations that may come into play here rather than just financial ones. One such operational consideration could be that typically plastic pipes don't include leak detection wires and hence finding the location of potential leaks in the future may prove more challenging. It should also be noted that certain pipe constructions have limits in terms of diameter, temperature and pressure ratings. For example, twin pipes generally have a maximum nominal diameter of 200mm. Polymer pipes are typically rated for 6bar pressure and have a lower recommended operating temperature in order to maintain a longer lifespan. These limits should be checked with specific pipe manufacturers (e.g. Logstor, Isoplus, Brugg, Rehau, Powerpipe, Inpal, Ecoline, etc.) before selecting the right pipe system for the project.

The Table 15 below provides a simple example method through which the route options can be compared and the preferred option can be identified. It is recommended that a similar table be filled out as part of the feasibility study and this is the primary output of section 8.1.

Table 15: Route Option Comparison Table (See Table 7 in Feasibility Study Template)

Route	Option 1	Option 2	Option 3
Network Trench Length (km)			
Life Cycle Costs (€)			
Pipework Capital Cost (€)			
Combined Cost (€)			
Comments (Major obstacles/no-go areas avoided etc.)			

8.2 District Heating Plant Sizing Assessment

Plant sizing assessment outputs:

- Plant sizing comparison table (including life-cycle costs and CO2 savings) – showing contribution of primary and backup heating plant.
- Optimal size of primary and backup plant the thermal storage

- Comment on potential phased installation of equipment

The plant in the energy centre (heat production equipment and thermal storage) represents a significant capital cost for a district heating scheme. Therefore, it is important to ensure that these are sized to maximise the financial viability (minimise the life-cycle cost) of the district heating scheme while also delivering on CO2 savings. The main factors which influence the cost of the energy centre is the size of the heating plant and thermal storage required. The optimal size of the heating plant (e.g. heat pump, backup heating plant, etc.) will depend on the peak heating load (the diversified peak load at the energy centre), the annual load profile and the fuel cost (including variations in cost between night and day). To accurately model the peak load and annual load profile an hourly energy model will need to be created. Such models will likely include the following main elements:

- The size/capacity of the heating plant, its cost and the total heat demand supplied by this plant
- The efficiency and turndown of the heating plant
- The size of the thermal store, its associated cost and its effect on the contribution and efficiency of the heating plant
- Electricity/fuel prices at different times of day for determining the operation of the plant (based on net production cost)
- Heat demand profiles (both DHW and space heating)
- Heat losses

RESOURCES & TOOLS: Modelling software such as energyPRO (https://www.emd-international.com/energypro/) or nPro (https://www.npro.energy/) can be used to develop these temporal energy models.

It should be noted that primary and backup plant are characterised in two different ways due to number hours for which they run each year. Primary heating plant will generally have higher capital costs but lower operation costs and CO2 emissions (as the low cost of producing large volumes of heat offsets the up-front capital cost). Backup or peaking heating plant is generally characterised by smaller up front capital cost and higher operating costs and carbon emissions (as it spends much of its time not generating).

These models need to consider the hourly heat demand. If metered information is available this will provide the best data for the model (as discussed in section 6.1). If metered data is not available, then demand profiles can be generated for the model using:

- Annual heat demand (from bills, building energy models or benchmarks)
- Heat demand dependency on external air temperature i.e. the proportion of heat demand that is for space heating
- Demand/occupancy profiles - example heat demand profiles for different building types can be found in the Appendix of this guide.

Further considerations will include:

- Operation and maintenance costs of the plant and thermal storage
- Reinvestment costs of the plant and thermal storage
- Capital funding contributions for various heating technologies.

The figures below provide examples from energy modelling work as part of a feasibility study. Figure 19 provides a graphical representation of the system being modelled with the majority of heat being supplied from the ground source heat pump (primary production unit) and the remainder being provided by an electric boiler. This also shows the thermal store with arrows representing this being charged and discharged.

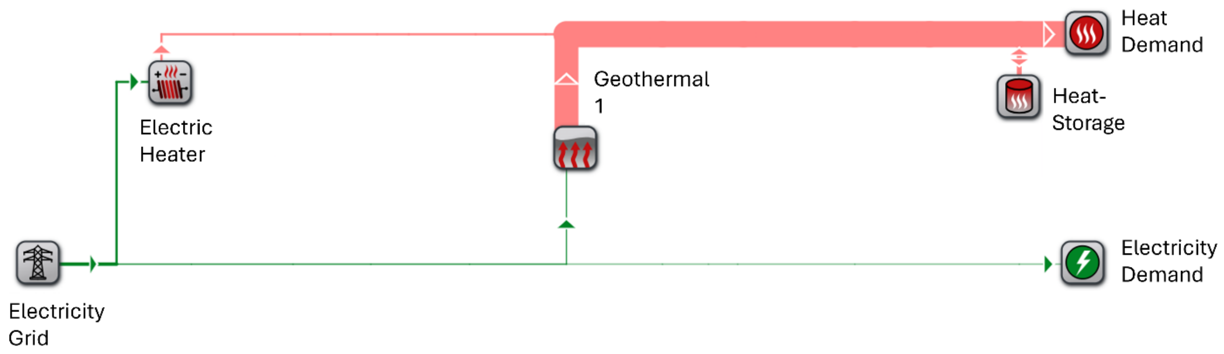


Figure 19: nPRO Graphical Representation of GSHP Example Model

Figure 20 shows the load duration curve from the same model. The medium grey area shows the heat output from the GSHP (operating for over 5,000 hours per year), the light red area shows the heat demand duration curve and the dark grey area shows the heat that has been used to charge the thermal shore. This stored energy is then discharged (in light grey) to satisfy the full heat demand (in light red).

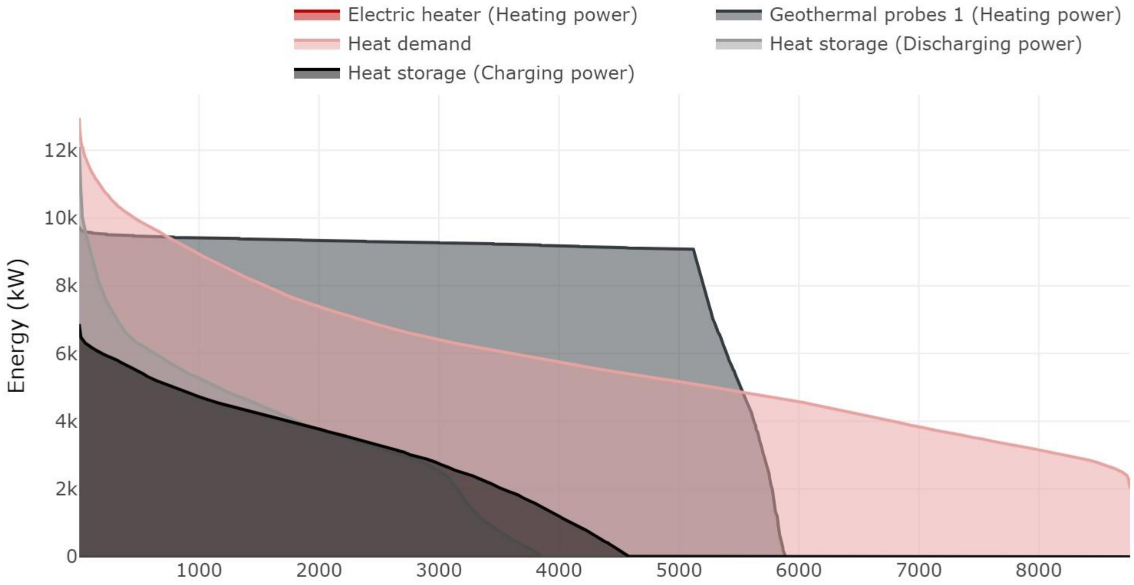


Figure 20: Load Duration Curve from GSHP Example Model

8.3 Building Connections to DH systems

Building connections represent a critical component in the district heating system as they directly affect both the feasibility and the efficiency of the heat distribution network. This section focuses on establishing high-quality, robust connections between the heat distribution network and individual buildings or heat consumers.

Building Connections outputs:

- Completed key considerations of building connections in Table 8 of Template.

8.3.1 Key Considerations

- **Connection Types:** Outline the types of connections appropriate for different building categories (residential, commercial, institutional). Each type requires specific interface equipment like heat exchangers or sub-stations.
- **Integration Challenges:** Address common obstacles such as the physical integration of network pipes into existing buildings, regulatory compliance, and the retrofitting needs for older buildings.
- **Technical Requirements:** Describe the technical specifications for connection equipment, including dimensions, heat transfer rates, and control mechanisms. This will also cover the required modifications within the buildings to accommodate the district heating connection.
- **System Compatibility:** Ensure that the building's internal heating systems are compatible with the district heating supply in terms of temperature and flow requirements. Highlight the need for potential upgrades or adjustments to existing systems.
- **Cost Implications:** Discuss the cost aspects associated with making building connections, including capital outlay, potential disruption, and long-term savings.
- **Stakeholder Benefits:** Elaborate on the benefits for building owners and occupants, such as reduced heating costs, increased energy efficiency, and enhanced property value.
- **Installation Process:** Provide a step-by-step guide on the installation process from initial surveys and engineering assessments to the physical connection and commissioning.
- **Safety and Compliance:** Address safety standards and regulatory compliance that must be met during the installation and operation of building connections.

