

South West  
**NET ZERO  
HUB** 

# PLYMOUTH CITY COUNCIL - PLYMOUTH COMMUNITY HOMES

## Heat Decarbonisation Options Appraisal

Scene Connect

28th April 2026

*Prepared by Scene Connect Ltd.  
on behalf of the South West Net  
Zero Hub*



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# CONTENTS

Contents.....	3
Executive Summary .....	8
1. Introduction .....	10
2. Planning and Regulatory Context.....	13
3. Understanding & Applying User Behaviour .....	19
4. Baseline Energy Assessment.....	22
5. Technical Appraisal.....	28
6. Financial Appraisal.....	39
7. Recommendations .....	55
Appendix A - Detailed Technical Appraisal .....	61
Appendix B - City-wide Heat Network Technical Review .....	94
Appendix C – Baseline Methodology.....	98
Appendix D - Internal Temperature Analysis.....	101
Appendix E - Predicted RdSAP score Improvements.....	107
Appendix F – References.....	109

# Tables, Figures, and Acronyms

## Figures

Figure 2.1 - Heat Network Zones identified within the Plymouth Study Area.....	18
Figure 4.1 - Overview of site locations. ....	25
Figure 5.2 Tavy, Tamar, Lynher Heating System Specifications (Dark Blue = Water Immersion Heater) .....	31
Figure 5.3 Woodland's Court Heating System Specifications (Dark Blue = Water Immersion Heater) .....	32
Figure 5.4 Star Block Heating System Specifications (Dark Blue = Water Immersion Heater) ....	33
Figure 5.5 K/L Block Heating System Specifications (Dark Blue = Water Immersion Heater) .....	34
Figure 5.6 Easiform Block Heat System Specifications (Dark Blue = Water Immersion Heater) ...	36
<i>Figure 6.1 – High Rise 1-3: Resident Costs</i> .....	42
Figure 6.2 – High Rise 1-3: Comparison of Lifetime Costs .....	43
Figure 6.3 – High Rise 1-3: Greenhouse Gas Emissions .....	43
Figure 6.4 – Woodlands Court: Resident Costs .....	44
Figure 6.5 – Woodlands Court: Comparison of Lifetime Costs .....	45
Figure 6.6 – Woodlands Court: Greenhouse Gas Emissions.....	45
Figure 6.7 – Star Block: Resident Costs.....	46
Figure 6.8 – Star Block: Comparison of Lifetime Costs.....	47
Figure 6.9 – Star Block: Greenhouse Gas Emissions .....	47
Figure 6.10 – K/L: Resident Costs.....	48
Figure 6.11 – K/L: Comparison of Lifetime Costs .....	49
Figure 6.12 – K/L: Greenhouse Gas Emissions .....	49
Figure 6.13 - Easiform: Resident Costs.....	51
Figure 6.14 - Easiform: Comparison of Lifetime Costs .....	51
Figure 6.15 - Easiform: Greenhouse Gas Emissions .....	52
Figure 7.1 - Implementation pathways across archetypes .....	58
Figure 0.1 – Location of the Devonport High Rises .....	63
Figure 0.2 - Location of Woodlands Court.....	68
Figure 0.3 - Location of Star Blocks .....	73
Figure 0.4 - Location of K/L Blocks.....	79
Figure 0.5 - Location of Easiform Blocks and Plymouth City HNzs.....	85

## Tables

Table 4-1 - Breakdown of residential block typologies.....	22
Table 4-2 - Median whole-block total annual energy demand before efficiency losses .....	26

Table 4-3 - Median total annual energy demand (before efficiency losses) per flat for each block type .....	26
Table 4-4 Fabric upgrade options per block type.....	27
Table 5-1 Overview of sites and archetypes and heating system suitability.....	28
Table 5-2 - Technical appraisal summary for Tavy, Tamar, and Lynher House .....	30
Table 5-3 - Technical appraisal summary for Woodland's Court.....	31
Table 5-4 - Technical appraisal summary for the Star Block Archetype .....	32
Table 5-5 - Technical appraisal summary for the K/L Block Archetype .....	33
Table 5-6 - Technical appraisal summary for the Easiform (6771) Archetype.....	35
Table 5-7 Easiform Flat Archetypes .....	36
Table 6-1 – Recommended LCHO across sites / archetypes .....	40
Table 6-2 – ‘Alternative’ LCHO options across sites / archetypes .....	40
Table 6-3 – Comparative DHN financial performance (bulk and retail supply – central scenarios) .....	40
Table 6-4 - Summary of shortlisted options (central scenarios) .....	41
Table 6-5 - Summary of shortlisted options (central scenarios) .....	44
Table 6-6 - Summary of shortlisted option (central scenarios) .....	46
Table 6-7 - Summary of shortlisted option (central scenarios) .....	48
Table 6-8 - Summary of shortlisted option (central scenarios) .....	50
Table 0-1 - Key Financial Terminology .....	54
Table 0-1 - Assumed seasonal air temperatures for Plymouth. ....	62
Table 0-2 - Borehole input assumptions for Local Heat Network GSHP appraisal .....	62
Table 0-3 - Heat decarbonisation options appraised for Lynher, Tavy, and Tamar House.....	63
Table 0-4 - Heating options appraisal demand inputs .....	64
Table 0-5 - Air-source heat pump parameters .....	65
Table 0-6 - Indicative communal heat network pipework quantities .....	66
Table 0-7 - City-wide DHN technical requirements for Tavy House, Tamar House and Lynher House.....	66
Table 0-8 - Heat decarbonisation options appraised for Woodlands Court.....	68
Table 0-9 Heating options appraisal demand inputs.....	69
Table 0-10 - Air-source heat pump parameters .....	69
Table 0-11 - Indicative communal heat network pipework quantities .....	70
Table 0-12 - Energy hub parameters.....	71
Table 0-13 - Borehole calculation results.....	71
Table 0-14 - Indicative communal heat network pipework quantities.....	72
Table 0-15 - Heat decarbonisation options appraised for Star block archetype.....	73
Table 0-16 - Heating options appraisal demand inputs.....	74
Table 0-17 - Indicative scaling of Star Block heating solutions .....	74
Table 0-18 - Air-source heat pump parameters .....	75
Table 0-19 - Indicative communal heat network pipework quantities.....	76
Table 0-20 - Energy hub parameters.....	76
Table 0-21 - Borehole calculation results.....	77
Table 0-22 - Indicative communal heat network pipework quantities.....	78

Table 0-23 - City-wide DHN technical requirements for Star Block .....	78
Table 0-24 - Heat decarbonisation options appraised for K/L block archetype.....	80
Table 0-25 - Heating options appraisal demand inputs.....	80
Table 0-26 - Air-source heat pump parameters .....	81
Table 0-27 - Indicative communal heat network pipework quantities .....	82
Table 0-28 - Energy hub parameters.....	82
Table 0-29 - Borehole calculation results .....	83
Table 0-30 - Indicative communal heat network pipework quantities .....	84
Table 0-31 - City-wide DHN technical requirements for K/L Block .....	84
Table 0-32 - Heat decarbonisation options appraised for Easiform block archetype.....	86
Table 0-33 - Heating options appraisal demand inputs.....	86
Table 0-34 - Air-source heat pump parameters .....	87
Table 0-35 - Indicative communal heat network pipework quantities .....	88
Table 0-36 - Energy hub parameters.....	88
Table 0-37 - Borehole calculation results .....	89
Table 0-38 - Indicative communal heat network pipework quantities .....	90
Table 0-39 - Distributed ASHP parameters for each Easiform flat archetype .....	91
Table 0-40 - Indicative communal heat network pipework quantities .....	92
Table 0-41 - City-wide DHN technical requirements for Easiform Block .....	93
Table 0-1 - Key Financial Terminology .....	<b>Error! Bookmark not defined.</b>

## Acronyms

Acronym	Description
ADE	Association for Decentralised Energy
AMR	Automatic Meter Reading
ASHP	Air Source Heat Pump
AZP	Advanced Zoning Programme
CAPEX	Capital Expenditure
CCC	Climate Change Committee
CDD	Cooling Degree Days
CIBSE	Chartered Institution of Building Services Engineers
COP	Coefficient Of Performance
CPI	Consumer Price Index
DESNZ	Department of Energy and Net Zero
DHN	District Heat Network
DHNCS	District Heat Network Connection Study (Buro Happold, 2026)
DHW	Direct Hot Water
DPCV	Differential Pressure Control Valve
ESCO	Energy Services Company

EPC	Energy Performance Certificate
EWI	External Wall Insulation
GBE	Great British Energy
GHG	Greenhouse Gas Emissions
GIFA	Gross Internal Floor Area
GIS	Geographic Information System
GSHP	Ground Source Heat Pump
GW	Gigawatts
HDD	Heating Degree Days
HEM	Home Energy Model
HIU	Heat Interface Unit
IMD	Index of Multiple Deprivation
IRR	Internal Rate of Return
LCOE	Levelised Cost Of Energy
LCOH	Levelised Cost Of Heat
LCHO	Low Carbon Heating Options
LTHW	Low Temperature Hot Water
MEES	Minimum Energy Efficiency Standards
MJ	Megajoules
MS	Multi-storey
NESO	National Electricity Systems Operator
NPPF	National Planning Policy Framework
NPV	Net Present Value
OPEX	Operating Expenditure
PCH	Plymouth Community Homes
PICV	Pressure Independent Control Valve
REPEX	Replacement Expenditure
RFI	Request For Information
SAP	Standard Assessment Procedure
SCOP	Seasonal Coefficient Of Performance
SHDF	Social Housing Decarbonisation Fund
SHF	Social Housing Fund
SPF	Seasonal Performance Factor
SWNZH	South West Net Zero Hub
TFA	Treated Floor Area

# EXECUTIVE SUMMARY

This study assesses the technical options, capital cost implications, and investment options for four residential block typologies within Plymouth Community Housing's housing stock.



**Traditional (K/L type) block**



**Easiform block (series 6771)**



**Star design block**



**High rise tower block**

These buildings, many located in Plymouth's heat network zone, are coming up for renewal of their heating systems. Existing systems are mainly individual combi gas boilers. Plymouth Community Homes and Plymouth City Council seek to better understand potential heat decarbonisation pathways for these homes. The study provides a detailed options appraisal of connecting to different heating solutions, including the feasibility of connecting Plymouth Community Homes' residential blocks to the city's planned heat networks, which are a strategic priority for Plymouth City Council in meeting its pledge for a carbon neutral city.

For each of the four common block types, the study has undertaken a technical assessment identifying any significant technical barriers of implementing the following low carbon heating technologies:

- Connect to a 4G district heat network
- Direct electric heating
- Ground-Source Heat Pump array
- Air-Source Heat Pumps

The study provides a financial assessment comparing technically suitable low carbon heating options with business-as-usual gas boiler replacement, in respect of:

- Estimate of capex costs;
- Estimate of maintenance and opex costs;
- Estimate of tenant fuel costs to 2050;
- Cashflow analysis, economic indicators (NPV, IRR, payback) and funding requirements;
- GHG emissions to 2050 and the cost of carbon;
- Change to EPC rating and SAP assessment brought about by the installations.

The solution's likelihood of success has also been assessed considering requirements around tenant engagement, training and behaviour.

The results of the technical and financial modelling indicate that if the heat network is able to deliver a retail connection with charges similar to those stated in the District Heat Network Connection Study (prepared independently by Buro Happold, 2026), this is the recommended option for all archetypes within the heat network zone:

For the High Rise Blocks in Devonport (Tavy House, Tamar House and Lynher House), connection to the district heat network is recommended as the most technically and financially appropriate solution for both PCH and residents, even under the high connection charge scenario. At Woodlands Court - situated outside of the District Heat Network Zone - a local Ground Source Heat Pump network is the most viable low carbon solution.

At all other block types (Star, K/L, Easiform), further engagement with the city-wide District Heat Network is required in order to make connection decisions on a strategic and conditional basis. If connection can be agreed on a retail basis and with connection charges similar to those stated in the District Heat Network Connection Study, this is the recommended option. If connection on a bulk supply basis is required, moderate reductions to the stated connection charges are required. Otherwise, and for all locations not serviced by the District Heat Network, local Ground Source Heat Pump Heat Networks (and in the case of Easiform, distributed Air Source Heat Pumps) are the recommended alternative solution.

Connection cost thresholds to define the price point at which the recommended option changes from the District Heat Network to the alternative, have been provided to aid decision making by archetype.

For all 'central' scenarios (low and high scenarios were also modelled for sensitivity analysis), the whole-life cost of heat for the preferred low-carbon heat alternative *is higher than the counterfactual option of installing new gas boilers*. This could result in additional costs for residents, assuming gas prices remain low, on top of the already significant projected increases to annual Plymouth Community Home costs. DESNZ is also working to reduce the current disadvantage that electrically led heat networks have against gas.

Delivery should follow a phased, archetype-led programme that prioritises District Heat Network connection where viable, while retaining flexibility to deploy alternative low carbon heat options where these provide better financial outcomes.

Progression should initially focus on retail District Heat Network supply scenarios across all sites, with the exception of Woodlands Court. Where retail District Heat Network supply is not feasible or does not deliver an acceptable cost position, bulk supply arrangements should be investigated alongside detailed internal works design, costing and ownership analysis to define viable technical and commercial solutions. Where both retail and bulk District Heat Network options result in higher costs than alternative low carbon heat options, schemes should progress to the design and delivery of the preferred alternative Low Carbon Heat Option for those sites. In parallel, Woodlands Court should be advanced as a standalone Ground Source Heat Pump demonstrator to establish delivery capability, inform future communal system deployment and provide an early operational benchmark.

# 1. INTRODUCTION

Scene Connect Ltd (Scene) has been appointed by the South West Net Zero Hub (SWNZH) to undertake this low carbon heat options (LCHO) appraisal for the most common building typologies within the housing stock of Plymouth Community Homes (PCH), working with Plymouth City Council (PCC).

This study assesses the technical options, capital cost implications, and investment options for four residential block typologies within PCH's housing stock. The study provides a detailed options appraisal of connecting to different heating solutions, including the feasibility of connecting PCH's residential blocks to the city's planned heat networks, which are a strategic priority for PCC in meeting its pledge for a carbon neutral city.

The study provides the necessary detail to enable evidence-based decisions for investment and grant funding for PCH going forward, and reference data for feasible heat network connections. The outputs also support an understanding of heat decarbonisation options for residential blocks beyond those specifically assessed in this study.

## Project Overview

PCH's domestic housing stock includes four common block types repeated across the city.



**Traditional (K/L type) block**



**Easiform block (series 6771)**



**Star design block**



**High rise tower block**

These buildings, many located in Plymouth's heat network zone, are coming up for renewal of their heating systems. Existing systems are mainly individual combi gas boilers. PCH and PCC seek to better understand potential heat decarbonisation pathways for these homes.

For each of the four common block types, the study has undertaken a technical assessment identifying any significant technical barriers of implementing the following low carbon heating technologies:

- Connect to an ambient 5G district heat network
  - directly or
  - through a 4G energy centre.

- Direct electric heating
- Ground-Source Heat Pump array
  - centralised plant
  - individual heat pumps
- Air-Source Heat Pumps
  - centralised plant
  - individual heat pumps

The study provides a financial assessment, comparing each of the above options with business-as-usual gas boiler replacement, in respect of:

- Estimate of capex costs;
- Estimate of maintenance and opex costs;
- Estimate of tenant fuel costs to 2050;
- Cashflow analysis, economic indicators (NPV, IRR, payback) and funding requirements;
- GHG emissions to 2050 and the cost of carbon;
- change to EPC rating and SAP assessment brought about by the installations.

The solution's likelihood of success has also been assessed considering requirements around tenant engagement, training and behaviour.

The study provides recommended heat decarbonisation pathways for each block type, inside and outside heat network zones.

## Project Partners

### **South West Net Zero Hub (SWNZH)**

The South West Net Zero Hub is an initiative funded by the Department for Energy Security and Net Zero (DESNZ), providing impartial advice, technical support and funding to public and not-for-profit organisations to accelerate emission reductions and support the transition to a sustainable future. The Hub is one of five Local Net Zero Hubs in England and works with over 30 Local Authorities across the southwest, supporting the development of business cases and investment-ready energy infrastructure projects. In addition to regional project support, SWNZH delivers large-scale programmes including domestic retrofit and public sector decarbonisation, while also supporting community energy initiatives and sharing best practice across the region. The West of England Mayoral Combined Authority acts as the Accountable Body, with this project managed by SWNZH staff within the Combined Authority, who are the Client to the Contract.

### **Plymouth City Council (PCC)**

Plymouth City Council declared a climate emergency in March 2019 and committed to achieving carbon neutrality by 2030. Heating and hot water account for approximately 28% of Plymouth's emissions, and PCC is therefore progressing the long-term delivery of a city-wide heat network to support its decarbonisation ambitions and wider sustainability objectives. Plymouth forms

part of the Advanced Zoning Programme (AZP), which aims to bring 10-15 heat network projects to market ahead of zoning regulations. A phased city centre heat network has been developed, with Phase 1 linking multiple networks to a South West Water treatment plant via a 5G ambient spine, connecting directly to buildings or via 4G energy centres. PCC is currently procuring a commercial partner to deliver, own and operate the network. The scheme will be commercially owned under a Golden Share model, with PCC retaining oversight, and will operate under Ofgem regulation.

### **Plymouth Community Homes (PCH)**

Plymouth Community Homes, formed from a transfer of PCC housing stock, is the city's largest social housing provider, managing over 16,000 properties. Nationally, social housing accounts for around 4 million households (17% of England's total), with residential buildings contributing approximately 20% of UK greenhouse gas emissions. Government support for decarbonisation includes the Social Housing Decarbonisation Fund (SHDF), with £3.8bn committed over 10 years, now continuing through the Warm Homes: Social Housing Fund (SHF). PCH's Environmental Strategy commits to achieving a minimum EPC rating of C by 2030 and net zero by 2050. The near-term focus on the 2030 target presents a risk of defaulting to gas boiler replacement, rather than adopting lower carbon but more complex heat decarbonisation solutions.

### **Scene Connect Ltd (Scene)**

Scene is a specialist consultancy in community and local energy with a strong track record in delivering decarbonisation and renewable energy projects - working with many communities, developers, public sector, and landowners alike. The company was founded in 2011 and operates as both a practitioner and research organisation, providing market research and engagement services supported by a tangible development portfolio and associated technical expertise. Scene is the technical consultancy which has undertaken this feasibility study in partnership with PCC and PCH.

## 2. PLANNING AND REGULATORY CONTEXT

A review of relevant environmental and planning legislation, regulations and policy in relation to the development context is presented in this chapter. The following reference sources are of relevance:

- National legislation and policy documents, including The Climate Change Act 2008, (HM Government, 2008), Heat and Buildings Strategy, (HM Government, 2021), Powering Up Britain (HM Government, 2023), Energy Act (HM Government, 2023), Net Zero Strategy: Build Back Greener (HM Government, 2021), Environment Act 2021 (HM Government, 2021) and National Planning Policy Framework (2021)
- Relevant national policy on heat decarbonisation for social housing and flats, such as the Heat and Buildings Strategy (2021), Future Homes and Buildings Standards (due 2025), Social Housing Decarbonisation Fund, Minimum Energy Efficiency Standards (MEES), and Net Zero Strategy (2021).
- The Plymouth Advanced Zoning Programme, PCC Heat Network Feasibility Studies, PCH Environmental Strategy (2021-2026), PCC Net Zero Action Plan (2022-2025), Plymouth Plan (2014-2034), and Devon Carbon Plan (2022).

### National Context

There are several relevant UK Government policies and strategies which underpin the UK's ambitions and progress in relation to energy and carbon. PCH's low carbon ambitions fall within the aims of these policies, meaning development proposals are likely to start with a presumption of support from planning policies.

The UK government aims to reduce emissions to net zero by 2050. This is to be achieved across multiple different sectors, focusing on low carbon innovation, the green economy and supply chains, low carbon technologies and services, warm and comfortable homes powered by clean and affordable energy, zero emissions vehicles, and protection of the natural environment. Specifically in relation to heat in buildings, national goals aim to improve the energy efficiency of all homes to EPC band C by 2030, to grow the market in heat pumps to 600,000 installations per year by 2028 (DESNZ, 2023), and through designating zones where district heat networks are expected to offer the lowest-cost solution for decarbonising heat to accelerate the development of heat networks.

#### Climate Change

The UK is a leading country in terms of climate change policy and action. It has made considerable progress, reducing emissions by 48% on 1990 levels, including a reduction of 3% between 2018 - 2019 (CCC, 2019). This has largely been driven by renewable power deployment

and a large reduction in coal use. The UK also benefits from a strong policy framework for climate commitments in the form of the Climate Change Act (2008).

## Energy Policy

The Clean Power 2030 Action Plan aims to accelerate the transition to renewable energy and reduce carbon emissions, investing an estimated £40bn per year between 2025 - 2030. Key goals include expanding offshore wind (43-50 GW), solar (47 GW), wind (29 GW), and hydro capacity, energy storage (31 GW), nuclear power, modernizing energy grids, and phasing out other high-emission sources. It prioritises energy efficiency, clean technology innovation, and electrification of transport and industries.

The policy focuses on investment in electricity generation infrastructure and network infrastructure, including investment in energy network upgrades and smart energy infrastructure, as well as changes to planning and consenting, to ensure that projects can progress through the planning and grid connections systems more smoothly. Lastly, the action plan seeks to deliver electricity market reform, proposing greater levels of storage capacity and flexible connections, as well as reform in how network use costs are determined and applied. In turn, this may allow for local energy supply and management within the UK power grid. A publicly owned National Energy System Operator (NESO) was officially launched on October 1st, 2024. NESO unifies electricity and gas network planning under a single entity and will collaborate with Great British Energy to integrate new generation projects into the electricity grid.

Great British Energy (GBE) is anticipated to be a delivery vehicle for this investment and / or implementation, including policy measures which specifically support community-led renewable capacity and other forms of local energy development, via the Local Power Plan.

As part of the plan, Great British Energy will provide up to £1 billion in funding for local authorities and communities via grant funding, low-cost loans, direct investment and development support (GBE, 2025). It will also collaborate with energy companies, local authorities, and cooperatives to develop up to 1,000 renewable power projects and generate up to 8GW of renewable energy by 2030.

The UK Government's **Warm Homes Plan** (announced January 2026) establishes a national framework for large-scale domestic energy efficiency improvement and electrification of heat. Backed by £15 billion of public investment to 2030, the programme aims to upgrade up to five million homes through fabric improvements, low-carbon heating, and domestic renewable technologies. By reducing overall energy demand and improving dwelling efficiency, the plan supports lower system loads, reduced consumer bills, and improved affordability outcomes, particularly for low-income households and social housing tenants. The associated Warm Homes Fund also provides low- and zero-interest finance to stimulate supply chains and accelerate uptake of clean energy technologies.

## Heat Policy

Heat accounts for over a third of the UK's annual greenhouse gas emissions, estimated at 468 MtCO<sub>2</sub>e, with 18% of all carbon emissions driven by energy use for household heating. Meeting

the UK's net zero targets will require decarbonising nearly all heat in buildings as well as across commercial and industrial processes. Reducing carbon emissions from household heating will require a combination of reducing energy demand by making homes more energy efficient and converting heating systems that use fossil fuels to a low-carbon alternative (*Decarbonising Home Heating, 2024*).

The benefits of decarbonising heat in buildings are clear: reduced energy bills, more comfortable environments, and better performing households (*Heat and Buildings Strategy, 2021*). The affordability of heat lies at the heart of fuel poverty: integrating low carbon heating solutions needs to be delivered in parallel with reducing fuel poverty for over 2.4 million households in the UK (*Heat Decarbonisation: Potential Impacts on Fuel Poverty, 2017*). The UK government has committed to tackling fuel poverty and has set out initiatives such as leveraging the Warm Homes Fund and providing support for low-income households to switch to low carbon heating, noting this as an important part of the UK's transition towards Net Zero (*Sustainable Warmth, 2021*). To this end, heat networks have been identified as a recommended "low-regret" solution to be taken forward, classed as such due to its cost-effectiveness in both the present and the future (*Clean Growth - Transforming Heat, 2018*).

The Warm Homes Plan is expected to become the principal delivery mechanism for residential heat decarbonisation across the UK. The programme prioritises the replacement of fossil fuel heating systems with clean heating technologies, including air- and ground-source heat pumps, alongside coordinated fabric upgrades to improve performance and reduce peak heat demand. Social housing is identified as a priority sector for area-based retrofit and network-scale interventions, with funding support for both individual heat pump installations and communal or shared heating solutions.

For typologies such as those assessed in this study, the policy direction aligns closely with heat network deployment and heat pump-led solutions, improving the feasibility of both communal and building-level low-carbon heating options while reducing delivery risk through grant funding and low-cost finance.

Heating is one of the most difficult sectors of the economy to decarbonise. Buildings primarily use natural gas for heating, with 86% of households in the UK connected to the gas grid, and shifting away from this reliance on natural gas presents a significant challenge. A leading obstacle here is cost: an estimated £162b in investment is required through 2050 to install low carbon heating in existing UK homes (*Decarbonising Home Heating, 2024*). Around 20% of households would be exempt from the government's plans to phase out fossil fuel boilers in 2035, such as those in densely populated urban areas and blocks of flats, citing reasons such as a lack of space to install heat pumps. To combat this, DESNZ intends to invest around £530m in heat networks, seen as the next major alternative low carbon technology for inhabitants of such areas, between 2025 and 2028 (*House of Commons, 2024*). Another £270m has been allocated towards the Green Heat Network Fund, which introduces sector regulation and new heat network zones (*Net Zero Strategy: Build Back Better, 2021*).

DESNZ estimates that while only 3% of total heat demand is currently supplied to buildings through heat networks, there is potential for that to expand to around 20% by 2050 (*UK Heat*

*Networks - Market Overview, 2024*). Core to this growth is heat network zoning, a system that designates geographic zones where heat networks are the likely lowest cost solution for decarbonising heat. The government is working to produce a framework that can deliver this on a national scale and has selected Plymouth alongside 27 other English cities and towns for a pilot study to refine the heat network zone identification methodology (*Heat Network Zoning, 2024*).

Action at the national level creates the enabling environment; local authorities are responsible for the delivery of heat network schemes. Local authorities hold a ‘general power of competence’ that grants them broad-ranging powers to develop growth strategies (*Localism Act, 2011*) such as those involving large-scale development of heat networks and are well-placed to make decisions on low carbon heating solutions with their understanding of local housing stock and residents’ needs. More recently, DESNZ established the framework to scale up heat networks across the UK, intending local authorities to play a key role in the planning, delivery and monitoring of heat networks through a new Zoning Coordinator role (*Energy Act 2023*). Local authorities will move to a more central, delivery-facing role by leading on procurement and contracting, as well as zone identification and demand mapping.

## **Planning Policy**

While Permitted Development rights apply to some low-carbon heat options (e.g. air source heat pumps and internal works within a building such as a Heat Interface Unit to connect to a heat network, or a ground-source heat pump to connect to a share ground-loop), in other circumstances planning permission will be required for new development (e.g. to erect a building or structure to accommodate an energy centre, or for energy services infrastructure). National Planning Policy Framework (NPPF) provides the planning framework at the national level across England.

In respect to energy development, there are several important sections within the NPPF which are laid out below. Whilst these sections provide the justification, guidance and policy base for energy planning, all sections of the NPPF must be considered in respect to any planned development.

It addresses topics that are relevant to the economic, environmental, and social sustainability of development proposals, including but not limited to:

*2. Sustainable Development states that, ‘at the heart of the Framework is a presumption in favour of sustainable development,’ meaning development plans should seek to promote development which meets the development needs of their area; aligns growth and infrastructure; improves the environment; mitigates climate change; and adapts to its effects.*

*11. Making Effective Use of Land states that ‘Local planning authorities, and other plan-making bodies, should take a proactive role in identifying and helping to bring forward land that may be suitable for meeting development needs,’ which includes identifying opportunities for development as considered within this study.*

*12. Achieving well-designed places, highlights the need to remain sympathetic to local character and history (including built environment and landscape setting), whilst*

*optimising the scale and extents of development. Where available, development must follow local design guides or the national design guide and code in their absence.*

## Local Context

In 2019, Plymouth City Council unanimously voted to declare a Climate Emergency, pledging to make Plymouth carbon neutral by 2030. An action plan was subsequently prepared that targeted the elimination of scope 1 and 2 emissions and support the Council's drive towards net zero by 2030. With around 26% of the city's greenhouse gas emissions attributable to heating, transitioning towards the decarbonisation of domestic and commercial heat supply became one of the action plan's main focus points. Exploring and implementing heat networks have therefore risen as a key priority in Plymouth's drive towards net zero. (Net Zero Action Plan, 2025).

As part of the UK Government's Advanced Zoning Programme, Plymouth was selected by the government to partner in supporting the development of new zonal scale heat networks. The pilot study saw the identification of zones using spatial energy models and stakeholder engagement to determine where the most attractive heat network development opportunities lie. A total of 17 potential heat network zones were identified, including two of high strategic significance, referred to as 'strategic' zones. These zones are mainly centred in the South Coast area, as well as Derriford to the north (*Heat Network Opportunity - Plymouth, 2025*).

The success of the Heat Network Zoning pilot programme saw Plymouth's inclusion in the Advanced Zoning Programme, paving the way for £400m of investment into the development of heat network infrastructure in the city. As part of Plymouth's Delivery Plan for the next decade, the Council will be working with local stakeholders to develop and operate two zonal heat networks in the city, specifically in the city centre and the Derriford areas (*Economic Strategy, 2024*). Once operational, these heat networks will be able to deliver heat at a capacity of 7,500 MWh per year, cutting up to 10% of Plymouth's carbon emissions (*Action Plan Progress Report, 2024*). Rather than gas or other fossil fuels, the two heat networks will utilise large waste heat supplies as a primary heat source: two industrial plants in the southern area and a waste incinerator in the northern area will meet the heating and cooling demands of the heat networks' users (*Heat Network Exchange, 2025*).

The delivery of heat networks, such as the two zonal heat networks and future developments, plays a crucial role in Plymouth City Council's modern Economic Strategy, where sustainable growth and productive growth and high-value jobs form key pillars of the strategy. The strategy's delivery plan also focuses on innovation that embraces net zero and strives to grow clean energy infrastructure across the city. Similarly, the development of quality jobs and valuable skills are part of the Plymouth Plan, promoting the procurement and operation of heat network infrastructure and driving the city's decarbonisation efforts (*Plymouth Plan, 2021*). Facilitating this growth also sees raised productivity and improved living standards among Plymouth's urban and rural communities.

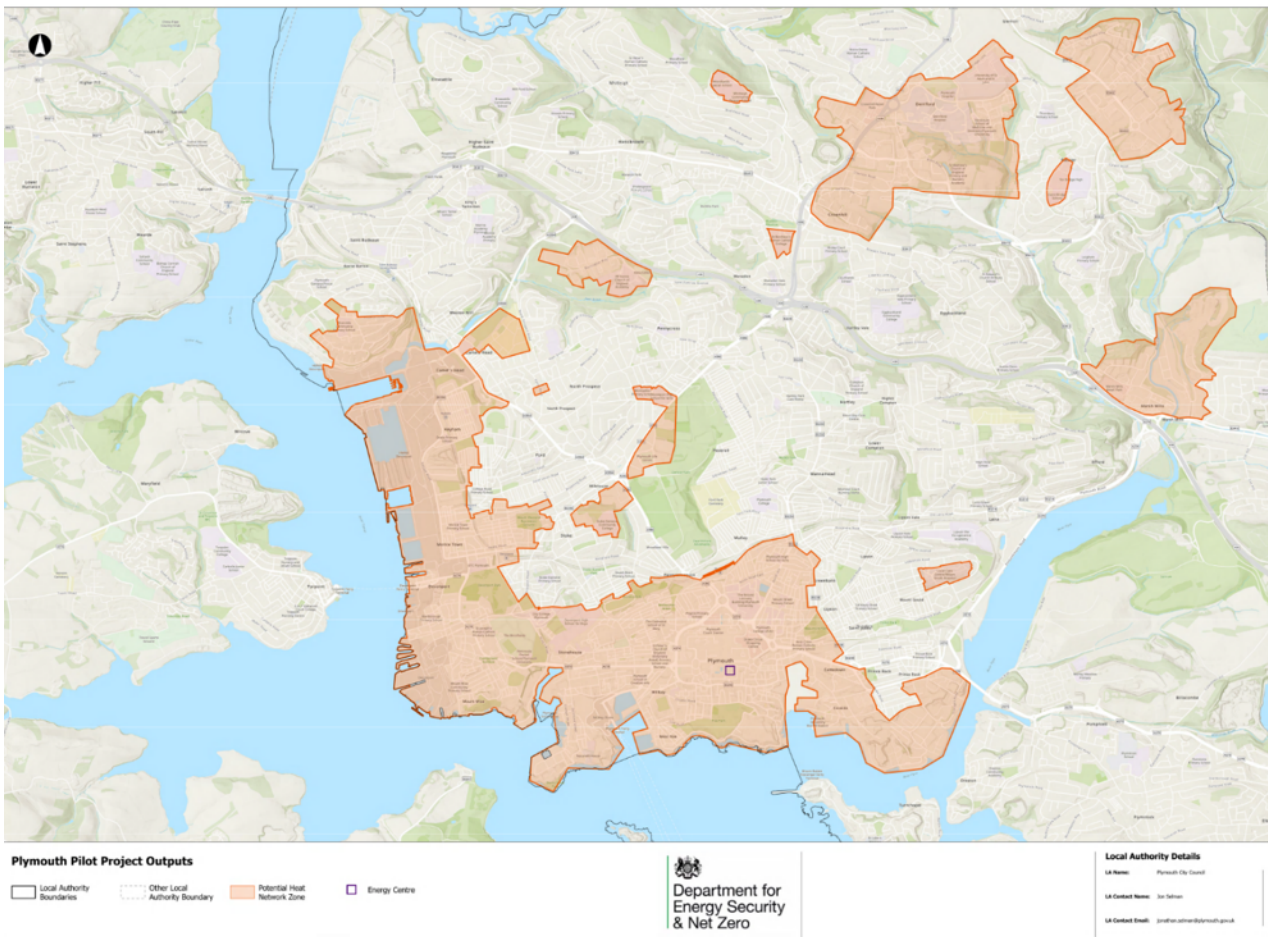


Figure 2.1 - Heat Network Zones identified within the Plymouth Study Area

Due to its critical role in the region’s plans for a low carbon future, the delivery of low carbon development was incorporated into a joint local plan produced by Plymouth and South West Devon, setting out strategic policies for sustainable growth. A key part of this policy includes increasing the use and production of decentralised energy and delivering low carbon heating systems to properties and households. Future domestic and commercial developments will also be required to connect to existing heat networks or be designed to be capable of connecting to a network in the locality. To increase the level of decentralised energy while mitigating the impact of growth on climate change, the Plan also mandates that new major developments must deliver a proportional contribution to renewable energy generation capacity, recognising heat networks using low carbon sources as a primary solution (*Joint Local Plan, 2019*).

# 3. UNDERSTANDING & APPLYING USER BEHAVIOUR

As part of the study, a comprehensive assessment was undertaken to understand how different occupancy types may influence heating and hot water use across all Low-Carbon Heating Options (LCHOs). This work drew directly on the specification requirements to incorporate behavioural sensitivities into technical and economic modelling and to evaluate tenant engagement, training needs, and implications for long-term system performance.

## 1. Review of Evidence and Case Studies

A literature and case-study review were conducted focusing on user behaviour in social housing settings equipped with heat pumps, communal heating, and heat network connections. This investigation highlighted several behavioural drivers that materially affect heating demand, system efficiency, running costs, and overall satisfaction. Key insights include:

- **Response to new heating technologies:** Tenants in heat pump deployments frequently require significant support to adapt from high-temperature, on-demand gas heating to lower-temperature systems operating more continuously (BEIS, 2020; EST, 2013).
- **Control interface usability:** Where occupants have unclear or overly complex controls, cases showed inconsistent use, increased reliance on boost or immersion functions, and higher seasonal bills (GLA, 2021).
- **Perceived control and fairness:** In heat network case studies, tenants express concern about fixed charges, the transparency of heat bills, and perceived lack of individual control, all of which shape consumption behaviours (BEIS, 2021; Ofgem, 2020).
- **Importance of early and continued engagement:** Projects that offer onboarding, in-home demonstrations, and early-season follow-ups reported more stable usage patterns and lower operational issues (Rosenow & Lowes, 2020; LSE, 2022).

Findings from this evidence base directly informed the development of PCH-specific behavioural archetypes and demand scenarios.

## 2. Development of Occupancy Archetypes

Using the evidence review, PCH demographic information, and observations from comparable social housing retrofits, four representative occupancy archetypes were developed to reflect the diversity of tenant lifestyles, comfort expectations, and energy awareness:

- **Comfort-Prioritiser:** Tend to maintain high set-points and prefer rapid thermal response. Under LCHO systems with slower ramp-up times (e.g., ASHPs), this group risks higher electricity use unless controls were well-managed.
- **Cost-Conscious Tenant:** Focus on minimising heat use to manage bills and was sensitive to tariff structures. Their behaviour influences peak-shaving potential but also introduced risks of under-heating in winter.

- **Technology-Confident Optimiser:** Quickly adapted to new interfaces, achieving higher system efficiencies. This group demonstrates strong alignment with heat-pump operating patterns and have potential to champion best practice within blocks.
- **Low-Engagement or Vulnerable User:** Include tenants with accessibility, literacy, or health barriers. They are most likely to misinterpret instructions or unintentionally disable optimal settings, emphasising the importance of tailored training and simplified controls.

These profiles are based on a comparative review of dominant archetypes within current literature (Huebner et al., 2021; KiWi Power & Innovate UK, 2018; EST, 2013; CCC, 2020; UKERC, 2020).

### 3. Behavioural Scenarios Across LCHOs

For each archetype, behavioural scenarios were developed to understand how real-world occupancy patterns would interact with the following heating options:

- **Air-Source Heat Pumps (Individual Units):** Scenarios examined variations in set-point choices, frequency of manual overrides, and likelihood of using supplementary heaters. Results were used to adjust system efficiency assumptions and model tenant cost range.
- **Ground-Source Heat Pump Systems (Centralised or Individual):** Modelling explored how behaviours influenced hot-water use, peak demand on shared GSHP arrays, and impact on long-term maintenance cycles.
- **Heat Network Connections (5G Ambient or 4G Secondary Network):** Scenarios assessed how tenants interacted with thermostats under perceived lower control and how consumption might vary with standing-charge-based tariffs.

These behavioural patterns were then embedded into load profiles and heating demand curves for each block archetype as absolute factors on energy consumption and diversity factors.

Occupancy models assume 2 adults per flat, with a single additional adult per additional bedroom, i.e. a 1-bed flat assumes 2 adults, and a 2-bed flat assumes 3 adults. Modelling incorporated metabolic gains and hot water use scaled to occupancy in all scenarios.

A single schedule for 9-to-5 workers was used to define occupancy and therefore heating schedules with a target temperature of 21°C and night-time setback of 16°C. Archetype-based methodology means that diverse occupancy times impact on peak-demand and the thermal-demand relative to the weather but has no impact on modelled party-wall-losses.

### 4. Impacts on Technical and Economic Modelling

The behavioural work produced quantifiable sensitivities for:

- Annual heat consumption and peak demand, influencing system sizing.
- Tenant fuel costs to 2050, particularly under electricity and heat-network tariff assumptions.
- System efficiency outcomes, reflecting realistic rather than theoretical SCOPs.
- Maintenance requirements and costs.

- Training needs and monitoring requirements, where vulnerable users or high-variability behaviours created additional risk (section 4.3.1).

These sensitivities were integrated into the technical and economic assessments, ensuring the recommended decarbonisation pathways reflect both engineering feasibility and real-world tenant behaviour.

### Tenant Training and Energy Monitoring

It is recommended that PCH adopt a structured tenant training and monitoring programme to ensure the successful operation of all low-carbon heating options (LCHOs). Evidence from comparable social housing schemes shows that tenant understanding and engagement are critical to achieving expected comfort levels, system efficiencies, and stable running costs. Training should begin before installation, with clear communication explaining the reasons for the heating upgrade, expected changes in system behaviour, and the support available.

**At installation**, all tenants should receive in-home handover training, including demonstrations of controls, guidance on how heat pumps or heat network systems operate, and simple printed quick-start materials. Particular attention should be given to occupants who may require enhanced support due to vulnerability, literacy challenges, or digital exclusion.

**Following installation**, PCH should provide follow-up support, including at the start of the first heating season. This helps correct early misunderstandings, optimise settings, and prevent avoidable increases in energy use. To protect system performance and tenant affordability, ongoing energy-use monitoring is recommended. Regular review of heat or electricity consumption will allow PCH to identify unusual patterns, such as excessive use or under-heating, and intervene early.

This approach will reduce long-term operational issues, support tenant comfort, and maximise the benefits of the selected LCHO pathways.

## 4. BASELINE ENERGY ASSESSMENT

This chapter presents the methodology and current energy situation ("baseline") for the four housing typology blocks and the individual flats within these blocks. This information is essential to understanding the energy, carbon and financial impacts of changing the existing heating systems to low carbon alternatives.

### Block types

Table 4-1 presents a breakdown of the residential block typologies considered in this study, relative to number of dwellings, blocks and emissions.

*Table 4-1 - Breakdown of residential block typologies*

BLOCK TYPE	NUMBER OF DWELLINGS	USUAL DWELLINGS PER BLOCK (AND RANGE)	NUMBER OF BLOCKS	NUMBER OF BLOCKS IN HEAT NETWORK ZONE	AVERAGE ANNUAL EMISSIONS PER DWELLING (TCO <sub>2</sub> E)	TOTAL EMISSIONS OF BLOCKS (TCO <sub>2</sub> E)
K/L	490	24 (12-40)	23	14	1.8	635
Easiform	430	6	73	24	2.1	888
Star	546	12	46	44	2.3	1,274
High rise	317	84 (66-84)	4	3	1.7	534
<b>Total</b>	<b>1,783</b>		<b>146</b>	<b>85</b>		<b>3,331</b>

### High Rise Multi-storey

There are four High Rise multi-storey (MS) blocks:

- Tavy House
- Tamar House
- Lynher House
- Woodlands Court

Tavy House, Tamar House and Lynher House are adjacent to each other in Devonport, and are located within the planned Heat Network Zone. Woodlands Court is to the north of the city, north of the Devon Expressway and not within a heat network zone.

### **Tavy House, Tamar House and Lynher House**

Each tower contains 90 flats<sup>1</sup> comprising a mix of bedsits, one and two bed properties. The ground floor contains utility and communal spaces, with 6 flats per floor over 15 inhabited floors. The blocks were constructed in the 1960's with concrete and have concrete floors (uninsulated); external rockwool cladding on walls with double glazing; and an uninsulated roof. Common areas are enclosed, but unheated.

The predominant heating system in the blocks is individual gas warm air heating. Hot water is typically electric immersion, with a few from a shared system. A small number of flat's EPCs stated electric room heaters, but for consistency all flats were modelled with gas warm air heating. The following parameters defined the archetypes:

- Floor (lowest, mid or top)
- Bedroom size (one or two)
- Corner or mid

This means 6 archetypes are modelled for each floor typology. Additionally, variations in orientation were modelled (grouped to a deviation of 22.5 degrees) as this is particularly relevant for passive solar gains (and potential for overheating).

### **Woodlands Court**

Woodlands Court comprises 66 flats, 6 to a floor across 11 floors, but otherwise has generally the same construction characteristics as the other three blocks and the same archetype parameters were used. Flats in this block also have mains gas individual boilers and radiators, with hot water from a shared system.

**In total, 36 different model runs were undertaken to represent the variation across the multiple flat types within the multi-storey blocks (336 flats in total).**

### **Star Blocks**

The Star Blocks are four storeys, with 3 flats to each floor (each flat forming a leg to the star). In some star configurations, the blocks are joined at one leg, extending the geometry. This is relevant from a building energy modelling perspective as the adjoining flats have two external walls rather than three (noting that the 4th wall joining the communal stair well is partially external and partially adjoining the communal area, which while enclosed, is unheated).

The Star Blocks were generally built in the 1950's. Roof insulation ranges from none to 400mm; wall insulation ranges from none to rockwool external wall cladding. All but two of the blocks (a double, at Alma Road) are located within the heat network zone, with three (a triple, at West Hoe Road), located within the AZP Phase 1. The following parameters defined the archetypes:

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<sup>1</sup> Not all the flats within the blocks are owned by Plymouth Community Homes, but all flats were modelled for the purpose of establishing the energy demand for each flat and the overall block.

- Floor (ground, mid or top)
- Block wing (left, long or right)
- Bedroom size (one, two or multiple)
- Standalone or adjoining
- Insulation levels

This means 7 flat archetypes are modelled for each floor typology. Additionally, variations in orientation were modelled (grouped to a deviation of 22.5 degrees) as this is particularly relevant for passive solar gains (and potential for overheating).

**In total, 396 different model runs were undertaken to represent the variation across the multiple flat types within the Star blocks (546 flats in total).**

### K/L Blocks

The K/L Blocks are brick built (with some walls with rendered facade) with external walkways for individual flat access on each floor. They are typically 4 or 5 stories, some with flats on the ground floor and others with shops. Stairwells are separate (no flat entrances directly from stairwells) and enclosed (unheated). Limited wall insulation, although there are a small number with EWI on some walls; there are thermal bridging implications from the external walkways which present a challenge to improving wall insulation. Roof insulation is varied, ranging from none to 200mm.

The K/L Blocks were generally built from the 1960's. Just over half of the K/L blocks are within the heat network zone. The following parameters defined the archetypes:

- Floor (ground, mid or top)
- Floor area (all are two bedroom)
- Terrace or end
- Insulation levels

This means 2 archetypes are modelled for each floor typology. Additionally, variations in orientation were modelled (grouped to a deviation of 22.5 degrees) as this is particularly relevant for passive solar gains (and potential for overheating).

**In total, 147 different model runs were undertaken to represent the variation across the multiple flat types within the K/L blocks (490 flats in total).**

### Easiform (6771) Blocks

The Easiform blocks are brick built with rendered facade. 3 stories, with flats on the ground floor, ranging from 6 to 18 flats per block, with 6 flats per unheated but generally enclosed stairwell. There is no external wall insulation. Roof insulation is varied, ranging from 75mm to 300mm. The Easiform blocks were generally built from the 1960's. 24 of the 73 Easiform blocks are in the neat network zone. The following parameters defined the archetypes:

- Floor (ground, mid or top)
- Terrace or end
- Insulation levels

This means 2 archetypes are modelled for each floor typology. Additionally, variations in orientation were modelled (grouped to a deviation of 22.5 degrees) as this is particularly relevant for passive solar gains (and potential for overheating).

In total, 204 different model runs were undertaken to represent the variation across the multiple flat types within the Easiform (6771) blocks (430 flats in total).

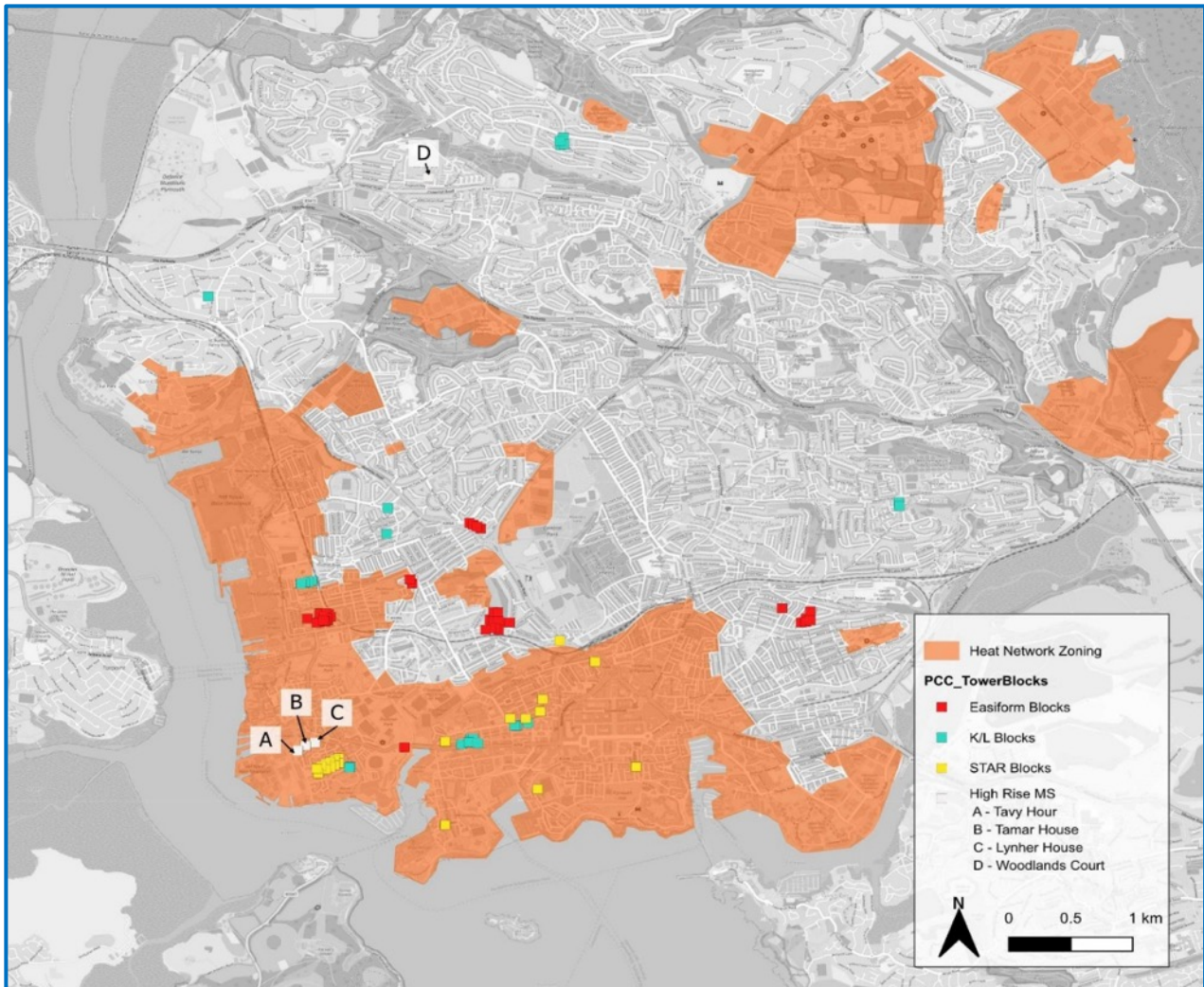


Figure 4.1 - Overview of site locations.