8.3.2 Implementation Strategy

- **Phased Connection Rollout:** Depending on the heat demand assessment and geographical logistics, propose a phased approach to connecting buildings. This strategy should align with the overall deployment phases of the district heating network.
- **Stakeholder Engagement Plan:** Develop a plan for engaging with property owners and other stakeholders to explain the process, benefits, and changes required for building connections. This includes informational workshops, consultation sessions, and support services.
- **Monitoring and Optimization:** After connections are made, set up a system for monitoring performance and optimizing the heat delivery to ensure efficiency and customer satisfaction.

Building Connections Outputs:

- **Detailed Connection Plans**: Provide detailed diagrams and specifications for necessary hardware and configurations.
- **Project Timeline**: Present a detailed timeline for the connection process, emphasizing key milestones and dependencies.
- **Cost evaluation**: Cost evaluation to feed the technical and economical assessments in following sections.

9 Detailed Energy Supply Options Assessment

This section of the guide describes the different scenarios that will be assessed in the techno-economic analysis (Chapter 10), including district heating, business as usual and counterfactual scenarios. In particular, it includes points which may be considered when assessing the counterfactual low-carbon heat alternative.

Outputs: Descriptions of different scenarios to be assessed.

DH development scenarios.

- The use of different primary and backup heat sources and the size and contribution of each
- Variations around loads which will connect and when.
- Network route options
- Energy Centre location options
- Electricity grid or other fuel carbon intensity projections

The Counterfactual Scenario

This section describes what is being assumed as the counterfactual heat supply scenario. This is the scenario against which the DH scenario(s) will be compared in the techno-economic analysis.

The Business-As-Usual Or 'Do Nothing' Scenario

This section of the feasibility study outlines the heat supply options that would be used were the DH network not to be developed.

9.1 Rationale for assessing district heating scenarios against the business as usual (BAU) or counterfactual scenarios.

By providing a thorough comparison, assessing a district heating scenario against a counterfactual ensures that all relevant factors are considered, leading to a well-informed decision that balances economic, environmental, and social considerations. The BAU scenario is crucial for making informed decisions about whether to invest in and implement a district heating system, as it provides a clear and measurable point of reference. This would be relative to the current state or baseline scenario where no changes are made to the existing heating systems and practiced. It may be important to assess a district heating scenario against a BAU/counterfactual for several reasons:

1. **Benchmarking performance**
    - Evaluating the district heating system against a counterfactual (typically the current or alternative heating systems) allows for a clear comparison of performance metrics such as energy efficiency, cost-effectiveness, reliability, performance and environmental impact.
2. **Financial/economic analysis**
    - Comparing life cycle costs involved in district heating versus the counterfactual helps in understanding the financial viability. This includes capital expenditures, operational costs, maintenance, and potential savings over time.
3. **Environmental Impact**
    - Assessing the greenhouse gas emissions, energy efficiency and other environmental factors associated with district heating in contrast to alternatives can highlight the environmental benefits or drawbacks.
4. **Policy and decision making**
    - Policymakers require comparative analyses to justify investments and subsidies. Demonstrating the advantages of district heating through counterfactual scenarios can support policy development and funding decisions.

5. **Stakeholder engagement**
    - Providing stakeholders (e.g., residents, businesses, investors) with a clear comparison helps in gaining their support. It allows them to see the tangible benefits or potential issues of adopting district heating over existing systems. Understanding how the transition to district heating might affect the community, including considerations of energy equity and access is important.
6. **Risk assessment**
    - Comparing against a counterfactual scenario helps in identifying potential risks and uncertainties associated with the district heating project, such as dependence on fuel prices, technological reliability, and regulatory changes.
7. **Strategic Planning**
    - Understanding the relative strengths and weaknesses of district heating compared to other options helps in strategic planning and optimisation. It can guide decisions on technology adoption, network design, and expansion strategies.
8. **Sustainability Goals**
    - Specific sustainability targets are present at all levels; European, National, Regional and Local. Comparing district heating to counterfactual scenarios helps in assessing how well it aligns with these goals, such as reducing carbon emissions and increasing energy efficiency.

9.2 The District Heating Network Development Scenarios

This section of the report summarises the DH options that were assessed in previous Chapters 6-8.
The DH scenarios will look at a number of variations to the energy system, demand and network, which may include common variations such as:

- The use of different primary and backup heat sources and the size and contribution of each
- Variations around loads which will connect and when.
- Network route options
- Energy Centre location options
- Average CO2 content of the heat supplied to buildings.
- Electricity grid or other fuel carbon intensity projections.

TIP: When looking at the CO2 emissions for each heating scenario it is important to consider how the fuel might decarbonise over the life of the project. This is especially important when considering electricity. The separate Appendices to this report include some CO2 intensity projections in Appendix G as an example. The user of the guide will need to take their own view on what they see as likely carbon intensity factors for the fuels being used.

9.3 Business as Usual (BAU) or 'Do Nothing' Scenario

This section of the feasibility study outlines the heat supply options that would be used were the DH network not to be developed. It refers to the current state or baseline scenario where no changes are made to the existing heating systems and practices. This scenario serves as a benchmark against which the proposed district heating system can be evaluated.

Essentially this would mean the continued use of installed heat systems (typically predominantly fossil fuel boilers). The duration for which these fossil fuel systems continue to be used (estimate remaining lifetime) should be considered. External factors like changes in policy, general attitude trends etc. and how these might impact continued use of fossil fuel heating system or indeed fossil fuel prices could be considered but a realistic view should be taken on how and when these external forces might be felt to the required extent to trigger the replacement of such boilers. All new or majorly renovated building would be subject to the latest Part L requirements and would need to install individual low-carbon heat sources.

9.4 The Counterfactual Scenario

The counterfactual scenario is the scenario against which the DH scenario is compared. Given the national targets to reduce emissions by 51% by 2030 and be carbon neutral by 2050, any counterfactual proposed would also need to be a low-carbon form of heating. Individual air source heat pumps are generally considered the most appropriate alternative and are currently the de-facto heating solution for the new build sector in Ireland.

9.4.1 Counterfactual Low-Carbon Alternatives (i.e. Individual building heat pumps)

The most common low-carbon heating alternatives to DH are standalone individual building heat pumps, however, users of this guide/ template may choose another low carbon alternative if more suitable to their situation.

When evaluating the benefits and drawbacks of District Heating (DH) systems compared to individual heat pumps, it's essential to present a balanced view that considers various economic, environmental, and practical factors. Here is an overview of the pros and cons, building upon the initial list provided:

Possible Advantages of a District Heating System relative to a counterfactual individual heating system

- **Economies of Scale**: DH systems can achieve higher efficiencies due to scale, especially with the use of technologies like multi-stage compression heat pumps. They can maintain efficiencies during colder months due to typically using higher temperature heat sources.
- **Lower Operational Costs**: Due to centralised monitoring and maintenance, DH systems often optimize efficiency better than individual solutions, which can reduce operational costs over time.
- **Diversification of Heat Sources and Improved Integration of Renewable/Low carbon heat sources**: DH allows for the use of various heat sources, including waste heat from industrial processes, biomass fuels, geothermal energy, or large-scale heat pumps, which can provide more stable and reliable heat supply and lower CO2 emissions.
- **Reduced Grid Impact**: By centralising heat production, DH can reduce the need for electrical grid reinforcement that individual heat pump installations might require due to high peak loads.
- **Longer Lifespan**: Large-scale infrastructure in DH systems generally has a longer lifespan compared to individual heat pumps, reducing the frequency and cost of replacement.
- **Efficient Use of Space**: In dense urban areas, DH systems can save space within buildings by eliminating the need for individual heating units and large water storage cylinders.
- **Noise prevention** When replacing standard boilers with air source heat pumps in residential areas, the operational noise from the outdoor unit and compressor could potentially impact neighbours, posing a risk of noise disturbances.

Possible disadvantages of District Heating System relative to a counterfactual individual heating system

- **High Initial Capital Cost**: DH systems require significant upfront investment in infrastructure, including pipework and central heat production facilities, which can be cost-prohibitive.

- **Infrastructure Dependency**: The effectiveness of DH is heavily dependent on the existing infrastructure and the proximity of buildings to the heat source. Extensive pipework might be needed to connect new areas.
- **Less Replacement Flexibility for individuals**: Once established, DH systems may offer less flexibility to change heat sources or upgrade technologies compared to individual systems where upgrades can be made independently by homeowners.
- **Risk of Heat Loss**: Extensive pipework can lead to heat losses if not properly insulated, especially over long distances, potentially reducing the overall efficiency of the system.
- **Complexity in Scaling Down**: While DH is advantageous for large-scale applications, it can be less viable for smaller communities or areas with low heat demand due to the fixed costs associated with infrastructure.
- **Regulatory and Planning Challenges**: Implementation of DH systems can face significant bureaucratic hurdles, including obtaining the necessary permissions for large-scale infrastructure developments and navigating complex regulatory environments.

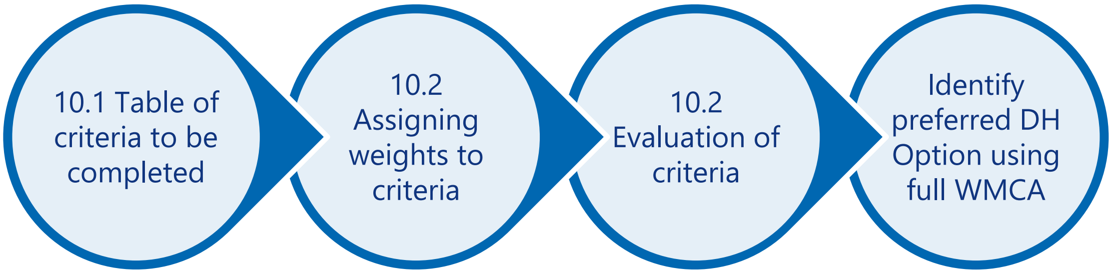
10 Techno-Economic Feasibility Analysis. Part 1- Weighted Multicriteria analysis.