# Energy Demand

The outputs from the modelling provide the following results by flat and by block (archetype):

- Total energy demand (gas and electric)
- Energy end use (space heating/hot water/lighting)

Output values for total energy and for electricity and gas are available for annual and monthly totals.

Table 4-2 - Median whole-block total annual energy demand before efficiency losses

BLOCK TYPE	ANNUAL ENERGY DEMAND			DEMAND BY END USE	
	Total (kWh)	Electric (kWh)	Gas (kWh)	Heating (kWh)	Hot Water (kWh)
MS	612,116	362,795	249,321	249,321	223,689
STAR	242,333	24,848	217,486	163,408	54,078
Easiform	169,961	22,349	147,612	98,941	48,671
K/L	278,439	36,646	241,793	152,584	81,118

Table 4-3 - Median total annual energy demand (before efficiency losses) per flat for each block type

BLOCK TYPE	ANNUAL ENERGY DEMAND		DEMAND BY END USE			DEMAND PER FLOOR AREA	
	Total (kWh)	Electric (kWh)	Gas (kWh)	Heating (kWh)	Hot Water (kWh)	Total (kWh/m <sup>2</sup> )	Primary <sup>2</sup> (kWh/m <sup>2</sup> )
MS	6,010	3,535	2,475	1,786	2,130	122	94
STAR	13,681	1,922	11,760	7,704	4,056	205	181
Easiform	14,243	1,858	12,385	8,329	4,056	224	200
KL	12,281	1,797	10,484	6,428	4,056	242	205

<sup>2</sup> Primary energy refers to heating, hot water and lighting to be consistent with the SAP methodology used in EPCs.

# Fabric Improvement Options

In addition to the baseline energy results, the baseline demand assessment has confirmed the options available for fabric improvements which can be factored into the options appraisal for low-carbon heat options, and which options can be discounted at this stage as they are non-viable. It also considers the suitability of the existing heat distribution system for LCHO.

Table 4-4 Fabric upgrade options per block type

Archetype	Key Narrative / Constraints
Multi-storey	No further wall/window upgrades; potential ground floor, ceiling and roof insulation. Requires replacement of air heating with radiators.
Star	External wall insulation (e.g. Pembroke Street) scalable; potential roof insulation. Existing radiators can be retained.
K/L	No further wall/window upgrades; potential roof insulation. Existing radiators can be retained.
Easiform	Potential for external wall insulation and roof insulation. Existing radiators can be retained.

## 5. TECHNICAL APPRAISAL

This chapter provides a summary of the technical appraisal of all properties within the study, setting out the technical options for heat decarbonisation alongside high level system performance and design analysis. As with the baseline analysis set out in Chapter 3, this technical appraisal follows an archotyping approach to define each heating system's suitability and design.

The purpose of this chapter is to assess the technical feasibility of each heating system across the individual properties, rather than to identify a preferred option. Only those systems deemed technically feasible are taken forward for financial appraisal, where final recommendations are presented. The options appraised at each property or archetype include:

1. Gas boiler heating systems, as the baseline comparator for all other heating systems.
2. Individualised systems, including air-source units and electric heating units for individual homes at each site or archetype.
3. Centralised systems, including communal air- and ground-source heat networks for individual buildings or archetypes.
4. City-wide District Heat Network (DHN), connecting to the planned Plymouth Heat Network.

The full, detailed technical appraisal of each option for each block archetype can be found in **Appendix A - Detailed Technical Appraisal**. This includes energy demand inputs; system specifications; external and plant arrangements; internal distribution and dwelling interfaces; pipework quantities.

A technical review of the City-wide Heat Network requirements can also be found in **Appendix B - City-wide Heat Network Technical Review**.

Table 5-1 provides a list of properties and archetypes assessed alongside the technical solutions which have been considered appropriate and progressed to detailed analysis.

*Table 5-1 Overview of sites and archetypes and heating system suitability*

BUILDING NAME	BUILDING TYPE	CITY DHN	LOCAL DHN (ASHP)	LOCAL DHN (GSHP)	DISTRIBUTED ASHP	STORAGE HEATERS
Tavy House	High Rise MS	Yes	Yes	No	No	Yes
Tamar House	High Rise MS	Yes	Yes	No	No	Yes
Lynher House	High Rise MS	Yes	Yes	No	No	Yes

BUILDING NAME	BUILDING TYPE	CITY DHN	LOCAL DHN (ASHP)	LOCAL DHN (GSHP)	DISTRIBU-TED ASHP	STORAGE HEATERS
Woodlands Court	High Rise MS	No	Yes	Yes	No	Yes
Star Block Archetype	Star Block	Yes	Yes	Yes	No	Yes
K/L Blocks Archetype	K/L Blocks	Yes*	Yes	Yes	No	Yes
Easiform Archetype	Easiform Blocks	Yes*	Yes	Yes	Yes	Yes

\* Although technically suitable, not all properties in this archetype are within the heat network zone.

## Technical Assumptions

For this technical appraisal, heat pump performance has been modelled assuming a high-temperature system (75 °C flow), reflecting system constraints and compatibility with existing emitters. At these temperatures, efficiency is significantly lower than for low-temperature systems. Further detailed investigation of individual blocks may help to determine if lower temperatures are possible, which would reduce capital and operating costs and overall viability.

Analysis of real-world data from the UK Electrification of Heat Demonstration Project shows a clear relationship between flow temperature and seasonal performance (SCOP) for high-temperature ASHPs. Regression of this data indicates a SCOP of around 2.5 at 75 °C under typical UK conditions. Adjusting for Plymouth’s milder climate, a value of 2.7 has been adopted.

For GSHP systems, a higher SCOP of 3.2 has been assumed, reflecting more stable ground temperatures and modelled system outputs.

These values represent heat pump performance only and exclude wider system losses. For comparison, gas boilers have been modelled at 90% efficiency, storage heaters at 98%, and hot water immersion heaters at 80%. Operating at 75 °C reduces heat pump efficiency significantly compared to low-temperature systems, increasing electricity demand and operating costs.

Achieving higher network temperatures would typically require larger or cascaded heat pumps, two-stage or booster heat pump arrangements, all of which increase plant complexity, capital cost, and space requirements.

Ground-source systems have been modelled using a representative bedrock thermal conductivity of 2.1 W/m·K at 200 m depth, reflecting Plymouth’s mudstone-dominant Tamar Group geology with interbedded sandstone/limestone units and local groundwater influence. This value is consistent with UK sedimentary rock GSHP feasibility assumptions and provides a conservative basis for borehole sizing. Lower conductivity would increase required borehole length/land take, while higher values would reduce array size requirements.

# Results

Based on the technical appraisal conducted, Table 5-2 to Table 5-6 provide individualised recommendations on which sites and heating system options to progress to detailed financial analysis.

## Tavy, Tamar, and Lynher House

Table 5-2 - Technical appraisal summary for Tavy, Tamar, and Lynher House

SITE 1-3 - TAVY, TAMAR, AND LYNHER HOUSE		
SCENARIO	TECHNICAL SUITABILITY	RATIONALE
Local DHN (ASHP)	High	A centralised ASHP heat network is well suited to the high-rise scale and density of the blocks, avoids dwelling-level complexity, and provides a technically robust solution which does not preclude future DHN connection.
City DHN	Medium	DHN connection is technically feasible and strategically aligned but is dependent on network rollout timing and external delivery, increasing short-term complexity and risk.
Local DHN (GSHP)	Low	GSHP systems are more efficient than ASHP systems but typically require significant land take for boreholes or ground arrays, with insufficient area locally to accommodate the required borehole field*.
Distributed ASHP	Low	Distributed ASHPs are poorly suited to high-rise buildings due to façade constraints, and high installation and disruption risk.
Storage Heaters	High	Direct electric heating is technically straightforward but results in high operating costs, increased electrical demand, low responsiveness, and poor alignment with long-term decarbonisation objectives.

\* Initial modelling showed that Tavy, Tamar and Lynher Houses require a 187 kWth heat pump delivering approximately 398 MWh/yr of heat. The system would require 28 boreholes with a total borehole field area of 1,792 m<sup>2</sup>. Potential locations were assessed within available green spaces and unused undercroft garages.

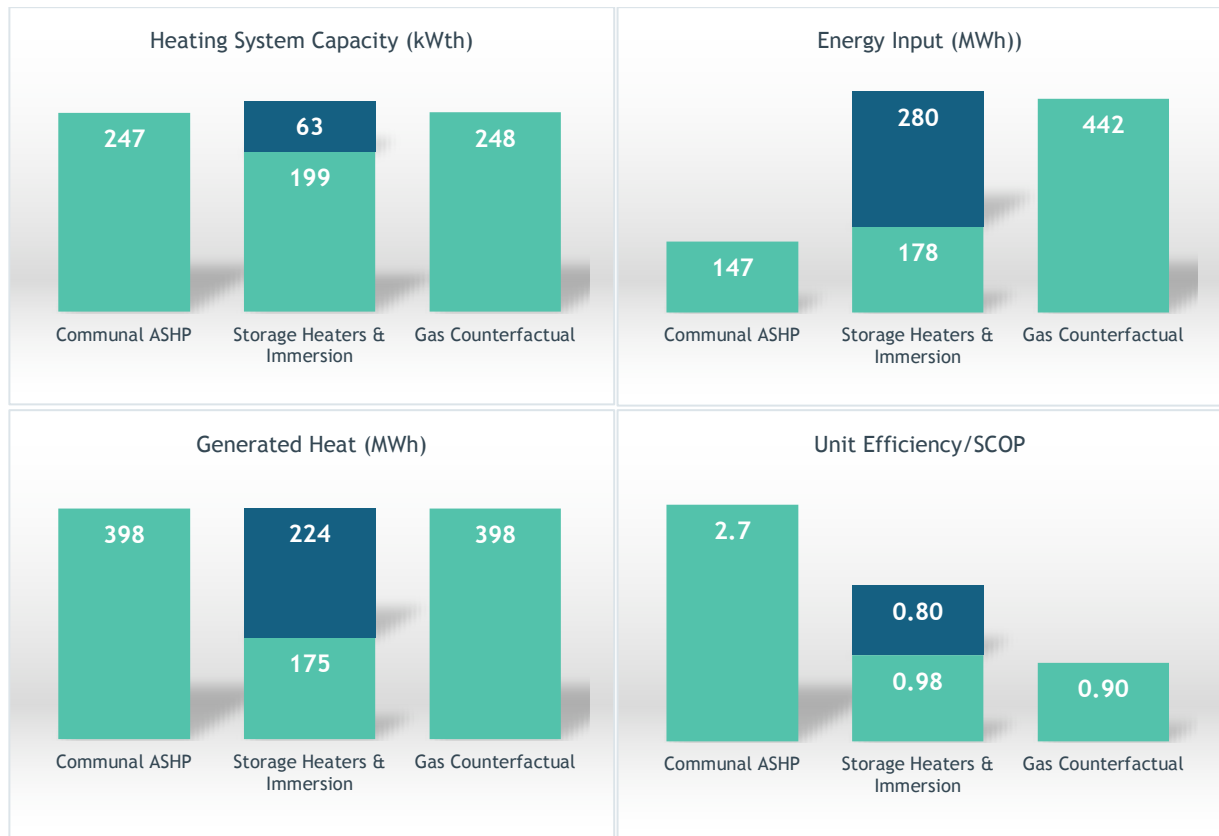


Figure 5.1 Tavy, Tamar, Lynher Heating System Specifications (Dark Blue = Water Immersion Heater) <sup>3</sup>

## Woodland's Court

Table 5-3 - Technical appraisal summary for Woodland's Court

SITE 4 - WOODLAND'S COURT		
SCENARIO	TECHNICAL SUITABILITY	RATIONALE
Local DHN (ASHP)	High	A centralised ASHP heat network is well suited to the high-rise scale and density of the block, avoids dwelling-level complexity, and provides a technically robust solution.
Local DHN (GSHP)	Medium-High	GSHP delivers high efficiency and low operating risk, but suitability is contingent on the availability and development of sufficient land for the borehole field.
City DHN	Low	DHN connection is technically feasible but currently speculative due to the building's location outside planned heat network zones, increasing delivery uncertainty.

<sup>3</sup> The DHN option is not included in this graphic as efficiency, energy input, and capacity are not yet known for the prospective DHN. "Generated Heat" is the same across all options.

Distributed ASHP	Low	Distributed ASHPs are poorly suited to high-rise buildings due to façade constraints, and high installation and disruption risk.
Storage Heaters	High	Direct electric heating is technically straightforward but results in high operating costs, increased electrical demand, and poor alignment with long-term decarbonisation objectives.

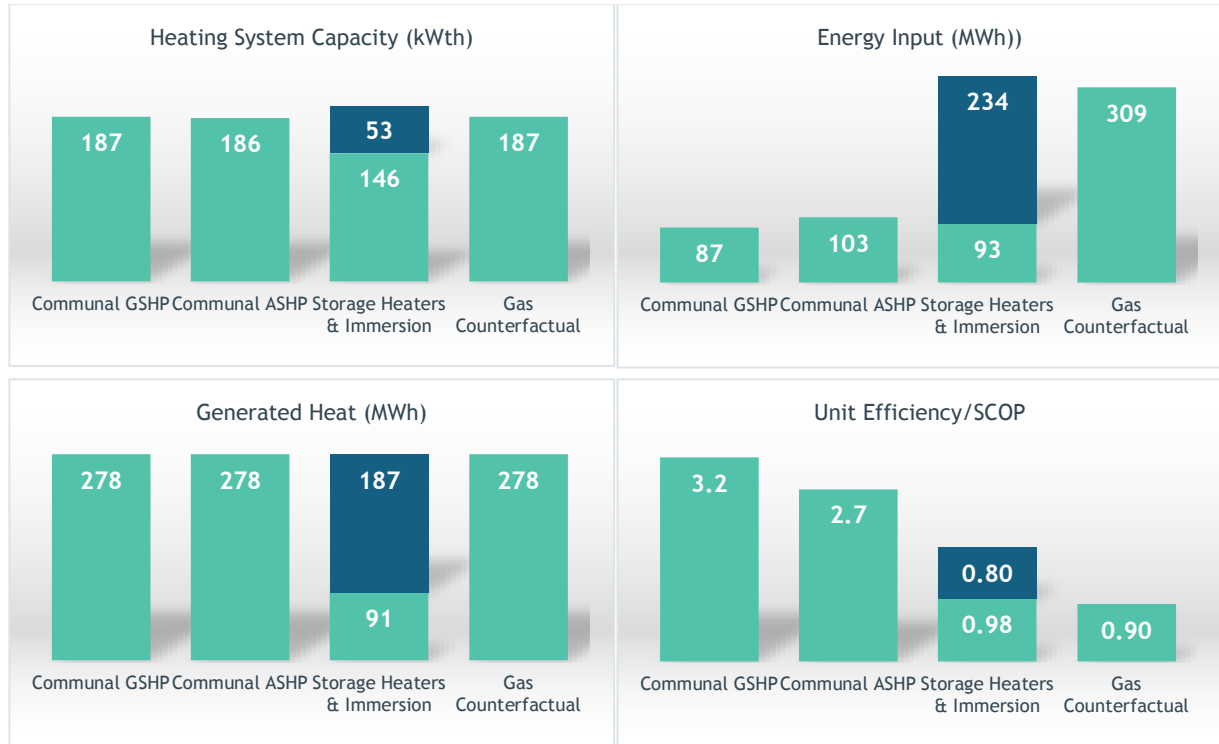


Figure 5.2 Woodland's Court Heating System Specifications (Dark Blue = Water Immersion Heater) <sup>4</sup>

## Star Block

Table 5-4 - Technical appraisal summary for the Star Block Archetype

SITE 5 - STAR BLOCK ARCHETYPE		
SCENARIO	TECHNICAL SUITABILITY	RATIONALE
City DHN	High	Most Star Blocks are located within planned DHN zones, and the wet-heated, medium-density typology is well suited to network connection with relatively low technical risk.

<sup>4</sup> The DHN option is not included in this graphic as efficiency, energy input, and capacity are not yet known for the prospective DHN. "Generated Heat" is the same across all options.

Local DHN (ASHP)	High	Block-scale ASHP systems are technically well matched to the Star Block form and can be modularly scaled to serve single, double, or triple block arrangements.
Local DHN (GSHP)	Medium	GSHP offers high efficiency but is contingent on sufficient external area adjacent to the building for the bore hole field, which must be assessed on a site-by-site basis.
Distributed ASHP	Low	Distributed ASHPs introduce multiple external units, higher visual and acoustic impacts, and greater installation complexity across joined blocks.
Storage Heaters	High	Direct electric heating is technically straightforward but results in high operating costs, increased electrical demand, and poor alignment with long-term decarbonisation objectives.

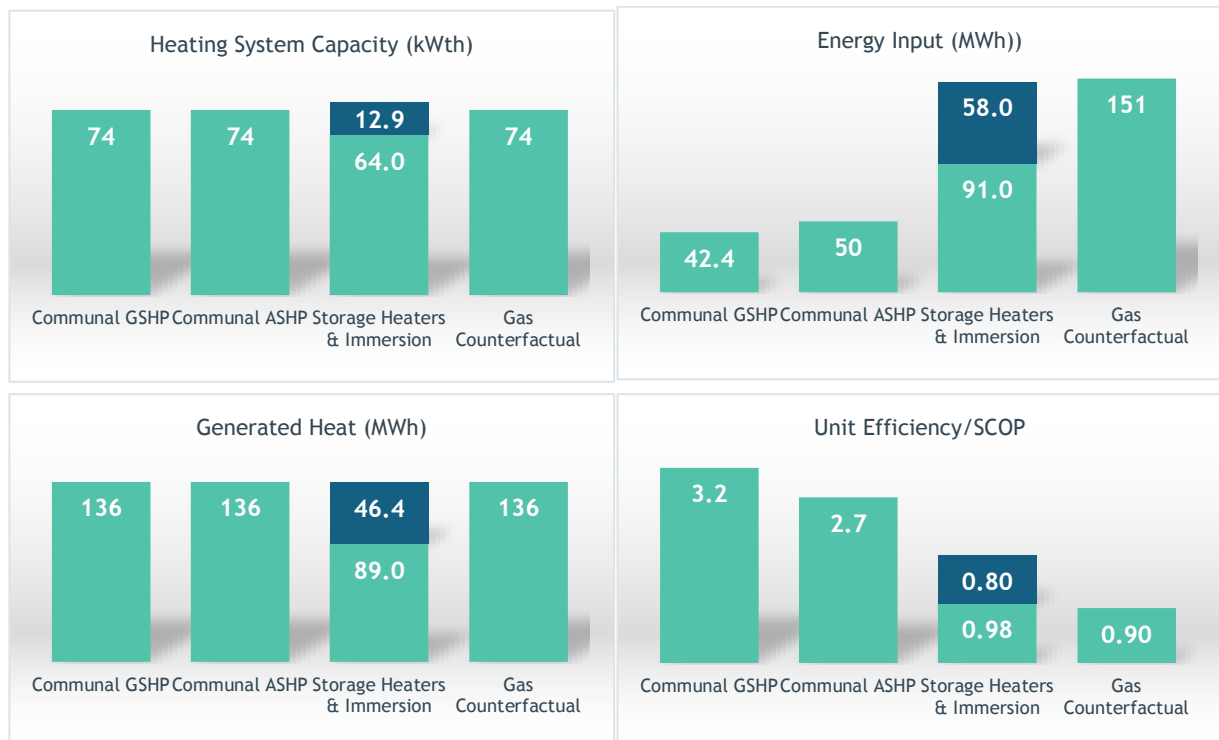


Figure 5.3 Star Block Heating System Specifications (Dark Blue = Water Immersion Heater) <sup>5</sup>

## K/L Block

Table 5-5 - Technical appraisal summary for the K/L Block Archetype

SITE 6 - K/L BLOCK ARCHETYPE
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<sup>5</sup> The DHN option is not included in this graphic as efficiency, energy input, and capacity are not yet known for the prospective DHN. "Generated Heat" is the same across all options.

SCENARIO	TECHNICAL SUITABILITY	RATIONALE
City DHN	High	Over half of K/L Blocks are located within planned DHN zones, and the wet-heated typology is well suited to connection with moderate technical complexity.
Local DHN (ASHP)	High	Block-scale ASHP systems align well with the existing wet heating systems and offer a flexible solution where DHN connection is delayed or unavailable.
Local DHN (GSHP)	Medium	GSHP offers high efficiency but is contingent on sufficient external area adjacent to the building for the bore hole field, which must be assessed on a site-by-site basis.
Distributed ASHP	Low	External walkways, façade constraints, and the number of individual installations increase complexity, disruption, and delivery risk.
Storage Heaters	High	Direct electric heating is technically straightforward but results in high operating costs, increased electrical demand, and poor alignment with long-term decarbonisation objectives.

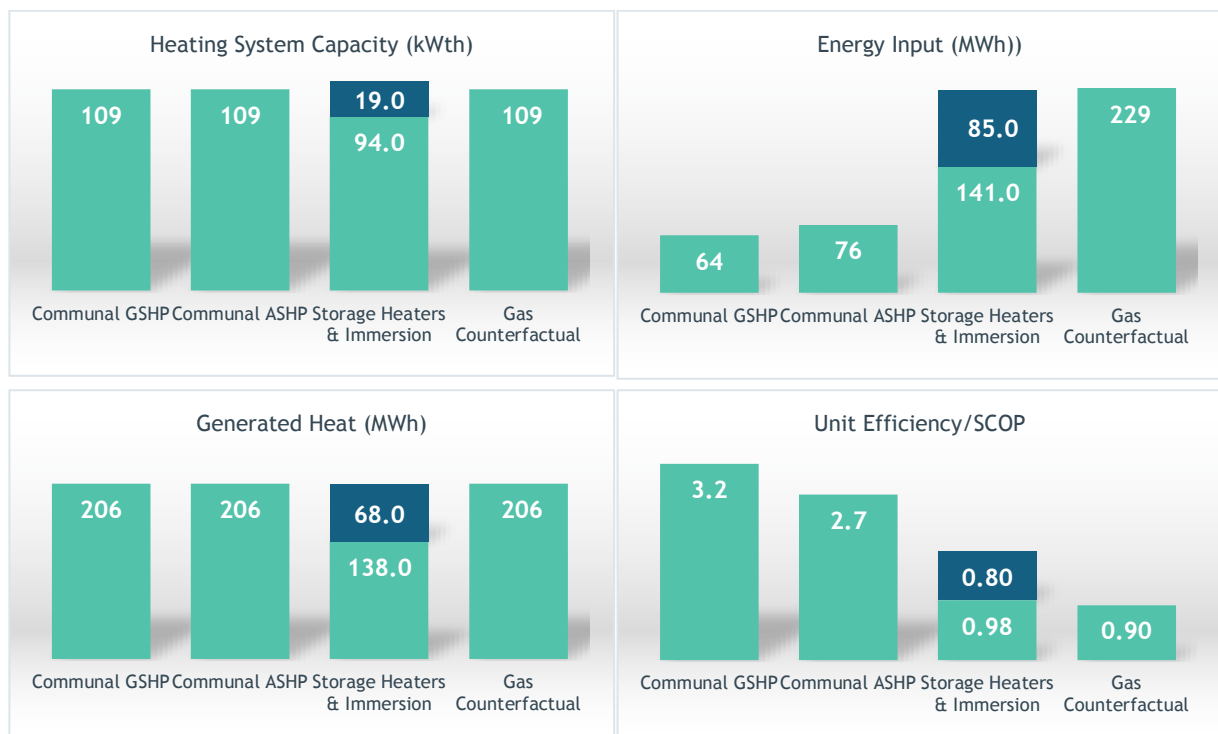


Figure 5.4 K/L Block Heating System Specifications (Dark Blue = Water Immersion Heater)<sup>6</sup>

<sup>6</sup> The DHN option is not included in this graphic as efficiency, energy input, and capacity are not yet known for the prospective DHN. “Generated Heat” is the same across all options.

## Easiform (6771)

Table 5-6 - Technical appraisal summary for the Easiform (6771) Archetype

SITE 6 - EASIFORM BLOCK ARCHETYPE		
SCENARIO	TECHNICAL SUITABILITY	RATIONALE
Local DHN (ASHP)	High	Block- or cluster-scale ASHP systems are technically compatible with existing wet heating systems and offer a scalable solution for low-rise blocks.
City DHN	Medium	Only 33% of Easiform blocks are located within planned heat network zones, limiting applicability across the wider stock.
Local DHN (GSHP)	Medium	GSHP offers high efficiency but is contingent on sufficient external area adjacent to the building for the bore hole field, which must be assessed on a site-by-site basis.
Distributed ASHP	Medium	Distributed ASHPs are technically feasible for the low-rise form but are less suitable where future DHN connection is anticipated.
Storage Heaters	High	Direct electric heating is technically straightforward but results in high operating costs, increased electrical demand, and poor alignment with long-term decarbonisation objectives.