This chapter further evaluates the DH network development scenarios with different heat supply options that were shortlisted in Chapter 7. The shortlisted options are assessed via a multi-criteria analysis, considering a) financial viability, b) operational efficiency, c) environmental impact, and d) strategic alignment. It identifies a preferred DH option for further detailed financial examination in the following Chapter 11.

In this chapter, DH options against a counterfactual scenario, should that be required. The chapter is divided in two sections:

- **Description of the Analysis Criteria.** The criteria used include financial aspects, implementation feasibility, operational efficiency, strategic alignment, and environmental impact. The analysis emphasizes metrics such as the life cycle assessment of costs (NPV of costs), along with considerations like CAPEX, OPEX, and REPEX.

- **Multivariable weighted analysis steps.** Additionally, it outlines a systematic approach for conducting a weighted multi-criteria analysis (WMCA), ensuring comprehensive evaluation by accounting for all relevant factors. Examples of such analyses are provided to assist decision-making.



10.1 Heat Supply Analysis Criteria

This section presents the four primary criteria in terms of categories and subcriteria (Table 16) and indicates which following sections contain more detail. Once the criteria are assessed for each scenario, they will be further analysed in the following multicriteria weighted analysis (WMCA) (section 10.2).

- **Financial Considerations**: These criteria assess the life cycle costs of each option: initial investment, maintenance and operation expenditure, energy costs, and dependability.
- **Implementation & Operability**: Considers influence on the energy centre, activation time, and space requirements.
- **Strategic/Market Vision**: Evaluates scalability potential and consumer cost impact.
- **Environmental Impact**: Reviews carbon emissions mitigation and overall environmental footprint.

Table 16 illustrates each of the criteria and sub-criteria of the Weighted Multi Criteria Analysis to be completed.

Criteria Categories	Sub-Criteria	Section with further detail
Financial Considerations. Life Cycle Costs	LCC (NPV of costs) *	10.1.1
	Initial and Lifespan Periodic Investment (CAPEX & REPEX) **	
	Maintenance & Operations Expenditure (OPEX)**	
	Energy/Fuel cost Expenditure**	10.1.2
	Dependability & Flexibility	10.1.3
Implementation & Operability	Installation impact	10.1.4
	Set up time	
	Space/Footprint Requirements	
Strategic/Market Vision	Scalability Potential	10.1.5
	Consumer Cost Impact	
Environmental	Carbon Emission Mitigation	10.1.6
	Environmental Impact	

**note criteria with two asterix ** may substitute NPV* evaluation.

The following subsections describe each of the sub criteria elements presented in the above table.

10.1.1 Financial considerations

The following section outlines the approach to calculating financial metrics for the different scenarios being assessed in the template (DH scenarios and/or BAU and/or CF). The completed metrics are then used in a WMCA (Section 10.2) to define a preferred DH solution to be taken through a more rigorous TEA in Chapter 11 (Insert figure). The subcriteria (See Table 16) are outlined in more detail below:

Life Cycle Cost Assessment (LCCA)

The cost of the installation throughout its lifetime is compared to other options can help stakeholders gauge the economic viability of district heating projects and guide decisions on investments, funding, and long-term operations.

LCCA through a net present value evaluation:

- NPV measures the value of cash flows of costs over time, in these case costs, discounted to their present value.
- A lower NPV in this case suggests lower cost and a potential profitability.

The metric should be calculated with a discount rate, typically set at 4% in real terms for public sector projects[26], although state-sponsored bodies or commercial projects may use different rates. This rate is used for cost-benefit and cost-effectiveness analyses and excludes projected inflation, meaning it should be

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[26] https://www.gov.ie/en/collection/e8040-infrastructure-guidelines/

applied to future costs and benefits expressed in constant prices. For public sector investments the Infrastructure Guidelines[27] should be followed. These guidelines are designed to ensure the evaluation, planning, and management of public investment projects are consistent and thorough, providing a clear framework for public sector project appraisals.

To evaluate both short-term profitability and long-term sustainability, these metrics should focus on cash flows (CAPEX, OPEX, REPEX), **excluding revenues**, during the lifetime of the DH options and other options being assessed e.g. business as usual and/or the counterfactual option.

Estimating the LCC for a district heating scheme is challenging due to the complexity and uncertainty of inputs like capital and operating costs and demand forecasting, Regulatory risks, technological uncertainty, and long-term project horizons add further complications. These factors necessitate sensitivity analyses and scenario planning to understand the range of possible financial outcomes. However, if estimating NPV is considered a challenge, an alternative could be to assess the CAPEX, OPEX, and REPEX independently. These are explained as follows:

Initial investment (Capital Costs (Capex) + Replacement Costs (Repex).

Capital costs are the investments required for the heating system during each phase of construction. The core scheme, or phase 1, should cater to all customers expected in this phase. Subsequent phases should facilitate the network extension to accommodate additional customers, as well as the expansion or adaptation of the existing district heating (DH) plant or future DH plants planned for subsequent development phases. Capital costs should be as realistic and robust as possible and could be based on discussions with suppliers and contractors and/or on initial quotations. They should include cost estimates for development, procurement, infrastructure, connection and metering, replacement, residual value and contingency.

1. **Development Costs:**
    - Include expenses for developing the feasibility study, financial appraisal, design, professional services, and planning.
2. **Procurement Costs:**
    - Encompass the development of the business model, assessment of procurement routes, and overall scheme procurement.
3. **Infrastructure and Construction Costs:**
    - Works Oversight, Commissioning, and Management: Supervision and management of construction.
    - Energy Centre: Costs for constructing the energy centre, including building and land.
    - Electrification: Costs for network connection, backup generation, and control infrastructure.
    - Water Supply, Treatment, and Drainage: Related infrastructure costs.
    - Low Carbon Heat Source Technology: Investments in boiler, heat pump, subsurface geothermal infrastructure, and waste heat connection.
    - Pipework: Costs for district heating network pipes.
    - Thermal Store: Equipment for storing heat.
    - Energy Monitoring and Billing: Infrastructure for monitoring and billing energy usage.
    - Administration: Infrastructure for DH administration, including possible office space.
4. **Connection and Metering Costs:**

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[27] https://www.gov.ie/en/collection/e8040-infrastructure-guidelines/

- Relate to connecting buildings to the heating network and setting up metering systems for heat consumption monitoring (ie building heat exchangers). Different types of buildings and customers may require distinct approaches. Refer to **8.3 Building Connections to DH systems** for a detailed description of connection systems.

  Determining DH Customer Connection Costs
- The connection cost for each building should be included in the technoeconomic assessment in Chapter 11 along with any contributions assumed from the customer. The connection cost will be determined predominantly by the length of the branch from the DH network to the plant room of the building being connected and the size of the substation required, driven by the peak heat demand to be served. Indicative costs per kW are provided in the Assessment of the Costs, Performance, and Characteristics of UK Heat Networks (Department of Energy & Climate Change UK, 2015). More accurate substation cost estimates can also be obtained through engagement with suppliers.

  The customer contribution to this cost in the financial model could be based on the installation of an alternative low-carbon heat source. In many cases this would be an individual air-source heat pump. Indicative costs for air-source heat pumps can be found in the Cost of Installing Heating Measures in Domestic Properties (DESNZ, 2020).

5. **Replacement expenditure (Repex).**
   - A sinking fund may be used to budget for lifecycle replacement costs of the district heat assets where revenues are not put aside for this purpose.

     Lifetime consideration of the feasibility analysis: It is recommended the analysis to cover at least the lifetime of the proposed DH system. The expected technical lifetime of large-scale boilers and large-scale heat pumps are around 20 and 25 years respectively, while the network itself is at least 40 years[28].

6. **Residual/Terminal value** is the estimated value of a fixed asset at the end of its lease term or useful life. The residual value should be discounted from the end year of the appraisal period. This can be difficult to calculate, but methods may include depreciated capital cost, observation of the market, specialist evaluation or valuation of an annuity.

7. **Contingency Factor:** It's important to add a contingency factor to account for unexpected costs during the project, that reflect the levels of risk identified in the risk register.

Maintenance and Operational Costs (Opex)

- **System Management:** This includes ongoing network management, contract governance, and reporting.
- **Insurance:** Coverage for the network's risks and liabilities.
- **Taxes:**
  - **Corporation Tax:** Applicable to taxable profits from the sale of heat, currently at 12.5%.

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[28] Energistyrelsen,Teknologikatalog for produktion af el og fjernvarmhttps://ens.dk/service/fremskrivninger-analyser-modeller/teknologikataloger/teknologikatalog-produktion-af-el-og

    - **Value Added Tax (VAT):** Charged at 13.5% for energy, goods, and assets, and at 23% for services and other expenditures.
- **Operation and Management of Assets:** These costs can be fixed or variable, depending on the capacity and running hours of the heat supply equipment. Maintenance of customer-side equipment will typically be the customer's responsibility.
- **Staff Costs:** These may increase as the system expands, balanced against an acceptable payback period.
- **Billing Costs**: Expenses associated with billing customers.
- **Water Purchase**: Costs associated with water usage.
- **Consumables**: Expenses for oils, dosing chemicals, etc.
- **O&M Margin**: Operating and maintenance margin.
- **Commercial and Marketing Costs**: Expenses related to increasing DH connections over time.
- **Energy Centre Monitoring and Control Operation Costs:** Costs for monitoring and controlling energy usage.
- **Backup System Operation Costs:** Include periodic testing and on-call team operations.