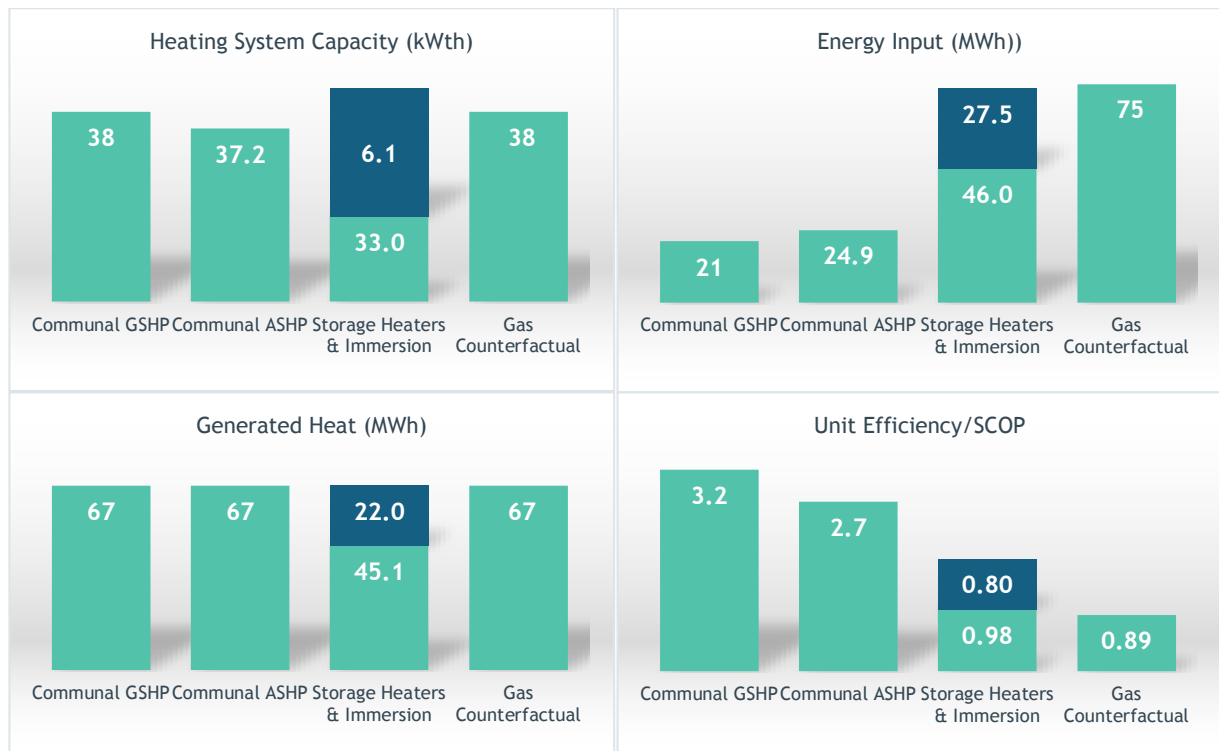


Figure 5.5 Easiform Block Heat System Specifications (Dark Blue = Water Immersion Heater)<sup>7</sup>

The distributed ASHP system outputs for the Easiform block are presented in

Table 5-7. Data is presented for each flat archetype within the Easiform block type. The Easiform archetype was the only block type evaluated as potentially suitable for distributed ASHPs due to their low-rise form and individual flat layouts.

Table 5-7 Easiform Flat Archetypes

Flat Archetype Abbreviation	Flat Archetype Name	Max Heating Power (kWth)	Generated High-Temp Heat (MWh)	Heat Pump Elec Demand (MWh)
GFE1	Ground Floor End 1	6.4	12.1	4.5
GFE2	Ground Floor End 2	6.3	12	4.4
GFM	Ground Floor Mid	5.7	11	4.1
MFE1	Mid Floor End 1	5.6	9.2	3.4
MFE2	Mid Floor End 2	5.5	9	3.3
MFM	Mid Floor Mid	4.8	7.9	2.9
RE1	Roof End 1	6.2	10.7	4
RE2	Roof End 2	6.1	10.5	3.9
RM	Roof Mid	5.3	9.3	3.4

<sup>7</sup> DHN is not included here as efficiency, energy input, and capacity are not yet known for the prospective DHN. “Generated Heat” is the same across all options.

# Building Energy Performance

Major reform in how energy performance of buildings is calculated and reported is underway, with the launch of reformed Energy Performance Certificates (EPCs) targeted for the second half of 2027:

- **New modelling software** (Home Energy Model will replace the Standard Assessment Procedure (SAP)), with the Government commissioning the modelling 'engine' and the EPC 'wrapper';
- **New Primary Metrics** for EPC reporting (as per the government response 9 March 2026 to the reform consultation), with the existing single cost metric replaced with four new headline metrics: **energy cost, fabric performance, heating system** and **smart readiness**.

While the EPC reform aims to maintain a level of consistency between existing EPCs and reformed EPCs, aligning scoring around Band C as this has been the threshold for many public initiatives and legislation for building performance improvement, there will inevitably be differences. For example, whereas the current SAP methodology favours gas heating over heat pumps due to the use of historic grid carbon intensity figures, under the new heating system metric it will no longer be possible to achieve higher than Band D with fossil fuel heating system. This context is important for decision making around how the different LCHO scenarios affect the EPC rating, inasmuch as compliance with achieving a specific EPC band under current EPC scoring will not necessarily ensure future compliance.

Full analysis of RdSAP score impacts across LCHO scenarios can be found in Appendix E - Predicted RdSAP score Improvements.

Analysis of RdSAP scores demonstrates that fabric improvements alone deliver consistent, but moderate, EPC score increases across all archetypes, typically ranging from 8 to over 40 points, with the greatest gains observed in Star and K/L blocks. These measures shift most properties toward EPC Band C, with some achieving Band B, but are generally insufficient to drive top-tier ratings independently.

When combined with heating system upgrades, performance improves further:

- Counterfactual gas boiler scenarios show strong EPC gains due to favourable RdSAP fuel cost assumptions, although these do not align with decarbonisation objectives.
- Heat pump solutions (ASHP and GSHP) provide solid improvements and carbon benefits, but EPC score uplift is more limited, reflecting RdSAP's bias toward gas under fixed pricing assumptions.
- Heat networks deliver the most significant EPC improvements, with score increases of up to ~48 points and the ability to achieve EPC Bands A or B across most block types, including high-rise buildings. This reflects assumed efficiencies and lower effective energy costs within the model.

Overall, the existing stock is predominantly EPC Bands C and D. Fabric improvements form a critical foundation, while heat networks offer the strongest route to higher EPC ratings, with heat pumps providing a balanced alternative where networks are not viable.

## Analysis of Internal Temperatures

Internal temperature and space heating modelling was undertaken to assess the feasibility of low-temperature heating systems across flat archetypes, with a primary focus on high-rise blocks. The analysis shows significant variation in space heating demand by floor level, driven primarily by fabric performance. Mid-level flats exhibit relatively low demand (c. 20-24 kWh/day) and are well suited to low-temperature systems, typically requiring only 1-3 radiators. In contrast, top-floor and ground-floor flats experience substantially higher demand due to uninsulated roof and floor elements, with peak requirements of up to 6-7 radiators, which challenges the viability of low-temperature heating without further intervention.

Targeted fabric improvements, particularly the addition of roof insulation, significantly reduce demand in top-floor flats, bringing them closer to the performance of mid-levels and improving the feasibility of low-temperature systems across the block. Ground-floor flats remain more constrained but are still considered deliverable with increased emitter sizing.

The analysis of internal temperatures also provides information around the risks of overheating. Overheating analysis presents mixed outcomes.

- **High-rise blocks** already exhibit high levels of overheating due to relatively high glazing ratios and solar gains. Fabric improvements, particularly roof insulation, result in a slight increase in overheating frequency, as solar gains are primarily driven through windows rather than the roof.
- **Easiform** blocks show similar trends, with modest increases in overheating following insulation.
- **K/L and Star blocks** perform more favourably. These typologies have lower glazing ratios and more advantageous orientations, resulting in lower baseline overheating risk. Fabric improvements further reduce overheating in many cases, particularly in Star blocks where some larger flats avoid overheating entirely.

Overall, low-temperature heating systems are viable for the majority of flats when combined with targeted fabric improvements. However, overheating risk must be carefully managed, particularly in high-rise and highly glazed typologies, to ensure a balanced approach between energy efficiency and thermal comfort.

Full analysis of overheating and cooling requirements across all sites and archetypes can be found in Appendix D - Internal Temperature Analysis.

## 6. FINANCIAL APPRAISAL

This section provides an overview of the financial appraisal of all options appraised in the Technical Appraisal Section. A full method statement can be found in at the end of the chapter.

### Financial Appraisal Outcomes

The recommended heating options focus on minimising the lifetime cost of providing heat and hot water, while keeping delivery risk and long-term obligations for PCH proportionate to each archetype. Achieving bill parity with counterfactual gas systems may result in ongoing additional costs to PCH. This will need to be reappraised at the point any decision is taken given the extreme volatility in fossil fuel markets at the time of reporting (April 2026), which has not been factored into gas pricing that is based on the existing unit rate paid by PCH. DESNZ is currently working to reduce the current disadvantage that electrically led heat networks have against gas.

At the large High Rise Blocks, connection to the district heat network is the most financially viable low carbon option, even in the high connection charge scenario.

Situated outside of the District Heat Network Zone, a local GSHP network is the preferred solution for Woodlands Court, albeit one that incurs ongoing operational and billing liabilities for PCH. The carbon abatement cost is significantly higher (£266 / t CO<sub>2</sub>e) compared to the preferred district heat network options at the other sites due to the higher overall costs.

For the smaller blocks of flats (Star, K/L, Easiform) the preferred option is highly contingent on the final DHN connection costs. If the DHN can supply heat on a retail supply basis at the connection charge, service fee, and heat tariff stated in the District Heat Network Connection Study (DHNCS) (Buro Happold, January 2025) (the “high cost” scenario in this report), then connection to the DHN is the financially preferred solution. Moderate reductions to indicated costs are required for connection on a bulk supply basis to reach whole-life cost parity with the best low carbon alternative.

A summary of the methodology, including definition of terms, and assumptions regarding cost allocation and DHN bulk and retail options are at the end of this chapter. A full detailed breakdown of assumptions for each technology, block type and scenario can be found in Appendix H - Financial & Technical Assumptions. An additional financial appendix provides full data tables breaking down capital costs, operating and replacement costs, resident billing, lifetime financial metrics, GHG assessment, and PCH net costs.

#### Financial Analysis

Table 6-1 provides an overview of the preferred heating option for each site / archetype. Analysis of the alternative LCHO financial performance can be found in Table 6-2.

Comparative analysis of Bulk and Retail DHN supply scenarios is provided in Table 6-3. This table demonstrates the relative benefits of a retail DHN supply approach alongside analysis of the point at which alternative LCHOs are preferred to DHN heat supply.

Table 6-1 - Recommended LCHO across sites / archetypes

Site / archetype (dwellings)	High Rise Sites 1-3 (90)	High Rise Woodlands Court (66)	Star Block (12)	K/L Block (21)	Easiform (6)
Preferred Heating Solution	DHN (Retail)	GSHP Network	DHN (Retail)	DHN (Retail)	DHN (Retail)
Whole-life cost (60yr) (PCH & Residents)	£2.99m	£3.88m	£1.19m	£1.78m	£0.59m
Carbon Abatement Cost (£ / t CO2e)	£21	£266	£105	£90	£111

Table 6-2 - 'Alternative' LCHO options across sites / archetypes

Site / archetype (dwellings)	High Rise Sites 1-3 (90)	High Rise Woodlands Court (66)	Star Block (12)	K/L Block (21)	Easiform (6)
Preferred "Low Carbon Alternative"	ASHP Network	GSHP Network	GSHP Network	GSHP Network	Dist. ASHP
Whole-life cost (60yr) (PCH & Residents)	£6.59m	£3.88m	£1.45m	£2.20m	£0.71m
Lifetime cost Vs DHN (Retail)	+£3.6m	N/A	+£0.3m	+£1.8m	+£0.6m
Carbon Abatement Cost (£ / t CO2e)	£322	£266	£248	£238	£225

Table 6-3 - Comparative DHN financial performance (bulk and retail supply - central scenarios)

Site / archetype (dwellings)	High Rise Sites 1-3 (90)	High Rise Woodlands Court (66)	Star Block (12)	K/L Block (21)	Easiform (6)
<b>DHN - Bulk Supply</b>					
Whole-life cost (60yr) (PCH & Residents)	£5.66m	N/A	£1.43m	£2.17m	£0.73m
Carbon Abatement Cost (£ / t CO2e)	£208	N/A	£188	£175	£205

Site / archetype (dwellings)	High Rise Sites 1-3 (90)	High Rise Woodlands Court (66)	Star Block (12)	K/L Block (21)	Easiform (6)
Required change in connection charges: to low carbon alternative*	+7%	N/A	-13%	-14%	-18%
Required change in connection charges: to counterfactual gas*	-41%	N/A	-62%	-60%	-64%
<b>DHN - Retail Supply</b>					
Whole-life cost (60yr) (PCH & Residents)	£3.99m	N/A	£1.19m	£1.78m	£0.59m
Carbon Abatement Cost (£ / t CO2e)	£21	N/A	£105	£90	£111
Required change in connection charges: to low carbon alternative*	+46%	N/A	+4%	+5%	+2%
Required change in connection charges: to counterfactual gas*	-21%	N/A	-44%	-41%	-45%

\* The % change in the DHNCS reported connection charge, service fee, and heat tariff required for the DHN option to reach whole-life cost parity with the best alternative low carbon option, or counterfactual new gas option. For example, -15% is a 15% reduction and is equivalent to the central scenario in this report.

## High Rise Sites 1-3 Archetype

The preferred “alternative low carbon” option to connection to a District Heat Network is a local ASHP heat network, with a whole-life cost of £6.59m and LCOH £0.347 / kWh. There would be an additional cost of £14 per dwelling per year to achieve parity between resident bills and the counterfactual new gas boiler scenario. When combined with operating and replacement costs, and tariff revenue, this results in an annual net cost to PCH of £51,245.

This compares unfavourably with even the high cost DHN scenarios connections, and therefore connection to the District Heat Network is the recommended option.

Connection to the District Heat Network achieves whole-life cost parity with the local ASHP heat network up to the following cost thresholds:

- Bulk Supply: 7% increase against the costs estimated in the DHNCS, equivalent to a connection cost of £1,131 per kWp, a service fee of £96 per kWp, and a heat tariff of £0.114 / kWh. This is achieved in all cost scenarios.
- Retail Supply: 46% increase against the costs estimated in the DHNCS, equivalent to a connection cost of £1,543 per kWp, a service fee of £131 per kWp, and heat tariff of £0.156 / kWh.

Table 6-4 - Summary of shortlisted options (central scenarios)

Shortlisted Options	CAPEX (to PCH)	Annual net cost to PCH *	Annual net cost to PCH	Whole-life cost (60yr)	LCOH (£ / kWh)	Change in Resident
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			<i>including additional cost to residents</i> **	(PCH & Residents)		Heat Cost ***
ASHP network	£1.42m	£49,954	£51,245	£6.59m	£0.347	+£14
DHN (Retail)	£0.58m	£20,694	£21,985	£3.99m	£0.196	+£14
DHN (Bulk)	£1.08m	£40,091	£41,382	£5.66m	£0.291	+£14
New Gas	£0.55m	£18,729	£18,729	£3.77m	£0.185	£0

\*Net income attributable to PCH includes all operating costs (maintenance, electricity costs, metering, DHN service fee split out), annualised REPEX, and revenues from heat supply.

\*\* Additional cost to reach bill parity with the counterfactual new gas scenario.

\*\*\* Annual space heat and DHW cost compared to counterfactual new gas scenario (no support).

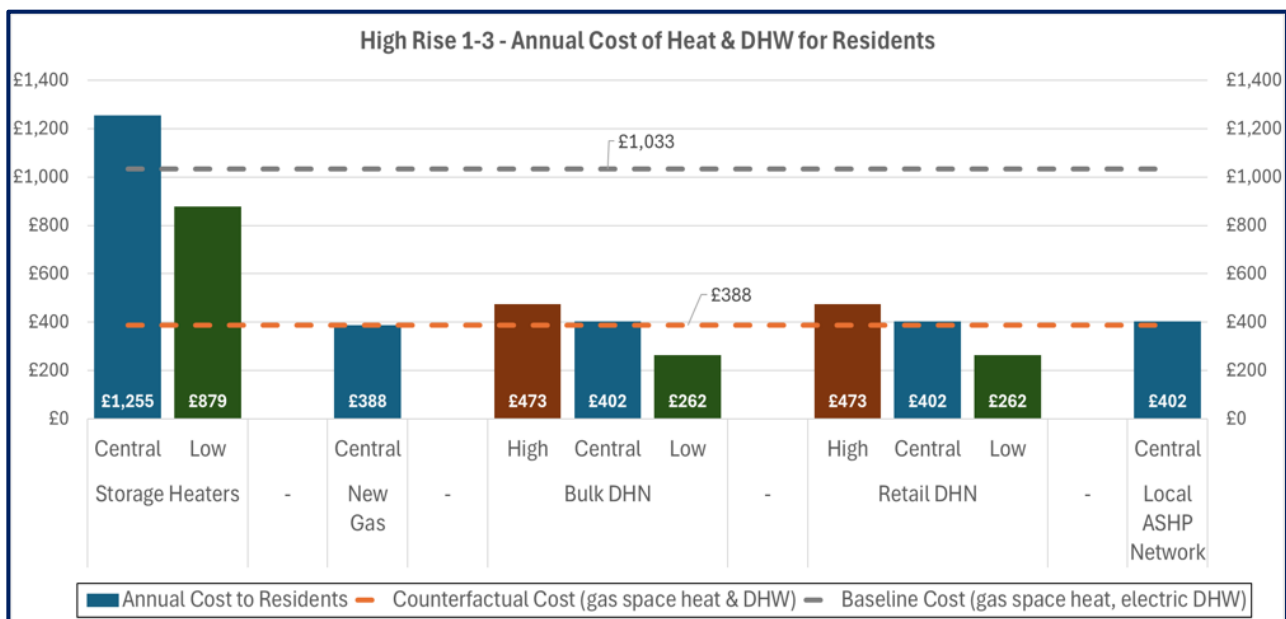


Figure 6.1 - High Rise 1-3: Resident Costs

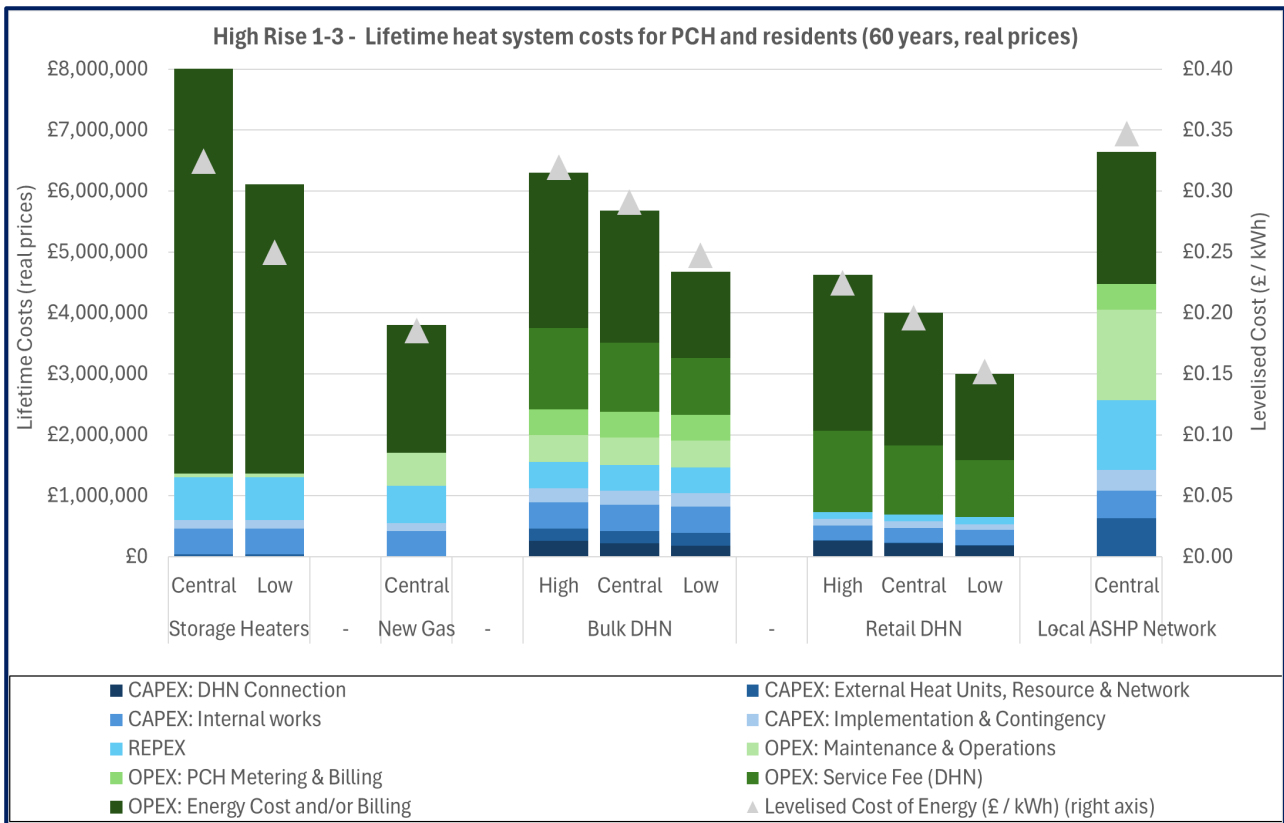


Figure 6.2 - High Rise 1-3: Comparison of Lifetime Costs

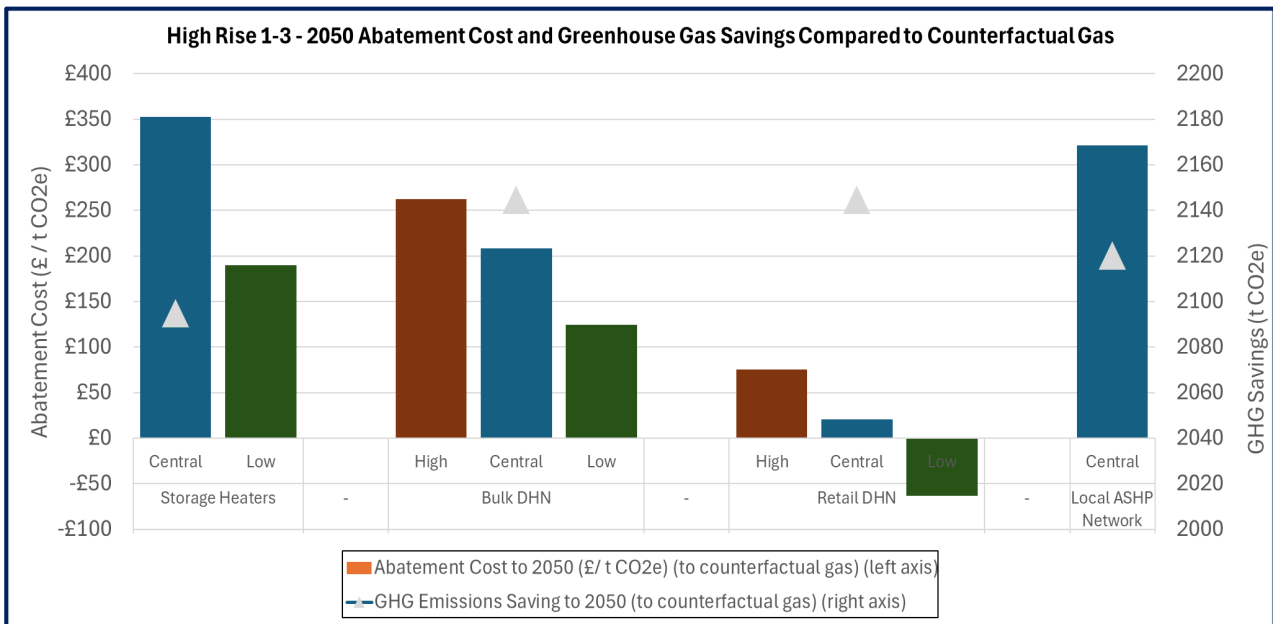


Figure 6.3 - High Rise 1-3: Greenhouse Gas Emissions

## High Rise Woodlands Court Archetype

The preferred low carbon option is a local GSHP network, with a whole-life cost of **£3.88m** and **LCOH £0.302 / kWh**. Achieving parity between resident bills and the counterfactual new gas boiler scenario would require an additional **£8** per dwelling per year. When combined with operating and replacement costs, and tariff revenue, this results in an annual net cost to PCH of **£23,769**.

However, this option is operationally complex, with PCH responsible for network operation, energy centre maintenance and billing.

With Woodlands Court outside of the heat network zone, the only low carbon alternative that would minimise operational complexity and ongoing liabilities for PCH is storage heaters. However, under the central (price cap) scenario this option has a significantly higher whole-life cost and would cost an additional £847 per property per year to achieve bill parity with the counterfactual new gas scenario.

Table 6-5 - Summary of shortlisted options (central scenarios)

Shortlisted Options	CAPEX (to PCH)	Annual net cost to PCH*	Annual net cost to PCH including additional cost to residents**	Whole-life cost (60yr) (PCH & Residents)	LCOH (£ / kWh)	Change in Resident Heat Cost***
Local GSHP	£969,224	£23,216	£23,769	£3.88m	£0.302	+£8
Local ASHP	£844,916	£35,039	£35,593	£4.47m	£0.328	+£8
Storage Heaters	£474,745	£8,915	£64,841	£5.85m	£0.331	+£847
New Gas	£239,580	£13,747	£13,747	£2.55m	£0.170	£0

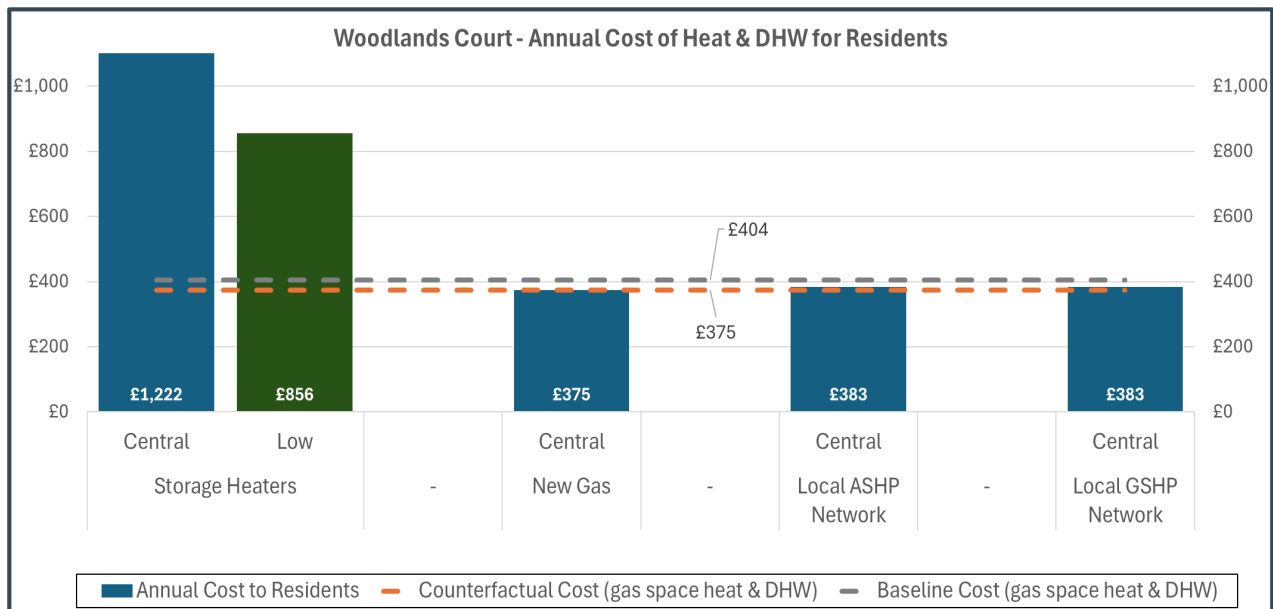


Figure 6.4 - Woodlands Court: Resident Costs

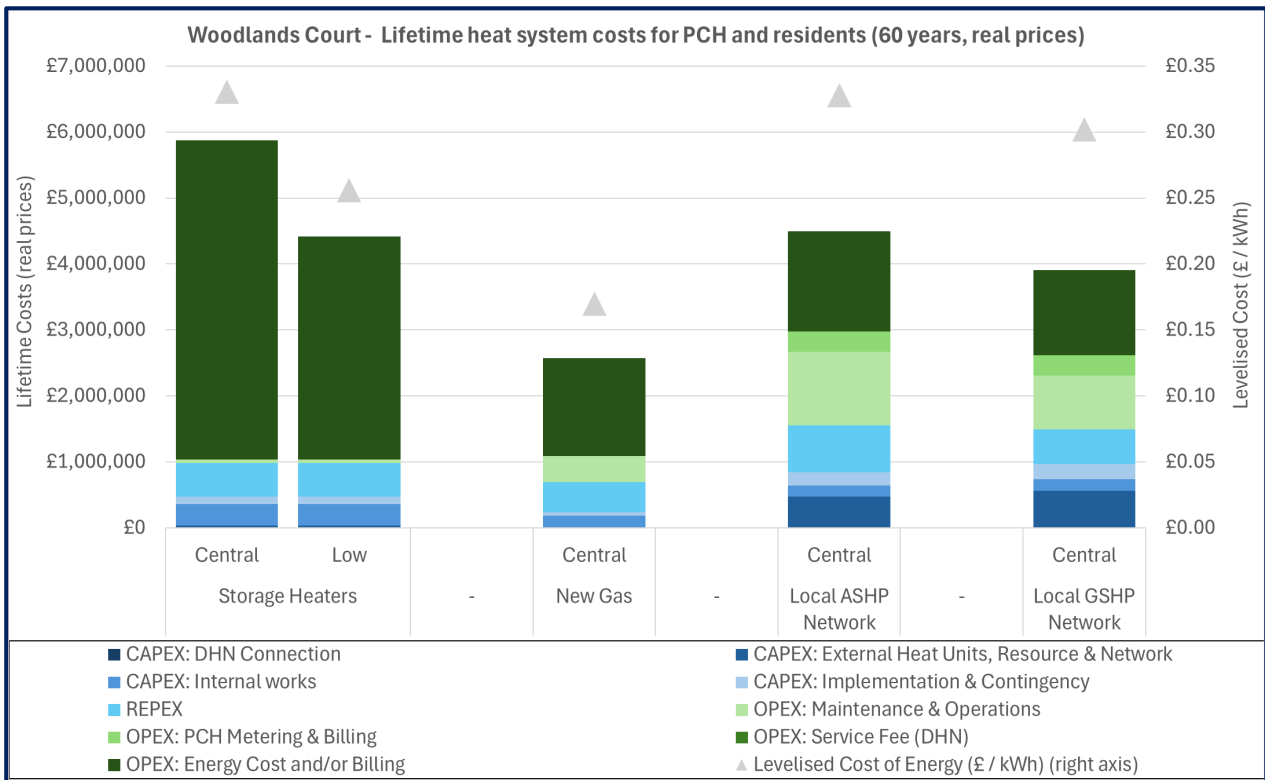


Figure 6.5 - Woodlands Court: Comparison of Lifetime Costs

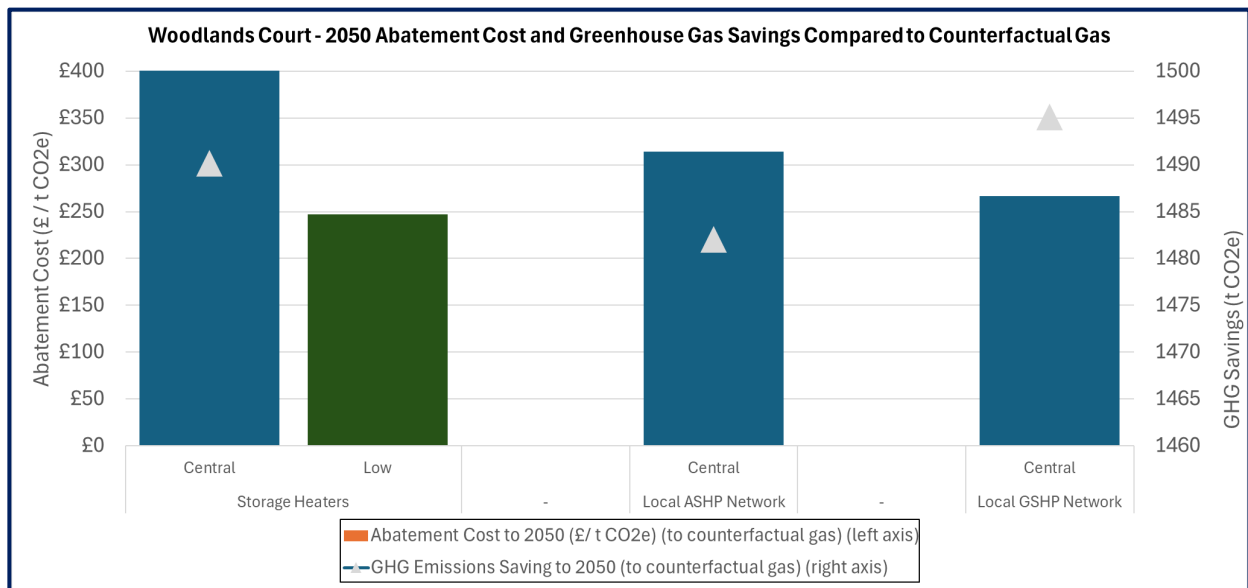


Figure 6.6 - Woodlands Court: Greenhouse Gas Emissions

## Star Block Archetype

The preferred “alternative low carbon” option to connection to a District Heat Network is a **local GSHP network**, with a whole-life cost of £1.45m and LCOH £0.228 / kWh. Achieving parity between resident bills and the counterfactual new gas boiler scenario would require an additional £203 per dwelling per year. When combined with operating and replacement costs, and tariff revenue, this results in an annual net cost to PCH of £8,446.

However, this option is operationally complex, with PCH responsible for network operation, energy centre maintenance and billing. There also may not be adequate space for the borehole field for all locations, and this would need to be assessed on a site by site basis.

Connection to the DHN achieves whole-life cost parity with the local GSHP heat network up to the following cost thresholds, and is therefore recommended in these scenarios:

- Bulk Supply: 13% reduction against the costs estimated in the DHNCS, equivalent to a connection cost of £920 per kWp, a service fee of £78 per kWp, and a heat tariff of £0.093 / kWh. This is achieved in the “central” cost scenario.
- Retail Supply: No more than 4% increase against the costs estimated in the DHNCS, equivalent to a connection cost of £1,099 per kWp, a service fee of £94 per kWp, and heat tariff of £0.111 / kWh.

Table 6-6 - Summary of shortlisted option (central scenarios)

Shortlisted Options	CAPEX (to PCH)	Annual net cost to PCH *	Annual net cost to PCH including additional cost to residents **	Whole-life cost (60yr) (PCH & Residents)	LCOH (£ / kWh)	Change in Resident Heat Cost ***
Local GSHP	£343,735	£6,011	£8,446	£1.45m	£0.228	+£203
DHN (Retail)	£89,134	£5,899	£8,333	£1.19m	£0.158	+£203
DHN (Bulk)	£171,631	£8,574	£11,008	£1.43m	£0.200	+£203
New Gas	£43,560	£2,604	£2,604	£0.80m	£0.104	£0

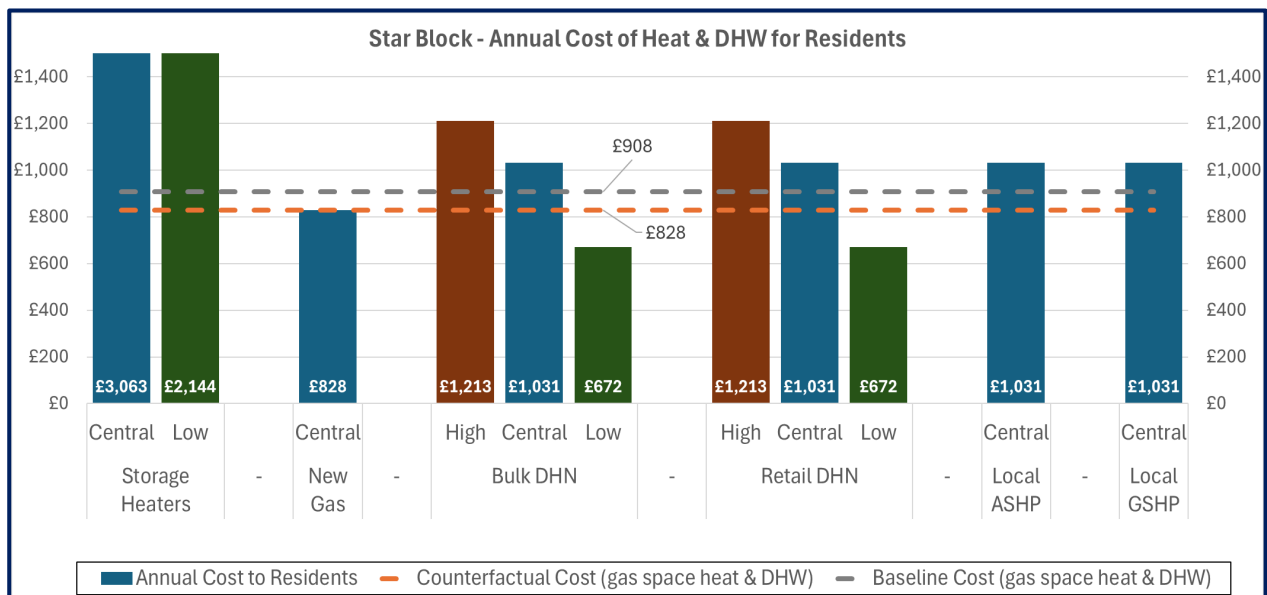


Figure 6.7 - Star Block: Resident Costs

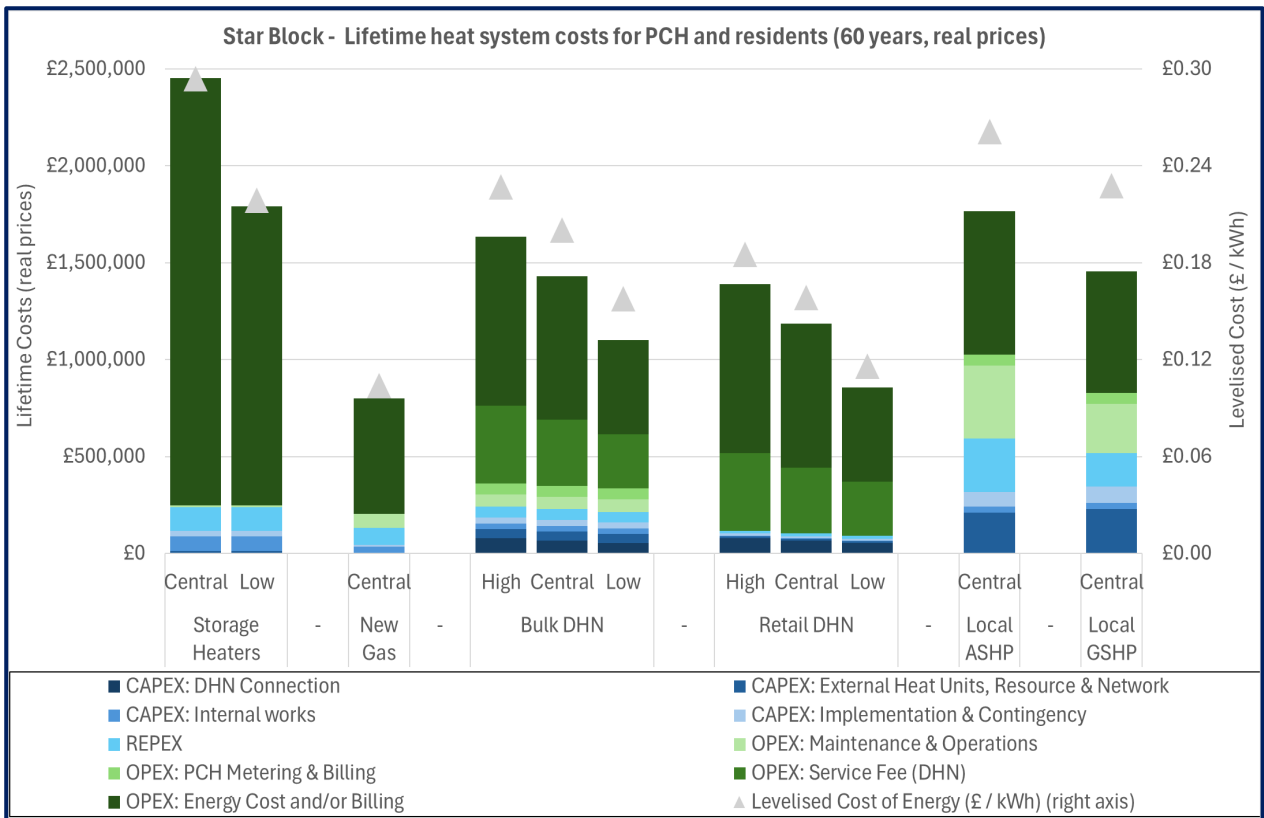


Figure 6.8 - Star Block: Comparison of Lifetime Costs

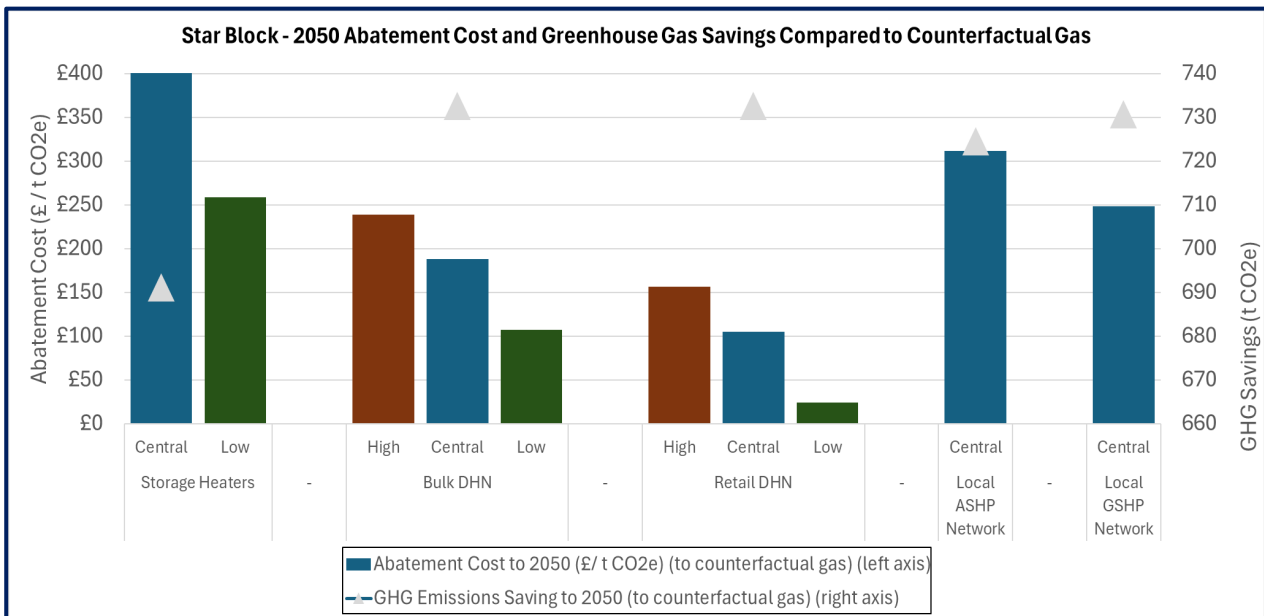


Figure 6.9 - Star Block: Greenhouse Gas Emissions

## K/L Block Archetype

The preferred “alternative low carbon” option to connection to a District Heat Network is a local GSHP network, with a whole-life cost of £2.20m and LCOH £0.228 / kWh. Achieving parity between resident bills and the counterfactual new gas boiler scenario would require an additional £161 per dwelling. When combined with operating and replacement costs, and tariff revenue, this results in an annual net cost to PCH of £12,664.

However, this option is operationally complex, with PCH responsible for network operation, energy centre maintenance and billing. There also may not be adequate space for the borehole field for all locations, and this would need to be assessed on a site by site basis.

Connection to the DHN achieves whole-life cost parity with the local GSHP heat network up to the following cost thresholds, and is therefore recommended in these scenarios:

- Bulk Supply: 14% reduction against the costs estimated in the DHNCS, equivalent to a connection cost of £909 per kWp, a service fee of £77 per kWp, and a heat tariff of £0.092 / kWh. This is achieved in the “central” cost scenario.
- Retail Supply: No more than 5% increase against the costs estimated in the DHNCS, equivalent to a connection cost of £1,110 per kWp, a service fee of £95 per kWp, and heat tariff of £0.112 / kWh.

Table 6-7 - Summary of shortlisted option (central scenarios)

Shortlisted Options	CAPEX (to PCH)	Annual net cost to PCH *	Annual net cost to PCH including additional cost to residents **	Whole-life cost (60yr) (PCH & Residents)	LCOH (£ / kWh)	Change in Resident Heat Cost ***
Local GSHP	£518,664	£9,292	£12,664	£2.20m	£0.228	+£161
DHN (Retail)	£127,449	£8,755	£12,127	£1.78m	£0.156	+£161
DHN (Bulk)	£249,909	£13,218	£16,590	£2.17m	£0.200	+£161
New Gas	£76,230	£4,392	£4,392	£1.126m	£0.109	£0