10.1.1.1 Energy and Fuel Cost Expenditure

This section examines the fuel costs in time, considering also potential price variability. Energy costs include expenses for electricity, biomass, etc. The technical model should provide the heating technology split and day/night split for accurate cost modelling. Running costs of heat pumps and boilers will also be influenced by their COP or efficiency. Encouraging lower return temperatures can reduce running costs, which indirectly increases net revenues. A useful resource for the cost of electricity is SEAI's commercial fuel cost guide[29].

10.1.1.2 Dependability and Flexibility (energy supply security).

This section evaluates fuel security and supply chain robustness. This is the system's ability to handle disruptions in fuel supply and evaluates the robustness of the supply chain infrastructure by assessing the stability and reliability of fuel sources and logistics.

This section can evaluate the system's ability to continue operating during disruptions and its adaptability to changing operational conditions. It looks at how well the system can maintain reliability and adjust to evolving demands or challenges.

10.1.2 Implementation & Operability Criteria

- **Influence of New Technology on Energy Centre Operations (installation impact)**
  Considers how introducing new technology might affect current operational practices and the learning curve associated with new system integrations.
- **Immediacy of System Activation and Grid Connection. Set up time**
  Measures the time and effort required to get the energy system operational after installation, including its connectivity to existing grid systems.
- **Space Availability for Setup and Ongoing Operation**
  Evaluates the physical space requirements for installing the system and the feasibility of expanding or modifying the setup as future needs evolve.

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[29] SEAI, Energy Data Downloads: https://www.seai.ie/data-and-insights/seai-statistics/key-statistics/energy-data/

10.1.3 Strategic/Market Vision

10.1.3.1 Potential for Future Scalability

Assesses the capability of the energy system to expand capacity or be upgraded to meet future demands or regulatory changes.

10.1.3.2 Effect on Consumers' Heating Costs

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This criterion is important as an early evaluation of market adoption. It evaluates how the chosen energy solution impacts end-user costs, thereby influencing overall market competitiveness. Unlike other financial parameters (LCC, CAPEX, Fuel Cost) that focus on specific cost components, this parameter provides a more holistic view of the financial impact on consumers. It takes into account the following factors:

- **Comparison to Alternatives:** This involves comparing the heating costs associated with the District Heating (DH) system to the Business as Usual (BAU) and/or Counterfactual (CF) individual heating solutions such as air source heat pumps. At this stage, the collective costs of the DH system may need to be compared to different typical applications of alternatives (e.g., domestic, commercial, industrial examples).
- **Cost Stability**: This assesses how predictable the heating costs are over time, considering factors such as fuel price volatility and regulatory changes.

10.1.4 Environmental

10.1.4.1 Potential for Lowering Emissions (CO2eq reduction)

Reviews the system's effectiveness in reducing emissions, including greenhouse gases and if considered the evaluation team of other pollutants like nitrogen oxides. Could consider the broader social cost of CO2 and NOx emissions.

10.1.4.2 Environmental Impact & Planning permission

Considers broader environmental impacts, such as effects on local water bodies, soil quality, air quality, and biodiversity, noise (ie risk of noise on neighbours), visual impact, ensuring the system's comprehensive sustainability.

This section could include detailed considerations such as required permissions and the potential environmental impact assessment results can help in understanding the feasibility and the regulatory challenges each option might face.

10.2 Weighted multi criteria analysis.

After the sub-criteria for analysis have been collated as described in Section 10.1 and table 10 completed in the template, this section outlines the process for conducting a weighted multi-criteria analysis (WMCA). The purpose of this WMCA is to identify and compare the different DH options (and/or BAU or counterfactual) by assessing multiple criteria, including weighting the criteria to reflect their relative importance to a given project or key stakeholders. The process involves the following steps:

1. **Evaluation Matrix (10.1):**
   An evaluation matrix is filled in by the evaluation team to assess each sub-criterion parameter defined in previous sections (e.g., Life Cycle Cost Assessment (LCCA) of each option). If required, this also includes a counterfactual solution, such as individual air source heat pumps. It is important to note that the counterfactual solution may not have a collective LCC or CAPEX value. The evaluation team may need to assess equivalent sub criteria parameters (ie CAPEX or OPEX) of the collective counterfactual scenario where heat pumps serve as an alternative to district heating.

2. **Weighting Criteria Matrix (10.2.1):**

A weighting criteria matrix is established where the evaluation team assigns weights to each sub-criterion based on their relative importance.

3. **Evaluation and Scoring (10.2.2):**
   The evaluation matrix is scored, with each sub-criterion parameter receiving a score. The scores are then aggregated to rank the options.

As a result of these three steps, the table 11 in the template is complete- weighted multicriteria analysis. This structured process ensures that all relevant factors are systematically considered, resulting in a comprehensive evaluation.

10.2.1 Evaluation Matrix

The evaluation matrix enables a comprehensive assessment of each heat supply option with respect to key sub criteria. This analysis includes the DH scenarios shortlisted in the previous sections, which cover variations in network or plant sizes, locations, phase options, etc., as well as a counterfactual scenario, if required. The multicriteria analysis provides the option to assess the counterfactual scenario in parallel (if required), it provides a comparative analysis against a system that uses individual heat pump systems for all heat demand users that the DH options are intended to serve. This helps to underscore the advantages or limitations of the DH options in contrast to a more traditional approach.

The table below shows an example of a completed Multicriteria Evaluation Matrix. It outlines the evaluation of each criterion for three proposed DH options alongside the counterfactual scenario, facilitating a clear comparative analysis.

Table 17: Example of a completed multivariable matrix (Table 11 in the template). It has been filled in with an evaluation of each criteria for each option based on the analysis in Section 10.1. (example)

Criteria Categories	Sub-Criteria	Option 1 Evaluation	Option 2 Evaluation	Option 3 Evaluation	Counterfactual
Financial Considerations	LCC (NPV of Costs) (1)	€10 million	€11 million	€12 million	€11.5 million
	(Initial Investment, inc REPEX)	€5 million	€4 million	€6 million	€7 million
	(Maintenance & Operations Expenditure)	€0.5 million	€0.4 million	€0.6 million	€0.5 million
	Fuel Annual Cost Expenditure	€1 million	€1.2 million	€1.1 million	€0.9 million
	Dependability and Flexibility	High	Medium	High	Low
Implementation & Operability	Installation impact	Significant	Moderate	Significant	Minor
	Set up time	1 year	1.5 years	1 year	2 years
	Space/Footprint Requirements	Moderate	Low	Moderate	High

Criteria Categories	Sub-Criteria	Option 1 Evaluation	Option 2 Evaluation	Option 3 Evaluation	Counterfactual
Strategic/Market Vision	Scalability Potential	High	Medium	High	Low
	Consumer Cost Impact	Moderate	High	Moderate	High
Environmental	Carbon Emissions Mitigation	5,000 tons	4,500 tons	5,200 tons	4,000 tons
	Environmental Impact & Planning	Minor	Moderate	Minor	Significant (heat pumps in commercial building)

(1) Parameters in brackets could substitute LCC/NPV assessment. Evaluation could include LCC or alternatively include CAPEX and OPEX evaluations.

10.2.2 Proposed Weighting of Criteria/ Sub-Criteria in the Weighted MCA

Now the criteria have been completed (Table 17), a weighting must be assigned to the various aspects of the heat source appraisal. This weighting highlights the relative importance of each aspect of the analysis and can be developed in collaboration with the project developer to reflect their own drivers. The Table 18 below provides an example of the weights assigned to each sub-criterion, a rationale for the weighting and an example of how to apply them in the weighted multi-criteria analysis. This information aids stakeholders in understanding and confirming the rationale behind the scoring in the main weighted analysis, ensuring transparency and informed decision-making throughout the evaluation process.

Table 18: Example of the weighting to be applied to different Criteria/ Sub criteria of the MCA. See (1) and (2) below.

Criteria Categories	Sub-Criteria	Weight (%) (1)	Weighting Rationale (2)	Scoring Criteria
Financial	LCC (NPV of Costs)	30%	Reflects the significance of return on investment relative to other factors.	Scored based on the projected internal rate of return, ranging from very low to very high.
	(If detailed breakdown is used instead of NPV evaluation			
	(Capital Expenditure inc REPEX)	12.5%	Balances the impact of initial investment costs in the economic viability of the project.	Scored by comparing initial capital outlay, from very low to very high costs.
	(Operational and Maintenance Costs)	5%	Weight justified by the ongoing financial commitment needed for system operation.	Varies based on the estimated regular costs, indicating potential financial burden.
	(Fuel Cost, including variability)	12.5%	Considered due to its impact on long-term operational expenses.	Scored based on the stability of fuel prices, from stable (low score) to highly variable (high

Criteria Categories	Sub-Criteria	Weight (%) (1)	Weighting Rationale (2)	Scoring Criteria
				score).
	Reliability	10%	Critical for ensuring reliable energy supply, thus weighted to reflect its importance in decision-making.	Assessed from robust (low risk of disruption) to fragile (high risk of disruption).
Implementation & Operability	Installation impact Disruption During Installation	10%	Reflects the potential for operational disruption during system setup.	Evaluated from minimal to significant disruption, impacting overall project timelines and cost.
	Set up time	5%	Important due to its effect on existing infrastructure and service continuity.	Scored from minimal (low impact) to severe (high impact) during network integration.
	Spatial Footprint	5%	Included due to the physical space requirements and their environmental and practical implications.	Evaluated based on area used, from minimal (compact setup) to extensive (large area required).
Strategic/Market Vision	Future Expansion Potential	5%	Weighed to highlight the importance of scalability in district heating investments.	Ranges from high (easy expansion) to low (limited scope for growth).
	Consumer Cost Impact	15%	Significance placed on the economic impact on end users.	Scored based on potential changes in user costs, from low impact to high.
Environmental	Carbon Emissions Mitigation	10%	Weighted to emphasize the environmental strategy of reducing emissions.	Scored from significant reductions to minimal or no impact compared to alternatives.
	Local Environmental Impact	10%	Stresses the importance of minimizing ecological disturbances.	Ranges from low (minimal impact) to high (significant disruption of local ecology). Planning permission risk evaluation
Total Score		100%		

(1) criteria under parenthesis may substitute LCCA evaluation.

(2) sub criteria weights in this table are examples, each feasibility study team may agree different weights for each case

10.2.3 Evaluation & Scoring. Weighted Multi-Criteria Analysis.

This weighted multi-criteria analysis (WMCA) uses a structured approach to ensure all relevant factors are systematically considered, enabling comprehensive evaluation.

Each criteria in Table 10 is given a grade of between 0 and 100, with 100 being the highest score. This grade should be based on quantitative analysis, where feasible. This grade is then combined with the weighting from Table 11 to give a weighted score. The sum of the criteria scores for each option is used to determine the best DH option. Table 19 is an example of such an analysis taken from a sample Feasibility Report. In this case, DH Option 3 achieved the highest score and therefore represents the preferred heat source. A similar table should be developed for each project in order to identify the preferred options to be analysed further in the following detailed techno-economic feasibility analysis section.

Table 19: An example of a completed Weighted Multi-Criteria Analysis. Score matrix (example)

Criteria Categories	Sub-Criteria	Weight (%)	Option 1 Score	Option 2 Score	Option 3 Score	Counterfactual Score
Financial Considerations	LCC	30%	85	75	90	60
	(Initial Investment)	15%	75	80	70	85
	(Maintenance & Operations Expenditure)	5%	70	80	65	90
	(Fuel Cost & Variability)	10%	80	70	75	85
	Dependability and Flexibility	10%	90	80	90	60
Implementation & Operability	Installation impact Influence on Energy Centre	5%	85	75	85	70
	Set up time	5%	80	75	85	70
	Space/Footprint Requirements	10%	75	90	75	60
Strategic/Market Vision	Scalability Potential	5%	90	70	90	60
	Consumer Cost Impact	15%	80	90	85	75
Environmental	Carbon Emissions Mitigation	15%	90	85	95	65
	Environmental Impact	5%	85	75	85	60
Total Score		**100%**	**82**	**80**	**85**	**71**
Ranking			**2**	**3**	**1**	**4**

(1) sub criteria under parenthesis may substitute the LCC (NPV) evaluation. In this case all sub criteria are evaluated for information only.

Following this appraisal, the most feasible DH scenario options will be brought forward to be modelled in the TEA. In the case where there is little to choose between certain options in the appraisal table it Is not uncommon for multiple options to be carried forward.

Outputs: Techno-Economic Feasibility Analysis- Weighted Multicriteria analysis

Evaluation Matrix:
A comprehensive matrix summarizing the scores for each sub-criterion. This matrix offers transparency and insight into how each option was evaluated across different dimensions, such as financial performance, operational feasibility, strategic alignment, and environmental impact.

Weighted Scores:
The output includes weighted scores for each heat supply option. These scores allow stakeholders to understand the relative importance of each criterion and how it contributes to the overall assessment.

Preferred Option Identification:
Based on the weighted scores, the output clearly identifies the preferred heat supply option. This allows for an informed decision that balances various key factors.

Decision Justification:
The section should include a brief justification for the preferred option, explaining how it aligns with the project's objectives and why it stands out among the alternatives.

Counterfactual Scenario Comparison:
The output should also address a counterfactual scenario, demonstrating how the preferred option compares to alternative solutions. This helps in validating the robustness of the decision.

11 Detailed Techno-Economic Feasibility Analysis: Financial & Sensitivity Analysis of the preferred option

This section presents an in-depth Technical-Economical analysis of the preferred DH heat supply option identified in Chapter 10. It integrates technical, economic, and environmental assessments to determine the viability of the proposed district heating solution identified in the study.

Outputs:

Financial & sensitivity analysis outputs:
More in-depth look at financial modelling of the preferred heating option (IRR, NPV, Cashflow, etc.) and discussing the sensitivities which will inform the risk register.

List of key inputs & variables to the financial model such as:

- Technical inputs
- Costing and financial inputs
- CAPEX, REPEX and OPEX costs
- Residual value
- Revenues

List of model outputs/results such as:

- Cashflow
- NPV
- IRR
- Simple Payback Period

Carbon evaluation
Evaluation of carbon savings up to 2050 of the proposed DH option to the BAU scenario.

11.1 Objective and Scope of a financial assessment

A financial analysis is a way to evaluate the financial impact and affordability of a proposed project through the assessment of net cash flows resulting from its implementation.[30] The financial analysis should include an analysis of the different technical options being considered, including a preferred DH option, and potentially a business-as-usual case or counterfactual.

A financial analysis only considers the affordability and financial impact, as distinct from an economic analysis which considers social and economic impacts on society. While the scope of this section is limited to financial analysis, a financial analysis is a useful starting point for an economic analysis.

A financial analysis has four stages:

1. Definition and assessment of key variables and inputs.
2. Definition of key outputs.

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[30] Department of public expenditure and reform, Public Spending Code
: https://assets.gov.ie/204635/906a266f-5a3c-4352-9777-5ea7585de55e.pdf

3. Construction of financial model based on key inputs and outputs.
4. Sensitivity analysis.

From the chosen inputs a cash flow should be created to assess the finances of the project throughout an agreed period. The cash flow will allow the assessment of other key outputs and financial parameters including Net Present Value (NPV), Internal Rate of Return (IRR) and Payback period. Following this a sensitivity analysis should then be performed to assess the effect of key variables on the financial parameters, and bias, uncertainty and risk should also be taken into consideration through various approaches.

Table 20 below provides a brief overview of the key considerations and methodology for a district heating financial analysis, including key inputs, outputs, options for sensitivity analysis and defining factors not included.

Table 20 - Overview of District Heating Financial Analysis Methodology

Key Variables & Inputs	Key Outputs	Options for Sensitivity Analysis[31]	Not included
Section 11.2	***Section 11.3***	***Section 11.4***	***Section 11.2.3***
Technical Inputs			
Capex (Capital Expenditure)	Cashflow	CAPEX	Commercial structuring
Opex (Operational Expenditure)	Net Present Value	Fuel prices	Corporate cash resources
Revenue	Internal Rate of Return	Discount rate	Corporate financing
Energy prices	Payback period	Customer payments	Project finance (equity & debt)
Asset replacement (REPEX)		Demand risk	
Discount rate		Coefficient of performance	
Taxation		Optimism bias	
Outputs from technical analysis		Grant funding	
Assumptions (incl. grant funding)			

11.2 Model Inputs

This section focuses on the inputs required for the financial analysis of a district heating (DH) system. Key decisions regarding the project's direction, such as connections and heat demand, route analysis, and

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[31] Note – due to the complexity of sensitivity analyses across multiple dimensions, it is not typically practical to carry out sensitivity analyses for all of these variables and a sub-set may be chosen.

equipment types, are typically made during the technical analysis stage. These decisions, along with various costing and financial inputs, guide the subsequent financial analysis.

11.2.1 Technical Inputs

The technical assessment should outline a recommended development option, covering the following aspects:

- **Energy Demands:** The heat demand assessment identifies potential customers and key anchor loads. This information helps calculate energy supply costs and customer connection revenues. It's essential to assess the sensitivity of customer connections to ensure the scheme's viability.

- **Heat Sources and Storage**: The energy models used for plant sizing provide details on heat sources, storage capacity, operational hours, day/night split, supply split, and COP/efficiency. This data informs energy supply and operational/maintenance costs.

- **Phasing:** The scheme may be phased to manage investment risks. The technical assessment should detail the phases, timing, and customers included, affecting CAPEX, OPEX, and revenue sections of the cash flow analysis.

- **Network Length:** The technical assessment should provide details on network length for each phase, enabling accurate network cost assessment.

- **Review of Energy Demands, Network, and Plant Sizing**
  At this stage, it's advisable to review the energy demand, heat sources, and network details for accurate cost evaluation. Potential review tasks may include:

    - **Energy System Modelling:** Conduct a detailed analysis of energy load requirements to ensure the proposed system accurately meets demand profiles. This step enhances system efficiency and reliability.
    - **Distribution Network Size and Layout Review:** Critically assess the network's configuration to optimize the integration of primary and backup heating plants. Key focus areas include network sizing and layout for efficient operation.
    - **Plant Sizing Assessment:** Evaluate the size of primary and secondary heating systems, focusing on optimizing total costs and assessing the feasibility of phased equipment installations. This analysis ensures practical and cost-effective system sizing**.**

11.2.2 Costing and Financial Inputs

RESOURCES & TOOLS:
Space requirements, expected lifespans and costs for different technologies can be found in the latest technology catalogue for district heating from the Danish Energy Agency: https://ens.dk/en/our-services/projections-and-models/technology-data/technology-data-generation-electricity-and

Cost estimates should be based on relevant previous projects where available and be informed by estimates of inflation and risk.