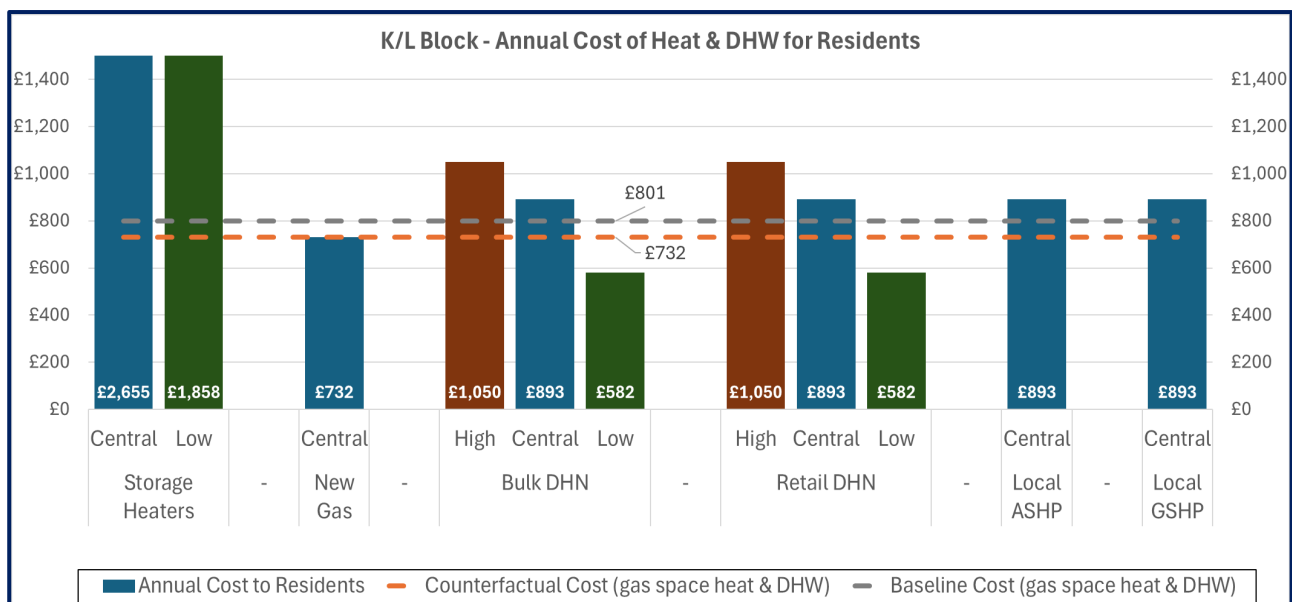


Figure 6.10 - K/L: Resident Costs

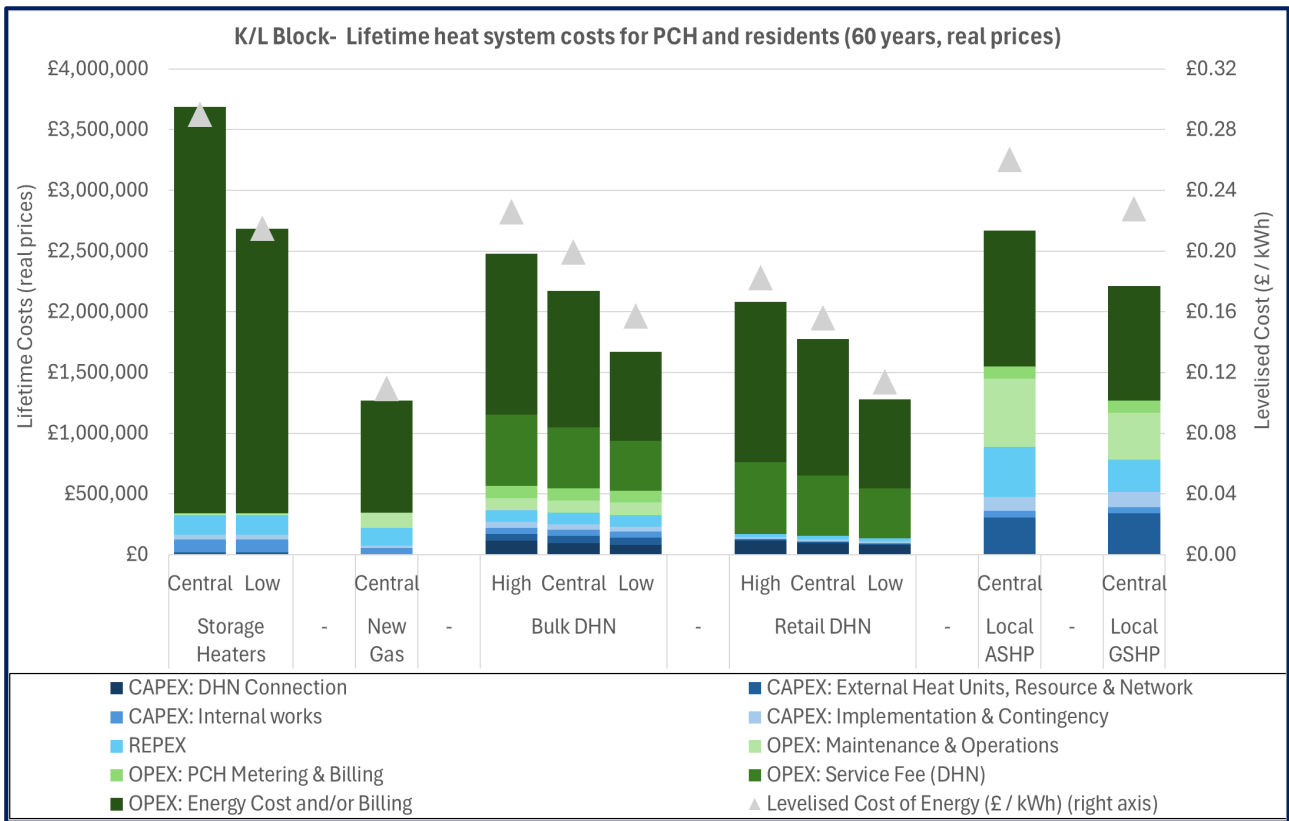


Figure 6.11 - K/L: Comparison of Lifetime Costs

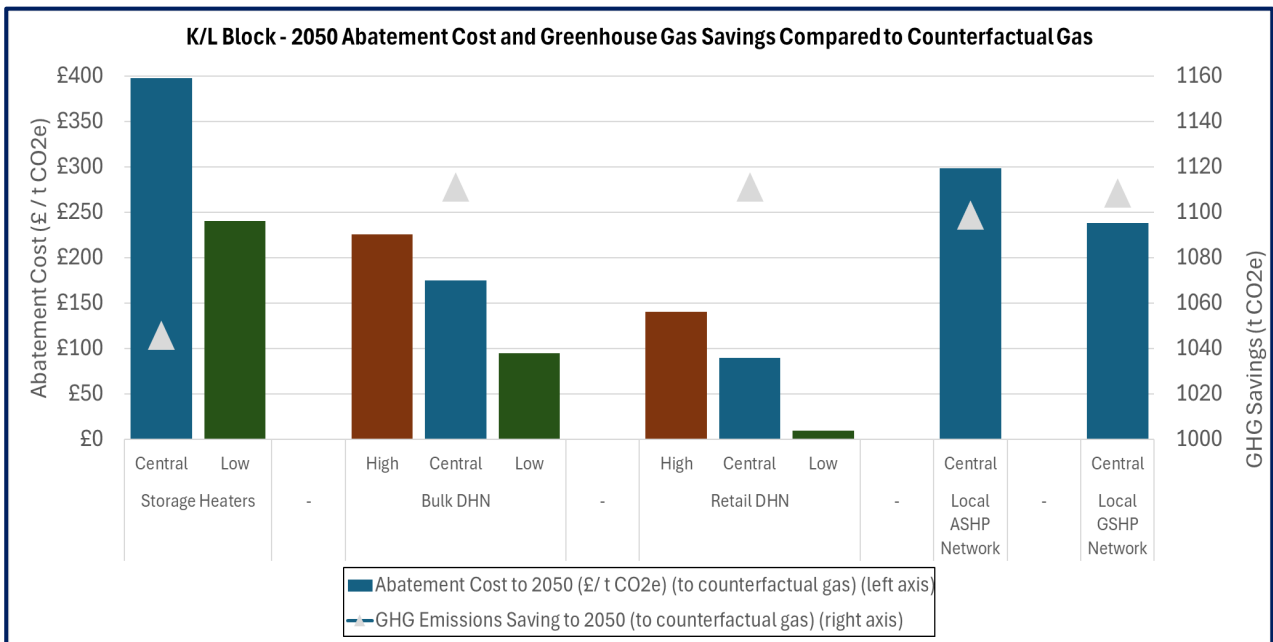


Figure 6.12 - K/L: Greenhouse Gas Emissions

## Easiform Archetype

The preferred “alternative low carbon” option to connection to a District Heat Network is distributed ASHPs, with a whole-life cost of £0.707m and LCOH £0.218 / kWh under the central price scenario. Achieving parity between resident bills and the counterfactual new gas boiler scenario would require an additional £197 per dwelling. When combined with operating and replacement costs, this results in an annual net cost to PCH of £4,469.

A local GSHP network presents a similar whole-life cost (£0.707m), but introduces greater operational complexity, with PCH responsible for heat network operation, energy centre maintenance and customer billing. There also may not be adequate space for the borehole field for all locations, and this would need to be assessed on a site by site basis.

Connection to the DHN achieves whole-life cost parity with the distributed ASHPs up to the following cost thresholds, and is therefore recommended in these scenarios:

- Bulk Supply: 18% reduction against the costs estimated in the DHNCS, equivalent to a connection cost of £867 per kWp, a service fee of £74 per kWp, and a heat tariff of £0.088 / kWh. This is *not* achieved in the “central” cost scenario.
- Retail Supply: No more than 2% increase against the costs estimated in the DHNCS, equivalent to a connection cost of £1,059 per kWp, a service fee of £92 per kWp, and heat tariff of £0.109 / kWh.

Table 6-8 - Summary of shortlisted option (central scenarios)

Shortlisted Options	CAPEX (to PCH)	Annual net cost to PCH*	Annual net cost to PCH including additional cost to residents**	Whole-life cost (60yr) (PCH & Residents)	LCOH (£ / kWh)	Change in Resident Heat Cost***
Dist ASHP	£142,305	£3,289	£4,469	£0.707m	£0.218	+£197
Local GSHP	£158,757	£3,035	£4,190	£0.707m	£0.218	+£123
DHN (Retail)	£50,288	£2,965	£4,120	£0.594m	£0.148	+£123
DHN (Bulk)	£97,998	£4,387	£5,542	£0.727m	£0.210	+£123
New Gas	£21,780	£1,271	£1,271	£0.395m	£0.105	£0

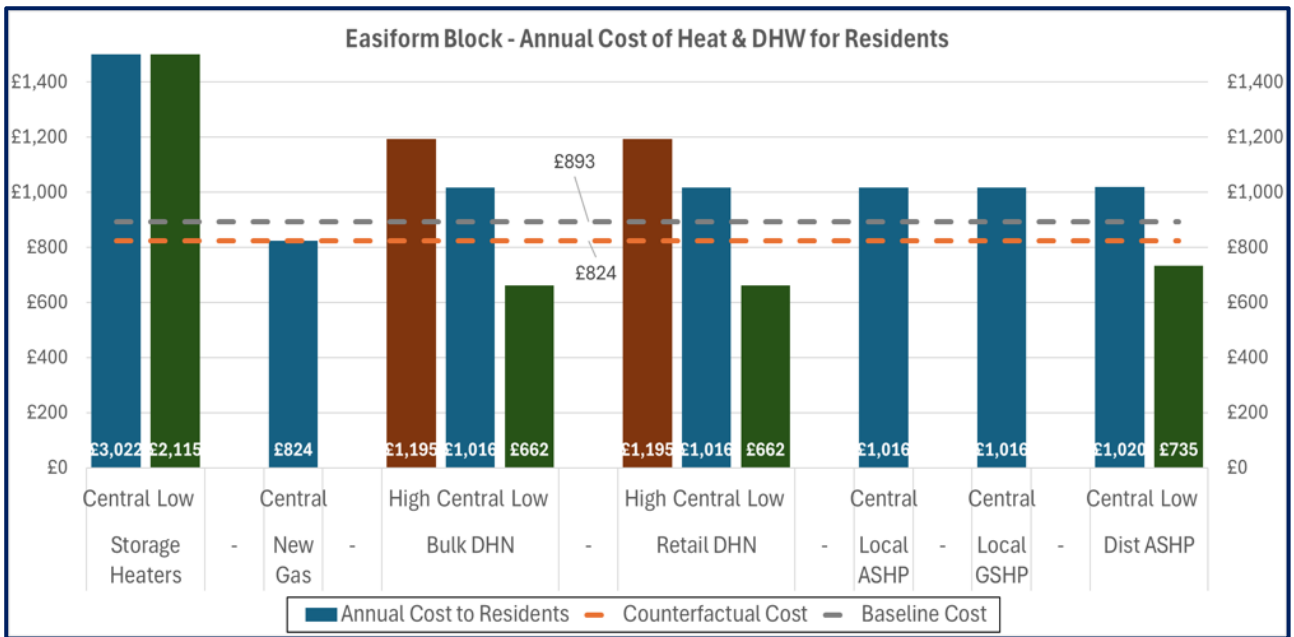


Figure 6.13 - Easiform: Resident Costs

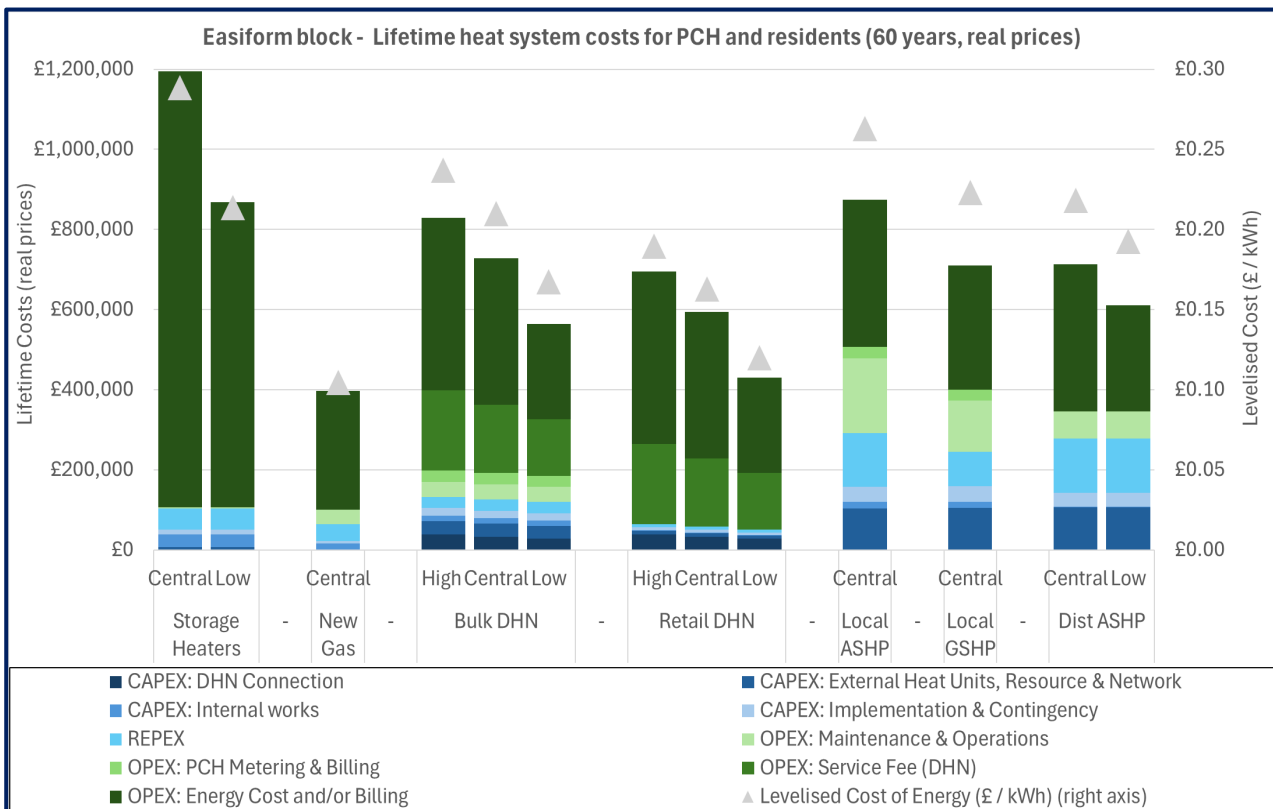


Figure 6.14 - Easiform: Comparison of Lifetime Costs

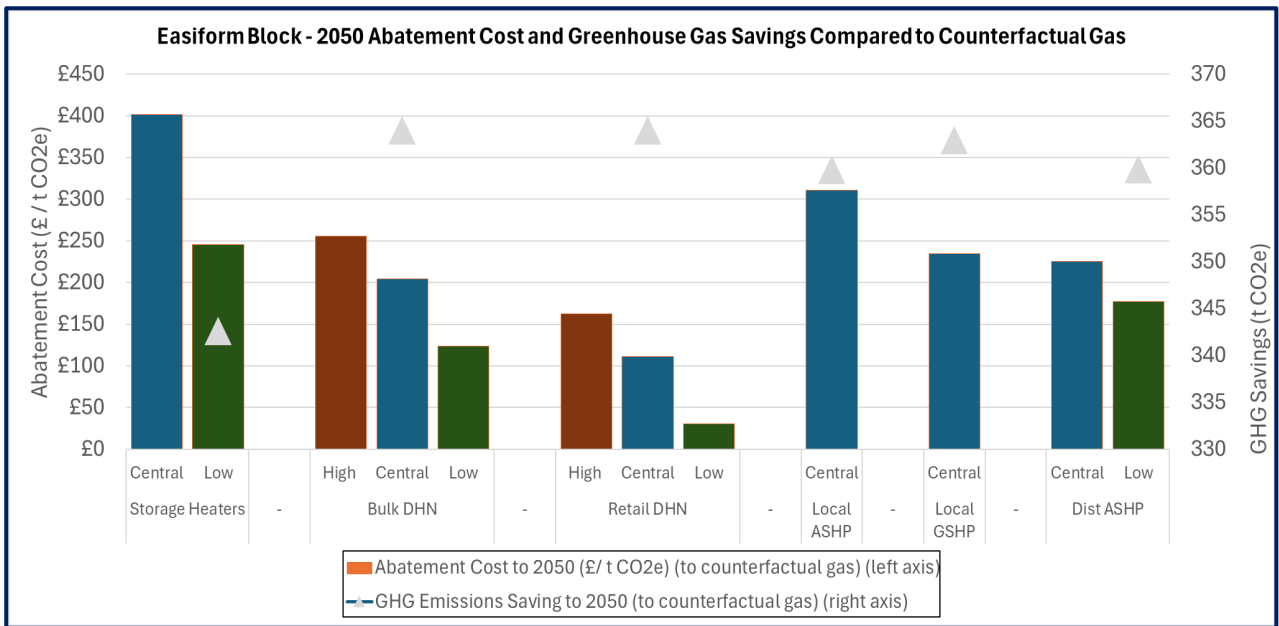


Figure 6.15 - Easiform: Greenhouse Gas Emissions

# Financial Appraisal Methodology

Heating system options are compared according to the following core metrics.

METRIC	DESCRIPTION
<b>Whole-life cost (60 years) to PCH and residents</b>	Provides the primary measure of overall value for money, enabling comparison of options with different capital and operating cost profiles.
<b>Levelised Cost of Heat (LCOH)</b>	Provides a normalised cost per unit of heat, supporting comparison between options with greater weighting on near-term costs.
<b>Change in resident heat cost</b>	Indicates the affordability impact on residents, showing how bills differ from the counterfactual prior to any intervention.
<b>Lifetime / Annual Net Cost to PCH</b>	Illustrates the funding requirement for PCH and demonstrates the impact of any support required to enable bill parity with the counterfactual scenario.
<b>Greenhouse Gas Savings to 2050</b>	Expressed as cumulative emissions reduction relative to the counterfactual, shows the extent that each option contributes to decarbonisation objectives.
<b>Carbon Abatement Cost to 2050</b>	Indicates the cost-effectiveness of emissions reduction, enabling comparison of the relative value for money of different decarbonisation pathways.
<b>DHN Connection Cost Requirements</b>	Identifies the commercial conditions under which district heat network options become viable. Presents the connection cost, service fee, and heat tariff required to achieve whole-life cost parity with the best alternative low carbon option.

## Cost Distribution Approach

The distribution of costs between residents and PCH (e.g., heat tariffs and service fees vs direct electricity bills) is treated as secondary to the central lifetime-cost comparison due to the ability of PCH to subsidise costs and control this cost distribution. The distribution is still reported to highlight affordability and delivery implications.

A range of high, central, and low-cost scenarios are applied to enable sensitivity testing. For the distributed ASHP and storage heater scenarios:

- The “central” scenario assumes electricity prices set at the current price cap.
- The “low” scenario reflects the potential cost if residents can switch to an optimal time-of-use tariff.

For connection to the District Heat Network (DHN):

- The “high” cost scenario uses the connection costs (£1,057 / kWp), service fees (£90 / kWp), and heat tariff (£0.107 / kWh) reported in the DHNCS.
- The “central” cost scenario applies a 15% discount to these values, and the “low” cost scenario applies a 30% discount to.

It is assumed that the service fee is split out to PCH and is not passed on to residents. To enable consistency with the DHN option, the local ASHP and GSHP heat network options assume the same heat tariff (£0.091 / kWh) as the DHN central scenario. In practice, this tariff would be set to balance resident affordability and PCH cost control.

## DHN Ownership Approach

District Heat Network connection is assessed under bulk and retail supply options:

- Bulk supply: Plate heat exchangers mark the demarcation between ESCO-owned equipment and PCH-owned equipment. PCH is assumed responsible for associated capital expenditure and operational expenditure including flow and return pipework, heat meter, HIUs and internal works.
- Retail supply: PCH responsibility is limited to the heat meter and internal decommissioning and making good works.

All else being equal, the retail supply option is therefore more cost-effective than bulk supply. If the DHN operator applies different charges depending on the supply type, this report presents the charges required to reach whole-life cost parity with the best alternative low carbon option in both cases.

**Error! Reference source not found.** provides key financial terminology used throughout this chapter. Underlying data and assumptions that have informed this financial analysis, including project costs, energy demand, financial metrics, and greenhouse gas emissions, are detailed in financial appendices.

Table 6-9 - Key Financial Terminology

Term	Description
Lifetime Cost to PCH	The net value of all costs and revenues accruing to PCH over 60 years, including CAPEX, REPEX, OPEX and any heat tariff or service fee income.
Resident cost of heat	The average annual cost paid by residents for space heating and hot water, either through direct electricity bills or heat tariffs and service fees.
Levelised Cost of Heat (LCOH)	The average cost of heat delivered (£/kWh), calculated by dividing the total lifetime cost of the heat system by the total heat supplied over the appraisal period, with application of a discount rate of 3.5% to provide a present value.
Bill parity	A scenario in which resident heat and hot water costs are set equal to those under the existing gas system, typically requiring changes to tariffs or support from PCH.
Whole-life cost (60-year)	The total real-terms cost of providing space heating and domestic hot water over a 60-year appraisal period, including CAPEX, REPEX, OPEX and resident energy or heat charges, with no double counting between PCH and residents.
Greenhouse Gas Savings	The total reduction in greenhouse gas emissions achieved by 2050 by a given option relative to the counterfactual new gas boiler scenario.
Carbon Abatement Cost	Compares the given option to the counterfactual new gas boiler scenario. Calculated as the total reduction in greenhouse gas emissions achieved by 2050 divided by the additional whole-life costs.

## 7. RECOMMENDATIONS

This report presents the findings of an Options Appraisal, and while there has been significant detailed analysis across the variation in flats within the archetypes (which has included modelling 10% of the flats within the High Rise, 30% of K/L, 47% of Easiform and 72% of the flats within the Star blocks), the conclusions are not based on a detailed engineering assessment for each block. Furthermore, the modelling is based on a number of assumptions, which will need to either be replaced with actual data (e.g. from energy bills) or reviewed and updated prior to any investment decision.

Based on this Options Appraisal, if the heat network is able to deliver a retail connection with charges similar to those stated in the District Heat Network Connection Study (DHNCS), this is the recommended option for all archetypes within the heat network zone.

At the High Rise Blocks, connection to the district heat network is recommended as the most technically and financially appropriate solution for both PCH and residents, even under the high connection charge scenario. At Woodlands Court - situated outside of the District Heat Network Zone - a local GSHP network is the most viable low carbon solution.

At all other block types (Star, K/L, Easiform), further engagement with the city-wide District Heat Network is required in order to make connection decisions on a strategic and conditional basis. If connection can be agreed on a retail basis and with connection charges similar to those stated in the District Heat Network Connection Study, this is the recommended option. If connection on a bulk supply basis is required, moderate reductions to the stated connection charges are required. Otherwise, and for all locations not serviced by the District Heat Network, local Ground Source Heat Pump Heat Networks (and in the case of Easiform, distributed Air Source Heat Pumps) are the recommended alternative solution.

Connection cost thresholds to define the point at which the recommended option changes from the District Heat Network to the lowest cost alternative, have been provided to aid decision making by archetype.

For all central scenarios, the whole-life cost of heat for the preferred low-carbon heat alternative *is higher than the counterfactual option of installing new gas boilers*. This is based on assumed gas prices in 2025, and doesn't account for prolonged high gas prices. For residents to maintain bill parity, significant ongoing additional cost is incurred, which adds further to the already significant projected increases to annual PCH costs. The overall carbon abatement cost for the preferred scenarios ranges from £21 to £266 / t CO<sub>2</sub>e.

The recommended approach minimises 60-year whole-life costs across the portfolio, protects resident affordability, and limits long-term support exposure for PCH. It aligns with the Warm Homes Plan and emerging zoning policy.

## Preferred Low Carbon Heat Pathways

### High-Rise Multi-Storey - Tavy, Tamar & Lynher House (Sites 1-3, 90 dwellings per block)

**Preferred pathway:** Retail District Heat Network (DHN)

These high-rise blocks are well suited to connecting to a city-wide DHN. The financial appraisal indicates that a retail DHN arrangement is the preferred option, albeit with the potential for higher costs to residents in comparison to the gas counterfactual.

- Aligns with Heat Network Zone expectations and policy direction
- Enables connection to strategic low carbon infrastructure
- Avoids on-site plant and operational complexity
- Provides long-term decarbonisation pathway

Bulk DHN arrangements may be required to deliver DHN connections at these sites; however, at the stated DHNCS charges, residents will be exposed to slightly higher heating costs without support. Alternative LCHO options perform poorly and only a centralised ASHP network is considered viable at these sites and would lead to significantly higher LCOH and resident heating costs.

### High-Rise - Woodlands Court (66 dwellings)

**Preferred pathway:** Local GSHP communal heat network

Woodlands Court is not located within a Heat Network Zone and has lower overall demand. The GSHP communal network:

- Delivers the lowest whole-life cost for this site
- Achieves strong seasonal efficiency
- Reduces long-term electricity exposure relative to ASHP
- Offers better long-term decarbonisation alignment

However, achieving resident bill parity requires a defined tariff structure and potentially some additional support. The adjacent land availability makes borehole deployment technically feasible, subject to ground investigation and stakeholder approval. This site would be a strong early-phase demonstrator for communal GSHP deployment.

### Star Block Archetype (12 dwellings)

**Preferred pathway:** DHN (Retail)

For the Star Block form, connection to a DHN represents the preferred route where feasible. The financial appraisal indicates that a retail DHN arrangement is the preferred option, albeit with the potential for significantly higher costs to residents in comparison to the gas counterfactual.

- Aligns with zoning and strategic network expansion
- Enables standardised delivery across multiple blocks
- Reduces on-site operational requirements

Bulk DHN arrangements may be required to deliver DHN connections at these sites; however, in this case lower connection charges than those stated in the DHNCS are required to maintain competitiveness with the alternative local GSHP solution. Where DHN connection is not viable or cost-effective, local GSHP communal systems represent the best alternative low carbon heat option.

### **K/L Block Archetype (21 dwellings typical)**

**Preferred pathway: DHN (Retail)**

K/L blocks benefit from medium-rise density and existing wet heating systems, making them suitable for both DHN connection and communal systems. The financial appraisal indicates that a retail DHN arrangement is the preferred option, albeit with the potential for higher costs to residents in comparison to the gas counterfactual.

- DHN connection aligns with strategic infrastructure and zoning
- Retail arrangements provide a deliverable route where bulk supply is not available
- Simplifies long-term asset ownership and operation

Bulk DHN arrangements may be required to deliver DHN connections at these sites; however, in this case lower connection charges than those stated in the DHNCS are required to maintain competitiveness with the alternative LCHO. Where DHN connection is not viable or cost-effective, local GSHP communal systems represent the best alternative low carbon heat option.

### **Easiform Block Archetype (6 dwellings typical)**

**Preferred pathway: DHN (Retail)**

For Easiform blocks, DHN connection is preferred where available, supporting alignment with wider network infrastructure. However, due to small scale and dispersed layout, infrastructure costs may be disproportionately high and both Retail and Bulk supply DHN scenarios may increase resident costs without support.

Where DHN is not viable, distributed ASHP systems represent the most appropriate alternative, delivering the lowest whole-life cost at small scales, requiring minimal infrastructure, and offering proven and scalable delivery and operation.

## **Implementation Pathway**

Delivery should follow a phased, archetype-led programme that prioritises District Heat Network (DHN) connection where viable, while retaining flexibility to deploy alternative low carbon heat options where these provide better financial outcomes.

Progression should initially focus on retail DHN supply scenarios across all sites, with the exception of Woodlands Court. Where retail DHN is not feasible or does not deliver an acceptable cost position, bulk supply arrangements should be investigated alongside detailed internal works design, costing and ownership analysis to define viable technical and commercial solutions. Where both retail and bulk DHN options result in higher costs than alternative low carbon heat options, schemes should progress to the design and delivery of the preferred alternative LCHO for those sites. In parallel, Woodlands Court should be advanced as a standalone GSHP demonstrator to establish delivery capability, inform future communal system

deployment and provide an early operational benchmark. Figure 7.1 provides an overview of the anticipated implementation pathway, alongside key metrics on capital and operational spend phases.