Independent peer review, benchmarking and reference class forecasting may be used to improve the accuracy of cost estimates. Section 4.2.1.1 of the Public Spending Code Financial Appraisal Guidelines provides further detail on approaches to costing[32]. Available cost information specific to district heating projects has been collated as part of developing this guide, however it is the responsibility of the project appraiser to make decisions based on the information available at the time of the analysis. This may include specific cost information provided by suppliers for the proposed DH network.

The Infrastructure Guidelines also provide supplementary "Guidance calculating and valuing greenhouse gas emissions in economic appraisal"[33]. This document sets out the shadow price of carbon which is used to account for the monetary cost of GHG emissions to society and have become a standard requirement when evaluating public spending.

11.2.3 Context of Financial Analysis - Project Development and Financing Not included.

The **route to market and business model** will likely not be decided at this stage. The financial model should be independent of the business model at the feasibility study stage. At the feasibility study stage, the financial model remains independent of specific operational parameters such as equity or loan financing structures, tariff schemes, or revenue models, ensuring a neutral evaluation that does not presuppose any business strategy.

Funding, financing and costs of capital will likely be uncertain at this stage. If so, the model may be used to assess different funding and financing scenarios using the sensitivity analysis.
Funding for district heating projects often comes from a combination of:

- Equity
- Loans
- Grants
- Developer contributions

As with all large public good infrastructure projects a degree of grant funding will likely be required to catalyse development. District heating infrastructure is no different and will likely require initial public funding support to allow it to develop. Large-scale District Heating networks in Ireland to date have availed of grant funding through the government's Climate Action Fund. Two large-scale projects have secured €24.5 million in funding through the CAF. There is currently no potential funding stream solely for DH. The SEAI also provide grants for Heat Pumps and Biomass installations (SSRH) which also apply to the heat production plant of a district heating networks.

Internal rates of return (IRR) are a key financing factor and will vary from project to project. A key differentiator influencing IRR is whether a project is privately funded or publicly funded, public projects can have lower rates of return, and private projects significantly higher. Other factors that can influence IRR include; grant availability, heat supply, phasing of Capex etc.

After the initial phase of investment is secured, and once the concept has been demonstrated to operate successfully, it may be possible to secure low-cost long-term loans to roll out further phases of the project,

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[32] Department of Public Expenditure and Reform, Public Spending Code; Carrying Out a Financial Analysis (2021))https://www.gov.ie/pdf/?file=https://assets.gov.ie/204635/906a266f-5a3c-4352-9777-5ea7585de55e.pdf#page=null

[33] Department of Public Expenditure and Reform, Infrastructure Guidelines Supplementary Guidance; Measuring & Valuing Changes in Greenhouse Gas Emissions in Economic Appraisal (2024)https://www.gov.ie/pdf/?file=https://assets.gov.ie/291235/6ecda5db-529b-46a3-ae82-c016857ad78a.pdf#page=null

or similar investment from pension fund investors. Other options which have worked successfully for new energy systems in Nordic countries are the establishment of Energy Cooperatives or crowd-funded systems. If so, the financial model may be used to assess different funding and financing scenarios using the sensitivity analysis.

Any **general information** about the project such as commencement, duration, phasing, expansion, configuration that is not provided by the technical assessment should be considered and analysed in the financial model.

To account for the time value of money, the cash flow should include consideration of the following:

- **Discount rate.** The discount rate is used to calculate the NPV and allows the conversion of future cash flows to a present value. For public sector projects, the current recommended Discount Rate is 4%.[34] However, if a commercial State Sponsored Body is discounting projected cash flows for commercial projects, the cost of capital should be used or even a project-specific rate.

- **Inflation**. The inflation rate refers to the annual price and cost increase over time. Inflation types include general inflation and construction cost inflation. Current guidance from the Department of Public Expenditure and Reform for public sector projects is to apply the discount rate excluding projected inflation[35].

11.2.4 Capital Costs & Operation Costs

Refer to the TEA Part 1 (Chapter 10) for a description of all capital costs, capital replacement, and operational costs of the preferred district heating (DH) system option. This section should evaluate costs in greater detail and with more accuracy than the previous section.

11.2.5 Revenue evaluation within the detailed technical-economical (feasibility) study

Existing developments

To assess the economic benefit of the scheme, revenues from heat, cooling and power sales (where applicable) shall initially be determined by setting these equal to the total heating costs (fuel, maintenance and capital replacement (ie boiler replacement)) that the customer would have incurred over the same period if retaining the existing equipment in operation, i.e. the overall avoided costs.

Revenue values should be estimated throughout the analysis lifespan. It's important to note that fossil fuel boilers of existing systems should not be considered beyond the period 2035-2040 due to the ban on fossil fuel boilers as per the latest Energy Performance in Buildings European Directive EPBD (2024).

New development

For new developments, the prevalent form of conventional heating used in similar developments at the time of the study (e.g., individual heat pumps) should be used as a counterfactual basis for determining revenue values (costs of counterfactual system).

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[34] Department of Public Expenditure and Reform, Public Spending Code Overview of Appraisal Methods and Techniques: https://www.gov.ie/pdf/?file=https://assets.gov.ie/43559/7b11c37290a44eceb1d59459abf4deb2.pdf#page=null

[35] Department of Public Expenditure, NDP Delivery and Reform, Project Evaluation/Appraisal: Applicable Rates (2023): https://www.gov.ie/en/policy-information/1a0dcb-project-discount-inflation-rates/

Consideration of alternative revenue assumptions is also valid, for instance, addressing fuel poverty. As well For the current feasibility study, revenue value estimations are to be derived from the categories previously discussed.

11.3 Key Model Outputs

11.3.1 Cash Flow

A cash flow will need to be modelled to assess the finances of the project throughout an agreed period. The cash flow will allow the assessment of other financial parameters including Net Present Value (NPV), Internal Rate of Return (IRR) and Payback period.

11.3.2 Net Present Value (NPV)

The Net Present Value (NPV) of the system is a key financial indicator. It is a parameter that is used for long-term projects to calculate the proposed net value of the project over a specified period by discounting projected cash flows to account for the time delay in receiving them. The period over which the NPV is analysed will depend on the project, however as the lifetime of the district heat network is usually estimated to be around 40 years, this period may be appropriate.

The NPV should be positive for the project to be financially viable. It is important to note that when considering public projects, many public capital projects have a negative return, but will have significant economic or societal benefits which may outweigh the negative financial impact.

11.3.3 Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) is a metric used to estimate the return on investment. A positive IRR indicates the cash flows from an investment are higher than the amount of the initial investment, while a higher IRR indicates a better return on investment.

11.3.4 Simple Payback Period

This is the time taken to return the initial capital expenditure. It is helpful to contribute to a high-level project evaluation, however it doesn’t take into account the time value of money or the inflow of cash after the payback period.

11.3.5 Other

The model should also evaluate total Capex, total Opex and total revenues, net cash from operation, tax and net cash from operation after tax.

11.4 Sensitivity Analysis, Uncertainty, Bias and Risk

This section evaluates the potential risks associated with a district heating (DH) system, particularly in terms of its financial and operational performance. The section covers various topics, including sensitivity analysis, bias, uncertainty, and risk management. The goal is to assess how changes in key variables might impact the system's outcomes and to outline strategies for managing potential risks.

11.4.1 Sensitivity Analysis

Sensitivity analysis can be used to assess how the values of key variables change the outputs of the financial analysis. Any variables which will likely have a significant result on the output of the financial analysis should be analysed using a sensitivity analysis. Key variables in a financial analysis may include funding, capital costs, fuel price, customer payments, demand risk and efficiency of the system.

- **Capex.** A reasonably accurate estimate of the capex of the system should have been developed through the creation of the financial model. However, to account for unforeseen risks and contingencies, it is useful to do a sensitivity analysis to assess various capex scenarios. The counterfactual capex cost can also be compared.
- **Fuel price**. Since the fuel prices are likely to fluctuate, it can be very useful to perform a sensitivity analysis on the price of fuel. It is also useful to compare the price of fuel supply to the counterfactual scenario.
- **Discount Rate**. It may be useful to assess the effect of different discount rates on the financial model outputs. While there is a standard value for the public sector, commercial organisations would typically apply a higher discount rate, but using a range of values can help assess the sensitivity of this variable.
- **Customer paymen**ts make up most of the revenue for a district heating scheme. For this reason, the results are highly sensitive to changes in these figures. It is important consider a range of connection scenarios, and identify anchor loads, i.e., buildings which have a large heat demand for long periods of the day. The financial analysis will help reveal which customers are critical to the success of the project. The financial viability of the scheme can be improved by obtaining a letter of intent or memorandum of understanding. The sensitivity analysis can also compare the proposed customer payments with the counterfactual scenario.
- **Demand risk.** This refers to the concept that the customers may not consume the same amount of heat as modelled. The higher the element of variable pricing, the higher the demand risk. The financial analysis should assess several scenarios to understand the extent of this risk.
- **COP.** The efficiency of the heat pump, also known as the Coefficient of Performance (COP), will likely have a major effect on the financial outcomes of a project. A sensitivity analysis should be performed to assess the effects of a range of expected COPs.

11.4.2 Bias, Uncertainty and Risk

In addition to a sensitivity analysis, other steps which may be taken to manage the risk, bias and uncertainty include accounting for optimism bias, including contingency costs and conducting a risk assessment.