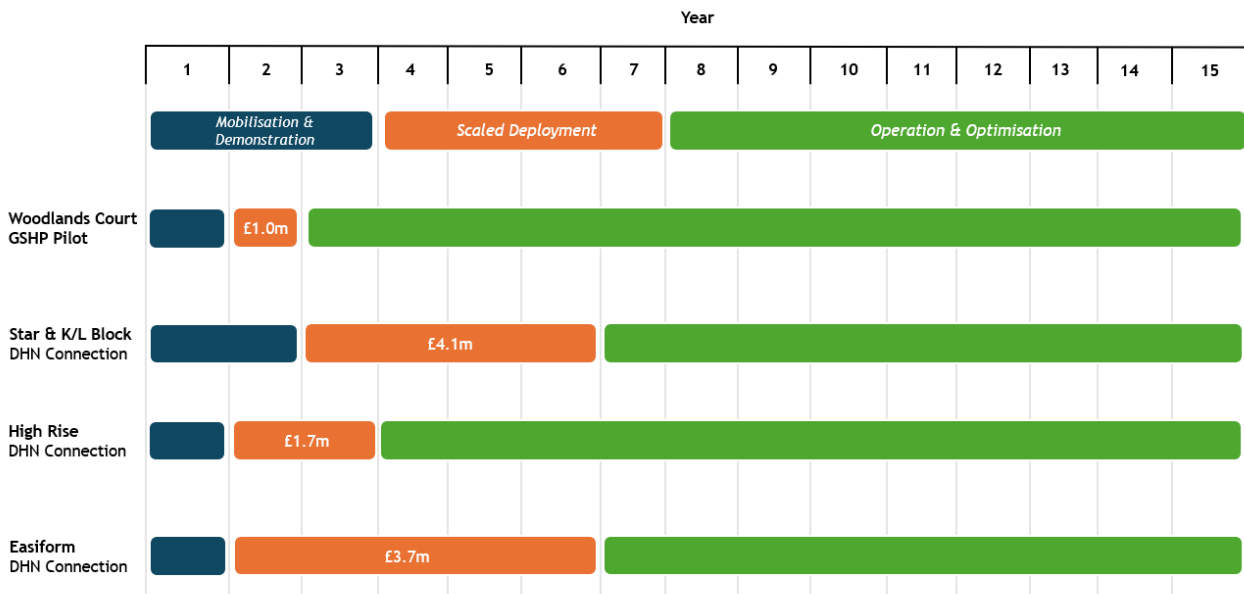


Figure 7.1 - Implementation pathways across archetypes

### Phase 1 - Mobilisation and Demonstration (Years 1 - 3)

Initial investment should prioritise pilot and early-phase schemes that build technical confidence and delivery capability. This includes progressing retail DHN feasibility and commercial structuring across applicable sites, alongside the development of bulk supply and internal system designs where required. In parallel, a GSHP demonstrator at Woodlands Court will be delivered, alongside early-stage deployment of alternative LCHO solutions (including GSHP or ASHP) where DHN is not viable.

Capital investment during this phase is focused on feasibility development, borehole drilling, energy centre construction and initial system installations. Operational systems for communal billing, monitoring and maintenance should be established in parallel. The objective is to create standardised design templates, procurement frameworks and resident engagement models.

**Number of properties targeted: 66 - 285**

**Total CAPEX: £1.0 - £3.0m**

### Phase 2 - Scaled Deployment (Years 3 - 7)

With lessons embedded, delivery scales across the portfolio, prioritising DHN connection where retail or bulk supply arrangements are viable and cost-effective. Where DHN solutions are not deliverable or result in higher costs, alternative LCHO pathways (including GSHP and ASHP systems) are deployed at scale through repeatable delivery models.

Investment peaks during this phase as multiple schemes progress concurrently. Infrastructure scaling includes network connections, expansion of borehole fields, modular energy centres and centralised monitoring platforms. Economies of scale reduce unit installation costs and strengthen contractor frameworks, while internal capability is established to manage a mixed portfolio of heat solutions.

**Number of properties targeted:** 1,500 - 1,700

**Total CAPEX:** £10 - 15m

### **Phase 3 - Portfolio Optimisation (Years 7 - 15)**

Capital intensity reduces as major retrofit works conclude. Focus shifts to performance optimisation, lifecycle planning and potential strategic integration with wider heat network infrastructure where DHN coverage expands or commercial arrangements improve.

Operational expenditure stabilises and becomes embedded within long-term asset management planning. Data-driven optimisation, tariff review and carbon performance monitoring become the primary levers for value management, ensuring continued alignment with cost, carbon and resident affordability objectives.

**Number of properties targeted:** 0

**Total CAPEX:** £0

## **Next Steps**

Following on from this Options Appraisal, more detailed assessment of the preferred options should be undertaken to review and confirm the final conclusion. From a technical perspective, this should include:

- MEP (Mechanical, Electrical and Plumbing) survey of the buildings;
- Obtaining smart meter records and/or energy bills from a representative sample of flats in each of the blocks to validate assumptions on energy demand;
- Engaging with the local Distribution Network Operator over electricity grid network capacity in the area to understand network capacity for the different electrification strategies and costs and timescales for any required upgrades;
- Developing the preferred low carbon heat option design to the equivalent of RIBA Stage 2 to understand space and design requirements, and identify locations for infrastructure for every site;
- Ongoing investigation by PCH into fabric improvements and enabling works to support low-temperature supply arrangements, which are no-regrets interventions that will reduce annual heat demand for all heat supply options, while also enabling efficiency improvements to low-temperature heat networks.

PCH should also consider:

- Defining their preferred point of demarcation between PCH assets and those to be operated by the appointed development partner, noting that this may vary by archetype;
- Investigating the potential for direct support from the Heat Network Delivery Unity (HNDU) to undertake a feasibility study for a communal heat network serving the Devonport High Rise tower blocks, taken to RIBA 2 to encourage a delivery partner to connect.
- Exploring grant funding opportunities, such as Green Heat Network Funding, for the communal network opportunity serving the Devonport High Rise tower blocks.

# APPENDIX A - DETAILED TECHNICAL APPRAISAL

## Technical Methodology

The below methodology was applied in the technical appraisal conducted within this report.

### 1. Define assessment scenarios:

Confirm the buildings and representative block archetypes to be appraised, and the appropriate technology scenarios to be appraised for each block based on an initial high-level assessment.

### 2. Compile baseline demand inputs at block-level:

For each building/block archetype extract baseline energy demand outputs from the baseline energy assessment, including space heating demand, domestic hot water demand, peak daily heating demand, and peak hourly space heating demand. These values define the thermal demand envelope from which all low-carbon heating options are sized.

### 3. Create representative 'average' blocks for variable archetypes:

For block archetypes with significant variation (K/L, Easiform, and Star) in baseline energy properties, generate a representative 'average' block by aggregating and averaging out baseline energy outputs. This produces a single block archetype suitable for technical feasibility assessment.

### 4. Map buildings against city-wide DHN Zones

Use GIS to map PCH buildings against Plymouth City Council heat network zoning layers, including Advanced Zoning Programme areas, to establish whether sites are located within, adjacent to, or outside planned DHN zones. This informs the inclusion and framing of the city-wide DHN option within the technical appraisal.

### 5. Size low-carbon heating solutions (nPro methodology)

Low-carbon heating solutions are sized using nPro software<sup>8</sup> for each applicable block archetype and scenario, applying a consistent methodology and local climate context.

- nPro is configured to Plymouth-specific climate basis, with local ambient air temperatures for ASHPs (Table 0-1) and ground temperature assumptions for GSHPs, ensuring that performance reflects local conditions.
- Baseline peak heating demand is used to determine nominal heat pump capacity, while annual space heating and domestic hot water demand are used to calculate annual heat generation, electricity demand, and full load hours.
- For local heat networks serviced by ASHP energy centres, nPro-outputs include nominal heating capacity, associated electrical capacity, annual heat generation, electricity demand, and full load hours, and year-long hourly heat generation and electricity-demand profiles of the ASHP.
- For a GSHP energy hub, nPro is additionally used to size the bore hole field required to meet annual heat extraction, defining probe number, arrangement, depth, total probe length, land take, and key inlet temperature constraints alongside heat pump capacity. These are depending on several input assumptions (Table 0-2).

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<sup>8</sup> nPro: A web-based planning tool for designing district energy systems and thermal networks. Marco Wirtz. Energy, 126575, 2023. DOI: 10.1016/j.energy.2022.126575

**6. Develop option-specific internal/external technical requirements.**

For each option and block archetype, document the implications of external plant arrangements, internal heat distribution, and heat interface units, including compatibility with existing wet heating systems.

*Table 0-1 - Assumed seasonal air temperatures for Plymouth.*

Month	Min. of Air temperature (°C)	Average of Air temperature (°C)	Max. of Air temperature (°C)
Jan	-0.2	7.4	12.2
Feb	-0.8	7.1	13.1
Mar	-2.9	8.0	19.9
Apr	1.9	9.4	16.5
May	3.4	11.9	25.4
Jun	5.3	14.4	25.1
Jul	8	16.3	28.2
Aug	9	15.6	24.5
Sep	5	14.2	21.5
Oct	5	12.2	17.9
Nov	0.7	8.8	13.8
Dec	-0.5	8.1	12.1

*Table 0-2 - Borehole input assumptions for Local Heat Network GSHP appraisal*

Input	Unit	Assumption
Borehole distance	m	8
Probe length	m	200
Temperature difference (probe)	K	3
Min. inlet temp. borehole	°C	-4.00
Max. outlet temp. borehole	°C	30.00
Thermal conductivity	W/(mK)	2.25
Volumetric heat capacity	MJ/(m <sup>3</sup> K)	2.4
Geothermal heat flux density	W/m <sup>2</sup>	0.07
Borehole resistance	mK/W	0.075
Borehole radius	m	0.08

# Site Appraisal

## Site 1- 3: Tavy House, Tamar House, and Lynher House

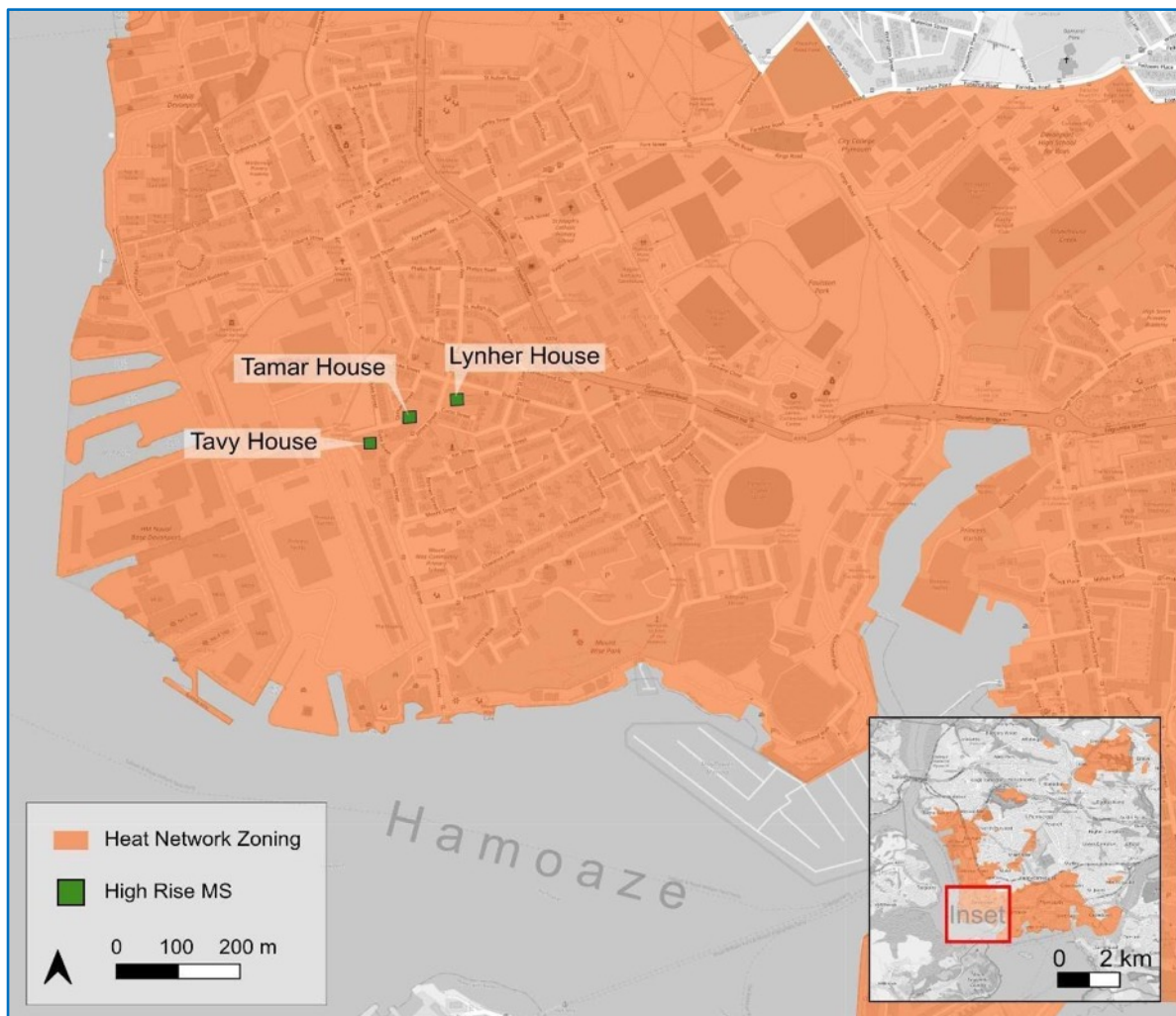


Figure 0.1 - Location of the Devonport High Rises

Table 0-3 - Heat decarbonisation options appraised for Lynher, Tavy, and Tamar House

OPTION	APPRAISED	RATIONALE
City-wide District Heat Network (DHN)	Yes	All three blocks are located within a planned heat network zone. Their scale, density, and proximity make them well suited to networked heat supply, with limited requirements for external plant at dwelling level.
Local Heat Network - ASHP Energy Centre	Yes	A building- or site-level ASHP energy centre is technically feasible in principle and avoids the need for individual external units on upper floors. This option provides a potential standalone or interim solution where connection to the city DHN is delayed or phased.

OPTION	APPRAISED	RATIONALE
Local Heat Network - GSHP Energy Centre	No	GSHP systems typically require significant land take for boreholes or ground arrays. Initial modelling showed that Tavy, Tamar and Lynher Houses require a 248 kWth heat pump delivering approximately 398 MWh/yr of heat. The system would require 24 boreholes with a total borehole field area of 1,536 m <sup>2</sup> . Potential locations were assessed within available green spaces and unused undercroft garages; however, the available area is insufficient to accommodate the required borehole field.
Distributed ASHPs (individual flats)	No	Distributed ASHPs are not considered technically appropriate for high-rise buildings due to installation complexity, façade and access constraints, acoustic considerations, and the scale of resident disruption required.

### Energy Demand and Data Inputs

Energy demand for the Devonport high-rise blocks has been derived from detailed dynamic modelling undertaken using representative dwelling archetypes. The modelling captures variation by floor level, flat size, and position within the building and has been aggregated to reflect a full 90-flat block.

The same baseline demand characteristics have been applied to Lynher House, Tamar House and Tavy House, reflecting their identical construction, layout, and services. As a result, the technical appraisal and subsequent system sizing are directly transferable across all three buildings.

The aggregated energy demand inputs form the basis for assessing technical feasibility, plant sizing, and compatibility with district and local heat network solutions in subsequent sections.

Table 0-4 - Heating options appraisal demand inputs

PARAMETER	INPUT VALUE
Total number of flats	90
Total annual energy demand (kWh)	537,319
Annual electricity demand (kWh)	537,319
Annual space heating demand (kWh)	174,520
Annual domestic hot water demand (kWh)	223,692
Peak hourly space heating demand (kWh)	198.3
Peak hourly hot water demand (kWh)	62.46
Peak hourly heat demand (kWh)	247.4

## Local Heat Network ASHP Appraisal

The local heat network ASHP option for the Devonport high-rise cluster has been modelled as a centrally located energy centre serving each block via a low-temperature communal heat network. The system is sized to meet aggregated space heating and domestic hot water demand for a representative 90-flat tower.

Table 0-5 - Air-source heat pump parameters

PARAMETER	VALUE
Generated heat	398 MWh
Electricity demand	147 MWh
Full load hours	1082 h/year
Nominal heating power	368 kW <sup>th</sup>
Nominal electric capacity	92 kW <sup>el</sup>
SCOP	2.7

**External and plant arrangements:** The ASHP units and associated plant (buffer vessels, pumps, controls, and electrical infrastructure) would be located externally at ground or podium level, subject to detailed spatial, acoustic, and planning considerations. Centralising plant avoids the need for external units on upper floors and reduces visual and acoustic impacts on dwellings.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas warm-air heating system would be removed and replaced with a heat-pump-compatible Heat Interface Unit (HIU) incorporating an integrated domestic hot water thermal store. The HIU would provide space heating and hot water via plate heat exchangers, with integrated heat metering, controls, and differential pressure regulation suitable for high-rise operation. New internal wet distribution pipework and heat emitters would be required within dwellings, reflecting the absence of existing wet heating systems. The use of a store-based HIU supports reliable domestic hot water delivery at lower network temperatures and is well suited to a low-temperature, heat-pump-led communal network. All gas-fired plant would be decommissioned as part of the transition.

**Pipework quantity and assumptions:** Indicative communal heat network pipework quantities have been estimated for the Devonport high-rise cluster using scaled architectural drawings, typical high-rise floor-to-floor heights, and conservative routing assumptions. The three towers are of near-identical form and layout; therefore, pipework quantities have been estimated on a per-block basis and can be applied consistently to Tavy House, Tamar House and Lynher House. The methodology assumes centrally located vertical risers within the stair/lift core, horizontal corridor-based distribution on each residential floor, and individual branch connections to Heat Interface Units (HIUs) within each dwelling.

Table 0-6 - Indicative communal heat network pipework quantities

PARAMETER	VALUE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 15 floors, incl. plant room and roof allowances	~105
Horizontal floor distribution	Flow and return along corridor spines on 15 floors (incl. fittings allowance)	~720
Branches to dwellings (HIUs)	Average 5 m per flat (flow & return) serving 90 flats	~990
Plant room pipework & headers	Allowance for headers, buffers, isolation valves and metering	~60
Total estimated pipework length (per block)		~1,875 m

The pipework quantities set out above relate to the internal building distribution network, including vertical risers, horizontal floor distribution, and branch connections to dwelling-level Heat Interface Units (HIUs). These elements are common to the Local Heat Network (ASHP) option.

For the ASHP option, additional pipework is limited to short low-temperature connections between the external air-source heat pump units and the building energy centre headers, together with associated isolation valves and fittings. These source-side connections are relatively minor in length compared with the internal distribution network and have therefore been excluded from the feasibility-level pipework quantities presented.

### City-wide District Heat Network (DHN)

To connect Tavy House, Tamar House or Lynher House to the city-wide DHN, it is anticipated that the technical works set out in Table 0-7 will be required and must be led by the building owner or manager. This information is the basis for cost estimation for all building-side installation works and therefore the financial viability of this option.

Further information on the connection requirements and all installation works required to connected to the PCC heat network is provided in **Appendix B - City-wide Heat Network Technical Review**.

Table 0-7 - City-wide DHN technical requirements for Tavy House, Tamar House and Lynher House.

WORKS REQUIRED	TAVY HOUSE	TAMAR HOUSE	LYNHER HOUSE	METRIC
Number of properties	90	90	90	Number
District heat supply and return	71	26	26	Meters
Plantroom:				

WORKS REQUIRED	TAVY HOUSE	TAMAR HOUSE	LYNHER HOUSE	METRIC
Expansion vessels	2	2	2	Number vessels
Heat Meter	1	1	1	Number and type
Heat network substation				
Plate heat exchanger	1	1	1	Number exchangers
Primary heat meter	1	1	1	Number and type of meter
Heat distribution system				
Flow and return distribution pipework (risers and laterals)	1,875	1,875	1,875	Meters
In-dwelling equipment				
Heat Interface Unit (HIU)	90	90	90	Number
Heat emitters (low temperature radiators)	390	390	390	Number and type
Thermostatic radiator valves	390	390	390	Number

## Site 4: Woodlands Court

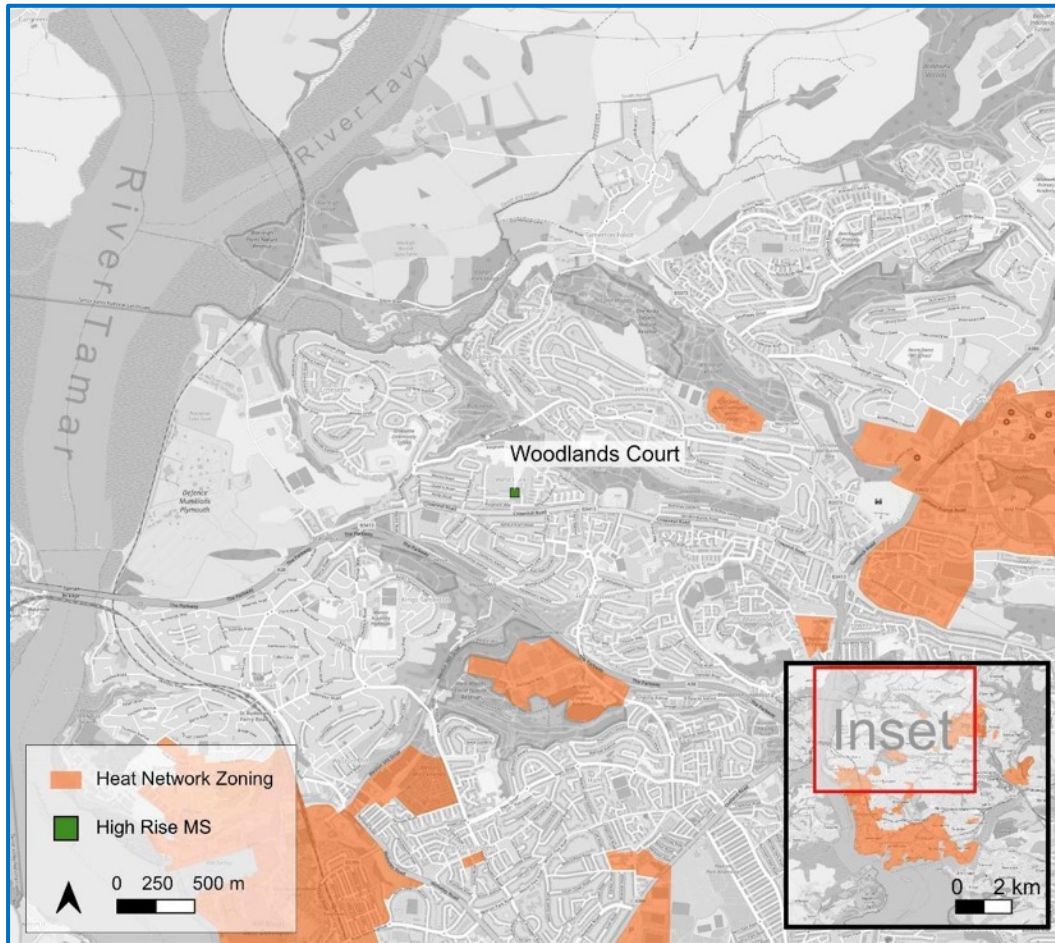


Figure 0.2 - Location of Woodlands Court

Table 0-8 - Heat decarbonisation options appraised for Woodlands Court

OPTION	APPRAISED	RATIONALE
City-wide District Heat Network (DHN)	No	The site is not within a planned heat network zone, and remote from other high-density heat loads.
Local Heat Network - ASHP Energy Centre	Yes	A building- or site-level ASHP energy centre is technically feasible in principle and can utilise the existing wet heating distribution within dwellings.
Local Heat Network - GSHP Energy Centre	Yes	Unlike the Devonport cluster, Woodlands Court has fewer immediate spatial constraints and is therefore included for GSHP appraisal at this stage, subject to confirmation of available land for ground arrays.
Distributed ASHPs (individual flats)	No	Distributed ASHPs are not considered appropriate for a high-rise building due to installation complexity, façade and access constraints, and resident disruption.

## Energy Demand and Data Inputs

Energy demand for Woodlands Court has been derived from dynamic modelling using the same archetype definitions as the other high-rise blocks, scaled to reflect the reduced number of dwellings and the different hot water supply arrangement.

Overall energy consumption at Woodlands Court is significantly lower than the Devonport high-rise blocks, reflecting:

- Approximately one third fewer flats (66 compared with 90);
- Gas-fired shared hot water provision rather than electric immersion heaters;
- Lower electricity demand as a result.
- The aggregated baseline demand inputs form the basis for assessing technical feasibility, plant sizing, and compatibility with district and local heat network solutions.

Table 0-9 Heating options appraisal demand inputs

PARAMETER	INPUT VALUE
Total number of flats	66
Total annual energy demand (kWh)	392,164
Annual space heating demand (kWh)	90,803
Annual domestic hot water demand (kWh)	187,471
Peak hourly space heating demand (kWh)	145.2
Peak hourly hot water demand (kWh)	52.3
Peak hourly heating demand (kWh)	186.3

## Local Heat Network ASHP Appraisal

The local heat network ASHP option for Woodlands Court has been modelled as a centrally located air-source heat pump energy centre supplying space heating and domestic hot water via a low-temperature communal distribution network serving the 66-flat block.