Contingency costs should be used to account for the fact that the estimated costs, benefits and delivery schedules may not reflect what was expected due to uncertainty, risk and bias. Reasonable contingency costs should be specified and incorporated based on previous similar projects.

Optimism bias is the demonstrated and systematic tendency for project appraisers to be overly optimistic.[36] Optimism bias can be assessed by adjusting the forecasted cash flows for optimism bias or considering these biases through sensitivity analysis or scenario testing. In the Green Book, the UK has developed guidance on optimism bias in capital expenditure, with recommended adjustments for different project types. This may be applied to the capital costs excluding contingency allowances.

The sensitivity analysis and optimism bias assessment will reveal critical success factors for the project that will feed into the **risk assessment**. The risk assessment discussed in the following chapter (Chapter 12) should:

- Ensure the input data and assumptions are realistic and reliable.
- Identify risks and assess their likelihood.
- Develop a strategy for managing and mitigating risk.
- Communicate the risk management strategy to stakeholders.

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[36] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/191507/Optimism_bias.pdf

11.5 Carbon emissions abatement

This section provides a detailed assessment of carbon emissions for the preferred district heating (DH) options compared to the Business-As-Usual (BAU) scenario. The carbon evaluation plays a crucial role in understanding the environmental impact of DH solutions compared to the present-day heating system.

Purpose:

- The carbon evaluation aims to compare the carbon emissions of the preferred DH options against the BAU scenario up to 2050. This analysis helps stakeholders understand the potential environmental benefits or drawbacks of different DH strategies.

Methodology:

- The analysis should leverage the data from the techno-economic feasibility study. Carbon emissions are assessed based on the expected energy consumption, heating technologies used, and other relevant factors for each option.
- The evaluation should account for direct emissions from heating systems and indirect emissions associated with energy production, aligning with relevant industry standards and regulations.

Comparative Analysis:

- The section should present a clear comparison between the preferred DH preferred option covered in this analysis and the BAU scenario. This includes a breakdown of emissions sources, highlighting the key drivers of emissions for each scenario.

Environmental Impact:

- The carbon evaluation could discuss the broader environmental impact, including potential contributions to climate change and alignment with sustainability goals.

Conclusion:

- The section should conclude with a summary of the findings, identifying the carbon savings offered by the prefer DH option or aligns best with environmental objectives.

12 Risk Assessment

Risk assessment outputs:

- Initial risk register which considers initial key risks to the project (technical, environmental, financial/economic, reputational, commercial, planning, health &safety) – will include the risk identified, the risk severity rating and mitigation measures.

12.1.1 Risks to Achieving a High-Quality Feasibility Study

Before discussing the risk to develop any DH network prosed in a feasibility study, it is worth mentioning that there are also risks that impact the quality of a DH feasibility report. The process set out in this guide should address many of the risks/issues encountered when conducting a feasibility study.

12.1.2 Overview of Project Development Risks

Different risks will be addressed at different points in a project's development. This section of the guide outlines risks that are typical of most DH projects being brought forward for further development and risks that are specific to individual projects (many of these project specific risks are related to the different heat sources or customer types relevant to that project).

The risk identification process will inform the choice of business model (Section **Error! Reference source not found.**) and the procurement options appraisal (Section **Error! Reference source not found.**). Risk ownership will play an important role in these aspects of the feasibility study, so it may be useful to assign risk ownership to each risk for this purpose. This is discussed in further detail in section 12.1.4.1.

Project risks generally fall into one of the following categories:

- **Technical risks** (generally these can be broken down into heat supply, heat distribution and heat demand/customer) e.g. performance of heating plant and heat loss in the network
- **Health and Safety**
- **Environmental risks** e.g. noise, cold nuisance and vibrations from heat pumps
- **Financial/Economic** risks e.g. loss of funding, increasing interest rates on loans, increasing fuel prices, increased capital costs
- **Reputational risk** e.g. heat price required is too high for connected customers, customer acceptance of availability, level of service is poor, etc.
- **Commercial risk** e.g. demand risk, customer connection risk
- **Planning risk** e.g. Planning permission, land availability, etc.

These risks are generally captured in the form of a risk register. In order to gain an understanding of the relative importance of the risk these are assigned a score rating in terms of likelihood of the risk occurring and the impact this would have on the project. A typical risk register and methodology for scoring risks can be seen in the sections below.

12.1.3 Scoring the Impact and Likelihood of Risks

This section of the guide indicates how risks might be scored within a project risk register. These scores are between 1 and 5 and relate to both the likelihood and impact of the risk. The combined risk severity score indicates the level of action be taken to address each risk. The tables below show what this score mean in terms of both impact and likelihood.

Table 21: Impact Scoring Description

Score	Impact	Description
1	Negligible	Insignificant impact
2	Low	Cost of impact is minor and, in most cases, can be easily absorbed by the project.
3	Moderate	Cost of impact is noticeable, but in most cases can be absorbed by the project. Project requirements would still be met.
4	High	Cost of impact is major. Ability to achieve secondary project requirements may not be achieved
5	Severe	Result in inability to achieve the minimum project requirements

Table 22: Likelihood Scoring Description

Score	Likelihood	Description
1	Rare	Will likely never happen
2	Unlikely	Not expected to happen but could do so
3	Possible	Might happen occasionally
4	Likely	Will probably happen
5	Almost certain	Will almost certainly happen

The combined severity score for each risk is a function of both the likelihood and the impact of the risk as described in the tables above (the scores for likelihood and impact are multiplied by each other). This gives the overall risk score and determines the level of action required with respect to each risk.

Table 23: Combined Risk Severity Scoring Table

Combined Severity Score		Likelihood				
		Rare (1)	Unlikely (2)	Possible (3)	Likely (4)	Almost Certain (5)
Impact	Negligible (1)	1	2	3	4	5
	Low (2)	2	4	6	8	10
	Moderate (3)	3	6	9	12	15
	High (4)	4	8	12	16	20
	Severe (5)	5	10	15	20	25

The combined severity scores relate to the required level of action to be taken. The table below indicates the level of action relevant to each severity level.

Table 24: Level of action required for each risk level

Risk Severity Score	Risk Level	Description
1-3	Very Low Risk	No additional actions required
4-7	Low Risk	Minor risk which is unlikely to warrant further action
8-14	Significant Risk	Moderate risk which will require further consideration during the development of the project to mitigate
15 or more	High Risk	Major risk which will almost certainly requires additional control and mitigation measures

12.1.4 Risk Register

The risks to the project are generally captured in the form of a risk register. At this stage of the project development such a register would generally include the risks identified under the categories listed above, provide a scoring of each of these risks in terms of impact and likelihood which will determine the overall risk rating and then recommend mitigation actions to address these risks where necessary (where the risk severity scoring warrants this). The table below does not provide an exhaustive list of risks and is just to provide some examples, however, a more complete list of 49 general risks that are common to many DH networks can be found in the Heat Network Detailed Project Development Resource: Economic and Financial Case report developed by BEIS in the UK[37].

RESOURCES & TOOLS: A list of 49 common risks to DH projects can be found in the Heat Network Detailed Project Development Resource: Guidance on Economic and Financial Case – Development of the Financial Model, Heat Pricing and Maximising Opportunities developed by BEIS in the UK - https://assets.publishing.service.gov.uk/media/5b2a1f7440f0b634c6141400/Economic_and_Financial_Case_development.pdf

Table 25: Risk Assessment Table – Including Some General DH Project Risk Examples

Risk Category	Risk Description	Likelihood (1 – 5)	Impact (1 – 5)	Risk Severity Rating (L x I)	Mitigation
Technical	Poor design increases cost of heat supply	4	5	20	Ensure minimum quality standards are included in procurement and that the award criteria and subsequent contract with the ESCo building the network includes penalties to ensure that the ESCo is assigned this design risk.

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[37] AECOM, Heat Network Detailed Project Development Resource: https://assets.publishing.service.gov.uk/media/5b2a1f7440f0b634c6141400/Economic_and_Financial_Case_development.pdf

Risk Category	Risk Description	Likelihood (1 – 5)	Impact (1 – 5)	Risk Severity Rating (L x I)	Mitigation
Commercial	Customers do not connect to the network	3	5	15	DH Company to ensure early & continued engagement with potential customers & system planning, ensure competitive pricing of heat, seek alternative financing for retro-fitting DH into existing buildings.
Financial	Contract delays mean loss of funding	2	5	10	Project management structure will be put in place, Funded elements to be invoiced and delivered as a priority in construction timeline.
Planning	Not enough interest for competitive tender process	3	3	9	Gauge market interest through 2-stage procurement process
Technical	Poor quality demand data available leading to sub-optimal sizing of network and plant	5	4	20	Detailed monitoring of building heat use prior to design stage (where possible to incorporate peak heating season). Where data cannot be found consider installing temporary heat meter (particularly on larger loads).
Planning	Limited space available for Energy Centre	2	5	10	Look at heat supply options that can fit within the space available, engage with other land owners in the area to assess availability of further land.
Planning/Technical	Grid connection capacity not available for heat pumps and/or electric backup boiler	3	5	15	Engage with grid operator as early as possible to secure grid capacity. Include contingency in grid connection cost to account for possible need for increased cost of accommodating connection. Endeavour to keep required grid capacity as low as possible by ensuring high efficiency of system and critically assessing factors of safety on plant sizing

12.1.4.1 Updates to Risk Register in Future Project Development Stages

Following the feasibility stage, mitigation actions will be refined/added/removed to reflect the latest information and the higher level of detail required as part of the further detailed project development stages. While not required during the feasibility stage it is likely that at future stages of development further columns may be added to the risk register. These may include:

- Risk Allocation – who will be assigned this risk will it be retained by the DH developer, transferred to another party or shared.
- At what point in the project's development is risk best addressed (may be multiple steps) – during contracting/detailed design/construction/operation?
- Will the risk be managed within a contract?
- Residual Risk – is there any residual risk following the implementation of mitigation actions and if so, how will this be monitored going forward.

12.1.5 Example Risks Associated with Specific Heat Sources

The table below provides a non-exhaustive list of risks to consider when investigating specific heat source options for a DH network.

Table 26: Potential Risk Examples for Specific Heat Sources

Heat Source	Potential Risks
Deep Geothermal	• Uncertainty about the available capacity of the subsurface (permeability and temperature gradient) • Uncertainty around licencing and permitting and the length of process required to secure such a permit. • Accurate equipment and drilling costs tend to be location specific and are often unavailable. • Large demand required for highest levels of cost-effectiveness. • Potential environmental impacts – seismicity, impact on water table and local ecosystems, radiogenic gas release • Insurance • Public support – as a result of misinformation regarding seismicity, noise & vibration • Relatively long construction time of typically 4.5 years
Shallow Geothermal	• Space availability • Consider need to recharge ground to avoid degradation of ground temperature over time. • Competition with other low carbon heating technologies such as ASHPs • Access to collector buried under ground. • Securing required size of electricity grid connection
Air-source heat pumps	• Space availability • Environmental impacts – noise, cold nuisance, visual impact, refrigerants • Performance of heat pump is affected by ambient conditions, resulting in lower efficiencies during periods of cold weather when heating is required most. • Securing required size of electricity grid connection • Increased electrical consumption can lead to reduced revenues for the DH operator resulting in a negative financial outlook for the scheme
Surface Water	• Abstraction license for large water use in open loop systems • Environmental impact on fisheries and local flora and fauna (reduction in water temperature)

Heat Source	Potential Risks
	• Performance of heat pump is affected by ambient conditions, resulting in lower efficiencies during periods of cold weather when heating is required most. • Grid connection for heat pump
Sea Water	• Abstraction license for large water use in open loop systems • Environmental impact on fisheries and local flora and fauna (reduction in water temperature) • Grid connection for heat pump • Saltwater environment leading to corrosion • Levels of filtration required for open-loop systems to prevent ingress of particles/dirt/sea life (e.g. mussel seeds) that can affect performance or damage the HP system
Solar Thermal	• Space availability • Periods of lower solar irradiance tend to coincide with high heat demand, resulting in lower system efficiencies. • Intermittency of supply with seasonal daily and weather variations • Lack of established supply chain
Waste-to-Energy	• Improved waste management practices could reduce availability of waste in the future – Although given the scale of waste relative to capacity of WtE in Ireland this is less of a concern. • Reduced electricity production from WtE plant due to waste heat capture from turbines – may require reimbursement
Waste Heat from Industry	• Low levels of interest or awareness of potential from the waste heat owner • Heat collector sometimes in harsh environment (high temperature, high moisture content, corrosive substances) could result in more expensive HEX or reduced lifespan. • Potential closure of industrial site • Loss of heat supply due to change of on-site processes. • Where using low temperature waste streams will need to boost with HPs – grid connections. • Potential disruption to primary business of heat source owner when integrating waste heat with DH network – will need to be planned appropriately to address this. • Specific requirements of industrial site when integrating with their systems – water quality, interaction/compatibility between control logics, etc.
CHP	• Environmental considerations – noise, air quality, vibration • Dependent on fossil fuels – less acceptance of this going forward and availability of waste heat is subject to dependency on cheap fossil fuels. Alternative fuels are more expensive and do not currently have a robust supply chain
Bioenergy	• Bioenergy has scalability limits in comparison with other resources, as the lowest carbon bioenergy sources will have many competing use cases. • Additional space requirements are needed for bioenergy storage, and further considerations about traffic impacts of high volumes of bioenergy supply in city locations. • To minimise air quality impacts and potential for pollution associated with bioenergy there may be a requirement for emissions abatement equipment installed in the plant. • Affordability of fuel dependent on proximity to supply. • Double contracts for security of supply are often required which creates

Heat Source	Potential Risks
	contracting complexities for DH operators
Waste Water Treatment Plant	• Need to maintain temperature of feed water to WWTP in order for biological processes to occur. • Temperatures vary with ambient when considering connection to tertiary tanks. • Scaling of heat exchangers leading to poor efficiency • Available grid capacity for HP

13 Conclusions and Recommendations

This chapter aims to provide a synthesis of key findings and analysis from the study. It offers a clear direction on the project's potential viability, highlighting the critical factors that may influence the decision-making process.

Outputs:

Conclusions:
This section summarises the conclusions from the techno-economic analysis undertaken. This includes:

- **Summary of the key findings; technical viability and financial analysis.**
- **Assessment of Benefits and Challenges**:
- **Feasibility Conclusion**

Recommendations:
- **Strategic actions**
- **Policy, Panning, Regulatory advice.**
- **Stakeholder engagement**

Next Steps:
- **Immediate actions**
- **Timeline**
- **Responsible parties/resources**

13.1 Conclusions

The conclusions section provides a concise summary of the study's main findings and assesses the overall viability of the project. It helps stakeholders understand the implications of the findings, guiding their decision on whether to proceed with the project. Additionally, it sets the foundation for the recommendations by offering a clear and reasoned assessment of the project's potential success or failure.

The conclusions section of the district heating feasibility study should include the following elements:

1.**Summary of Key Findings**:
- Technical Viability: Summarise the technical analysis, including the heat demand to be met, anchor loads and phasing, availability and suitability of heat sources, backup supply and storage needs, infrastructure requirements (network route, network construction (insulation level, pipe construction material, etc.) and technology options.
- Financial Analysis: Highlight the financial findings, such as NPV, simple payback period, cost estimates, potential funding sources, economic benefits, and return on investment.

2. **Assessment of Benefits and Challenges**:
- Environmental Impact: Summarise the potential environmental benefits, such as reductions in greenhouse gas emissions and improved noise/ air quality.
- Community Benefits: Discuss the social and economic benefits for the community, such as job creation, energy security, and cost savings for residents.
- Risks and Mitigation: Identify the major risks and summarise the proposed mitigation strategies.

3. **Feasibility Conclusion**:

- Overall Feasibility: Provide a clear statement on whether the district heating project is feasible based on the technical, financial, and environmental analyses.
- Decision Guidance: Offer a recommendation on whether to proceed with the project, suggest modifications, or abandon it.

By including these elements, the conclusions section will effectively summarise the feasibility study and provide a solid foundation for making informed decisions.

13.2 Recommendations

The recommendations section translates the comprehensive analysis of the feasibility study into practical, strategic advice, ensuring that informed and effective decisions are made. The recommendations are backed by data and analysis presented in the feasibility study, providing a solid rationale for the suggested actions. Based on the work undertaken in the feasibility study, the recommendations section serves several important purposes.

- Summarising key findings
- Providing rationale and guidance for decision-making
- Addressing stakeholder concerns
- Facilitating planning and implementation
- Identifying the need for revisiting and confirming key data, validating assumptions.

The recommendations section of a district heating feasibility study should include the following elements:

1. **Preferred Technical Solution**: Identify the optimal heat source, network route, pipe construction, and energy centre location derived from the technical analysis. Include specifications such as insulation level, pipe construction material, backup supply, and thermal storage size.
2. **Project Viability:** State whether the project is viable based on the financial analysis, including IRR, NPV, and cash flow assessments. Discuss the economic feasibility and how the project aligns with funding and investment requirements.
3. **Carbon Savings:** Provide a comparison of carbon emissions against the business-as-usual scenario, quantifying the environmental benefits of the DH project.
4. **Strategic actions**: specific actions or strategies to address identified issues
5. **Policy, Planning and Regulatory Advice**: Suggestions for navigating regulatory landscapes and securing necessary approvals.
6. **Stakeholder Engagement**: Guidance on how to engage and communicate with stakeholders effectively.

13.3 Next steps

While this is not considered a core or key part of the techno-economic analysis being undertaken here, it may be useful to outline concrete, actionable steps that stakeholders can follow based on the findings of the feasibility study, to advance the project from the feasibility stage to the more detailed business case development stage. This outlines the next steps required for project planning and implementation, providing a roadmap for moving forward. The timing and order of these are subject to the client's preferences and plans, however all are intended to assist de-risking the project and maximising its likelihood of delivery and commercial success.

The next steps section of a district heating feasibility study should include the following elements:

1. **Immediate Actions:** Specific tasks that need to be initiated promptly, such as detailed project planning, securing funding, or conducting further technical assessments or financial/ economic analyses.
2. **Timeline:** A clear timeline for these actions, often with short-term milestones.

3. **Responsible Parties:** Identification of who will be responsible for each action, ensuring accountability and clarity.

13.4 How to use the Accompanying Supplementary Guidance

Following completion of this feasibility study, the transition to the next stage in the DH development cycle (Fig. 2); the development of a detailed business case represents a crucial phase in the planning and execution of a district heating project. Feasibility studies typically assess the technical and economic viability of projects but often require more detailed and specific planning for actionable decision-making. This supplementary guide provides structured guidance to bridge the gap between the exploratory phase of feasibility studies and the comprehensive planning needed for the detailed business case stage.