Table 0-10 - Air-source heat pump parameters

PARAMETER	VALUE
Generated heat	278 MWh
Electricity demand	103 MWh
Full load hours	1,008 h/year
Nominal heating power	276 kW <sup>th</sup>
Nominal electric capacity	69 kW <sup>el</sup>
SCOP	2.7

**External and plant arrangements:** The ASHP units and associated plant (including buffer vessels, pumps, controls, and electrical infrastructure) would be located externally at ground or roof level, subject to detailed spatial, acoustic, and planning considerations. Centralised plant avoids the need for individual external units at dwelling level and simplifies long-term operation and maintenance.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas boiler would be replaced with a low-temperature Heat Interface Unit (HIU) with an integrated domestic hot water thermal store. The HIU would provide space heating and hot water via plate heat exchangers, with integrated heat metering and controls. Existing wet radiator systems would be retained where suitable, subject to confirmation of emitter sizing and control compatibility with lower flow temperatures. The use of a store-based HIU reduces reliance on higher network temperatures and is appropriate for both ASHP- and GSHP-led communal systems. All gas-fired plant and the existing shared hot water system would be decommissioned as part of the works.

**Pipework quantity and assumptions:** Indicative pipework quantities have been estimated for Woodlands Court using scaled architectural drawings, typical floor-to-floor heights, and conservative routing assumptions appropriate to a low-temperature communal heat network Table 0-11. The approach assumes centralised vertical risers serving all floors, horizontal corridor-based distribution on each residential floor, and individual branch connections to Heat Interface Units (HIUs) within each dwelling.

Table 0-11 - Indicative communal heat network pipework quantities

PARAMETER	VALUE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 11 storeys (incl. plant room and roof allowances)	~75
Horizontal floor distribution	Flow and return along corridor spine on each floor (11 floors, incl. fittings allowance)	~530
Branches to dwellings (HIUs)	Average 5 m per flat (flow & return) serving 66 flats	~725
Plant room pipework & headers	Allowance for headers, buffers, valves, metering and connections	~50
<b>Total estimated pipework length</b>		<b>~1,380 m</b>

The communal distribution pipework quantities for Woodlands Court are common to both heat network options. For the ASHP option, additional pipework is limited to short low-temperature connections between the external ASHP unit and the energy centre headers, together with associated isolation valves and fittings. These lengths are minor relative to the internal distribution network and have been excluded from the feasibility-level pipework quantities.

## Local Heat Network GSHP Appraisal

The local heat network GSHP option for Woodlands Court has been modelled as a centrally located ground-source heat pump energy hub supplying space heating and domestic hot water via a low-temperature communal distribution network.

The system comprises a 187 kW<sup>th</sup> ground-source heat pump supplied by a vertical borehole array, delivering approximately 278 MWh of heat per year with an associated electricity demand of 46.4 MWh. The resulting SCOP of 3.2 reflects the relatively stable ground temperatures available at depth and indicates high seasonal efficiency compared with air-source alternatives.

Table 0-12 - Energy hub parameters

PARAMETER	VALUE
Extraction rate	129 kW <sup>th</sup>
Generated heat	278 MWh
Heat pump capacity	187 kW <sup>th</sup>
Electricity demand	87 MWh
SCOP	3.2

The borehole field is modelled as 15 probes at 200 m depth, providing a total probe length of 3000 m over an indicative area of approximately 960 m<sup>2</sup>. The undisturbed ground temperature of around 14°C supports stable operation, with minimum inlet temperatures remaining above critical thresholds in the first year of operation.

Table 0-13 - Borehole calculation results

PARAMETER	UNITS	VALUE
Borehole arrangement	---	3 x 5 (15)
Probe length	m	---
Total probe length	m	3000
Min. inlet temp. borehole	°C	-2.62
Borehole field area	m <sup>2</sup>	960
Length of the probe field	m	24
Width of the probe field	m	40
Specific heat extraction	W/m	42.693
g-function value	---	18.982
Undisturbed ground temperature	°C	14.05
Min. temperature borehole inlet in 1st year	°C	6.85

**External and plant arrangements:** External works would include drilling and installation of the borehole field, ground loop pipework, and an energy hub housing the heat pump, buffer vessels, pumps, and controls. The spatial requirement for the borehole field represents a key site-specific dependency for this option.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas boiler would be replaced with a low-temperature Heat Interface Unit (HIU) with an integrated domestic hot water thermal store. The HIU would provide space heating and hot water via plate heat exchangers, with integrated heat metering and controls. Existing wet radiator systems would be retained where suitable, subject to confirmation of emitter sizing and control compatibility with lower flow temperatures. The use of a store-based HIU reduces reliance on higher network temperatures and is appropriate for both ASHP- and GSHP-led communal systems. All gas-fired plant and the existing shared hot water system would be decommissioned as part of the works.

**Pipework quantity and assumptions:** Indicative pipework quantities have been estimated for Woodlands Court using scaled architectural drawings, typical floor-to-floor heights, and conservative routing assumptions appropriate to a low-temperature communal heat network. The approach assumes centralised vertical risers serving all floors, horizontal corridor-based distribution on each residential floor, and individual branch connections to Heat Interface Units (HIUs) within each dwelling.

*Table 0-14 - Indicative communal heat network pipework quantities*

PARAMETER	BASIS OF ESTIMATE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 11 storeys (incl. plant room and roof allowances)	~75
Horizontal floor distribution	Flow and return along corridor spine on each floor (11 floors, incl. fittings allowance)	~530
Branches to dwellings (HIUs)	Average 5 m per flat (flow & return) serving 66 flats	~725
Plant room pipework & headers	Allowance for headers, buffers, valves, metering and connections	~50
<b>Total estimated pipework length</b>		<b>~1,380 m</b>

The communal distribution pipework quantities for Woodlands Court are common to both heat network options. For the GSHP option, additional pipework is required between the borehole field and the energy hub, including ground loop headers, trench pipework, and internal connections to the heat pump. These source-side pipework elements are specific to the GSHP option and are considered separately from the building distribution network at this stage.

## Site 5: Star Block (Archetype)

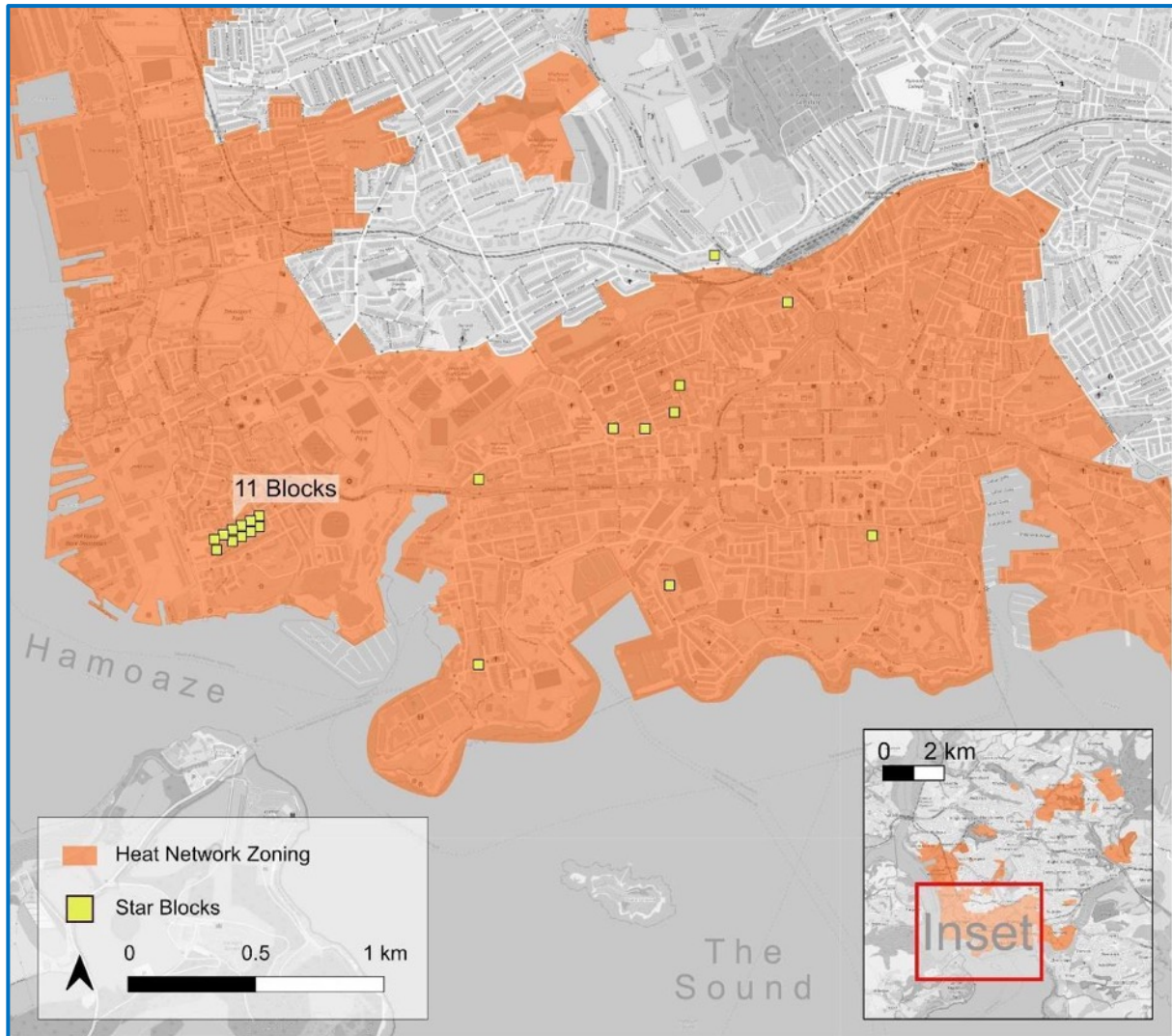


Figure 0.3 - Location of Star Blocks

### Energy Demand and Data Inputs

Table 0-15 details the heating options appraised for the star block archetype.

Table 0-15 - Heat decarbonisation options appraised for Star block archetype.

OPTION	APPRAISED	RATIONALE
City-wide District Heat Network (DHN)	Yes	Most Star Blocks are located within planned heat network zones, making DHN connection technically and strategically aligned.
Local Heat Network - ASHP Energy Centre	Yes	Block-scale ASHP energy centres are technically feasible and compatible with existing wet heating systems.
Local Heat Network - GSHP Energy Centre	Yes	GSHP systems are feasible in principle, subject to confirmation of available land for borehole arrays at site level.

OPTION	APPRAISED	RATIONALE
Distributed ASHPs (individual flats)	No	Distributed ASHPs are not appropriate due to space, visual, acoustic, and installation complexity across multiple dwellings.

Energy demand for the Star Block archetype has been derived by averaging outputs from multiple detailed model runs representing the range of Star Block configurations across the housing stock. The modelling captures variation in:

- Floor level (ground, mid, top);
- Block wing (left, long, right);
- Dwelling size;
- Standalone versus adjoining configurations;
- Fabric insulation levels;
- Orientation (grouped to  $\pm 20$  degrees).

The resulting archetype represents a realistic Star Block for technical feasibility assessment.

Table 0-16 - Heating options appraisal demand inputs

PARAMETER	INPUT VALUE
Total number of flats	12
Total annual energy demand (kWh)	153,537
Annual space heating demand (kWh)	89,355
Annual domestic hot water demand (kWh)	46,386
Peak hourly space heating demand (kWh)	63.5
Peak hourly hot water demand (kWh)	11.3
Peak hourly heating demand (kWh)	72.3

The preferred low carbon heating solutions for the Star Block archetype are inherently modular and scalable. Where blocks are joined or developed in clusters, plant capacity and distribution infrastructure can be scaled proportionally to serve multiple Star Blocks from a single energy centre.

Table 0-17 - Indicative scaling of Star Block heating solutions

CONFIGURATION	EQUIVALENT STAR BLOCKS	APPROX. DWELLINGS SERVED
Single Star Block	1×	~12
Double Star Block	2×	~24
Triple Star Block	3×	~36

## Local Heat Network ASHP Appraisal

The local heat network ASHP option for the Star Block archetype has been modelled as a block-scale energy centre supplying space heating and domestic hot water via a low-temperature communal distribution network. The system is sized on a per-block basis, representing a typical Star Block of approximately 12 dwellings, and can be scaled linearly to serve multiple adjoining Star Blocks from a single energy centre where blocks are physically connected.

Table 0-18 - Air-source heat pump parameters

PARAMETER	VALUE
Generated heat	136 MWh
Electricity demand	50 MWh
Full load hours	1,212 h/year
Nominal heating power	112 kW <sup>th</sup>
Nominal electric capacity	28 kW <sup>el</sup>
SCOP	2.7

**External and plant arrangements:** ASHP units and associated plant (buffer vessels, pumps, controls, and electrical infrastructure) would be located externally at ground or roof level, subject to site-specific spatial, acoustic, and planning constraints. Where Star Blocks are joined, plant capacity can be increased proportionally to serve multiple blocks from a shared energy centre.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas boiler would be replaced with a compact, low-temperature HIU incorporating an integrated domestic hot water thermal store. The HIU would supply space heating and instantaneous or stored hot water via plate heat exchangers, with integrated heat metering and dwelling-level controls. Existing wet radiator systems are compatible in principle with low-temperature operation, subject to confirmation of emitter sizing. Store-based HIUs are particularly well suited to heat-pump-led networks and support scalable deployment across multiple adjoining Star Blocks served by a shared energy centre. All gas-fired plant would be decommissioned as part of the transition.

**Pipework quantity and assumptions:** Indicative communal heat network pipework quantities have been estimated for the Star Block archetype using scaled flat plans (1:50) and conservative routing assumptions appropriate to a low-temperature communal heat network. The Star Block is appraised on a per-block basis (typically 12 dwellings: 4 storeys × 3 flats per floor). Where Star Blocks are joined (double or triple arrangements), the same per-block pipework quantities can be scaled proportionally, with additional inter-block connections dependent on the chosen energy centre location. The methodology assumes a centrally located riser within the stair/core, short horizontal distribution runs on each floor serving the three flats, and individual branch connections to Heat Interface Units (HIUs) within each dwelling.

Table 0-19 - Indicative communal heat network pipework quantities

PARAMETER	VALUE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 4 storeys, incl. plant room allowances	~25
Horizontal floor distribution	Short floor-level distribution/manifold runs to 3 flats per floor (4 floors, incl. fittings allowance)	~130
Branches to dwellings (HIUs)	Short runs from floor distribution to HIU within each flat (12 flats)	~80
Plant room pipework & headers	Allowance for headers, isolation valves, metering and connections	~20
Total estimated pipework length		~255 m

The pipework quantities presented above relate to the internal communal distribution network within a single Star Block, including vertical risers, horizontal floor distribution, and branch connections to dwelling-level Heat Interface Units (HIUs). These elements are directly applicable to the Local Heat Network (ASHP) option.

For the ASHP option, additional pipework is limited to short low-temperature connections between the external air-source heat pump units and the block-level energy centre headers. These source-side connections are minor relative to the internal distribution network and have therefore been excluded from the indicative pipework quantities at this feasibility stage.

### Local Heat Network GSHP Appraisal

The local heat network GSHP option for the Star Block archetype has been modelled as a block-scale ground-source energy hub supplying space heating and domestic hot water via a low-temperature communal distribution network. The system is assessed on a per-block basis (12 dwellings) and can be scaled proportionally to serve multiple adjoining Star Blocks from a shared energy centre where site conditions allow.

Table 0-20 - Energy hub parameters

PARAMETER	VALUE
Extraction rate	51 kW <sup>th</sup>
Generated heat	136 MWh
Heat pump capacity	74 kW <sup>th</sup>
Electricity demand	42.4 MWh
SCOP	3.2

Heat is supplied from a vertical borehole array of 5 probes at 200 m depth, providing a total probe length of 1000 over an indicative area of 320 m<sup>2</sup>. Ground temperatures are sufficient to maintain stable operation within acceptable limits in the first year.

Table 0-21 - Borehole calculation results

PARAMETER	UNITS	VALUE
Borehole arrangement	---	1 x 5 (5)
Probe length	m	200
Total probe length	m	1000
Min. inlet temp. borehole	°C	-2.05
Borehole field area	m <sup>2</sup>	320
Length of the probe field	m	8
Width of the probe field	m	40
Specific heat extraction	W/m	50.62
g-function value	---	10.515
Undisturbed ground temperature	°C	14.05
Min. temperature borehole inlet in 1st year	°C	4.73

**External and plant arrangements:** External works would include drilling and installation of the borehole field, ground loop pipework, and an energy hub housing the heat pump, buffer vessels, pumps, and controls. The requirement for suitable land to accommodate the borehole array represents the principal site-specific dependency for this option.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas boiler would be replaced with a compact, low-temperature HIU incorporating an integrated domestic hot water thermal store. The HIU would supply space heating and instantaneous or stored hot water via plate heat exchangers, with integrated heat metering and dwelling-level controls. Existing wet radiator systems are compatible in principle with low-temperature operation, subject to confirmation of emitter sizing. Store-based HIUs are particularly well suited to heat-pump-led networks and support scalable deployment across multiple adjoining Star Blocks served by a shared energy centre. All gas-fired plant would be decommissioned as part of the transition.

**Pipework quantity and assumptions:** Indicative communal heat network pipework quantities have been estimated for the Star Block archetype using scaled flat plans (1:50) and conservative routing assumptions appropriate to a low-temperature communal heat network. The Star Block is appraised on a per-block basis (typically 12 dwellings: 4 storeys x 3 flats per floor). Where Star Blocks are joined (double or triple arrangements), the same per-block pipework quantities can be scaled proportionally, with additional inter-block connections dependent on the chosen energy centre location. The methodology assumes a centrally located riser within the stair/core,

short horizontal distribution runs on each floor serving the three flats, and individual branch connections to Heat Interface Units (HIUs) within each dwelling.

Table 0-22 - Indicative communal heat network pipework quantities

PARAMETER	BASIS OF ESTIMATE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 4 storeys, incl. plant room allowances	-25
Horizontal floor distribution	Short floor-level distribution/manifold runs to 3 flats per floor (4 floors, incl. fittings allowance)	-130
Branches to dwellings (HIUs)	Short runs from floor distribution to HIU within each flat (12 flats)	-80
Plant room pipework & headers	Allowance for headers, isolation valves, metering and connections	-20
Total estimated pipework length		-255 m

The pipework quantities presented above relate to the internal communal distribution network within a single Star Block, including vertical risers, horizontal floor distribution, and branch connections to dwelling-level Heat Interface Units (HIUs). These elements are directly applicable to the Local Heat Network (GSHP) option.

For the GSHP option, additional pipework is required between the borehole field and the block-level energy hub, including buried ground loop headers and internal connections to the heat pump plant. These source-side pipework elements are specific to the GSHP option and are considered separately from the building distribution network at this stage of appraisal.

### City-wide District Heat Network (DHN)

To connect Star Blocks to the city-wide DHN, it is anticipated that the technical works set out in Table 0-23 will be required and must be led by the building owner or manager. This information is the basis for cost estimation for all building-side installation works and therefore the financial viability of this option.

Further information on the connection requirements and all installation works required to connected to the PCC heat network is provided in **Appendix B - City-wide Heat Network Technical Review**.

Table 0-23 - City-wide DHN technical requirements for Star Block

WORKS REQUIRED	QUANTITY	METRIC
Number of properties	12	Number
District heat supply and return	50	Meters
Plantroom:		

WORKS REQUIRED	QUANTITY	METRIC
Expansion vessels	2	Number vessels
Heat Meter	1	Number and type
Heat network substation		
Plate heat exchanger	1	Number exchangers
Primary heat meter	1	Number and type of meter
Heat distribution system		
Flow and return distribution pipework (risers and laterals)	255	Meters
In-dwelling equipment		
Heat Interface Unit (HIU)	12	Number

### Site 6: K/L Block (Archetype)

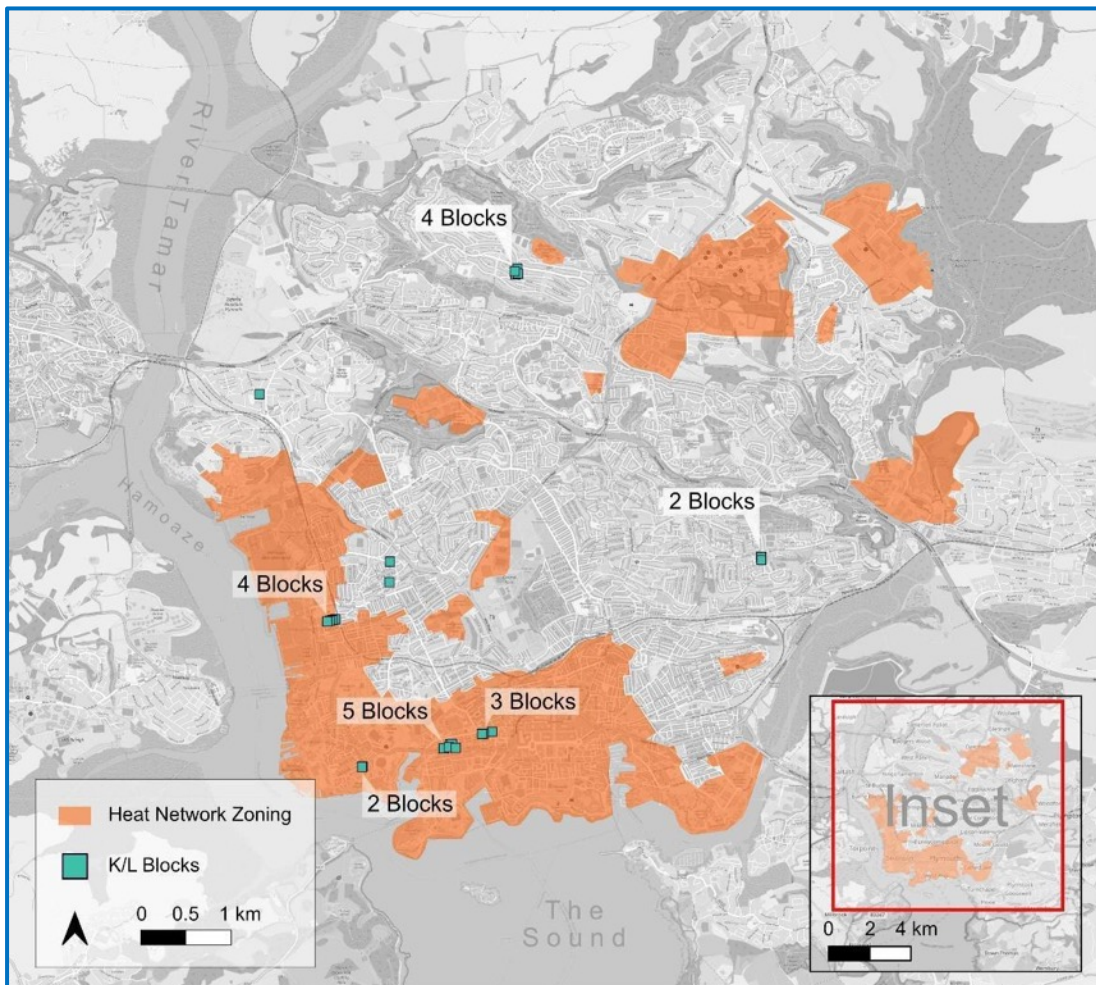


Figure 0.4 - Location of K/L Blocks

## Energy Demand and Data Inputs

Based on the building typology, spatial context, and strategic policy alignment, the following heat decarbonisation options have been included or excluded from the technical appraisal for the K/L Block archetype.

Table 0-24 - Heat decarbonisation options appraised for K/L block archetype.

OPTION	APPRAISED	RATIONALE
City-wide District Heat Network (DHN)	Yes	A significant proportion of K/L Blocks are located within planned heat network zones, making DHN connection a technically and strategically viable option.
Local Heat Network - ASHP Energy Centre	Yes	Block-scale ASHP energy centres are technically feasible and compatible with existing wet heating systems.
Local Heat Network - GSHP Energy Centre	Yes	GSHP systems are feasible in principle for this typology, subject to confirmation of available land for borehole arrays at site level.
Distributed ASHPs (individual flats)	No	Distributed ASHPs are not considered appropriate due to space constraints, external walkway interfaces, visual and acoustic impacts, and installation complexity.

Gas boiler replacement is excluded in line with policy direction, while direct electric heating is retained as a counterfactual for financial comparison.

Energy demand for the K/L Block archetype has been derived from a large number of detailed models runs representing the variation across the stock. The modelling captures differences in:

- Floor level (ground, mid, top);
- Terrace versus end-of-block position;
- Insulation levels;
- Orientation (grouped to  $\pm 22.5$  degrees).

In total, 147 individual model runs were undertaken to represent the diversity of K/L Blocks across 490 dwellings. The resulting archetype represents a realistic K/L Block, suitable for technical feasibility assessment and scalable to larger or smaller blocks.

Table 0-25 - Heating options appraisal demand inputs

PARAMETER	INPUT VALUE
Total number of flats	21
Total annual energy demand (kWh)	244,502
Annual space heating demand (kWh)	137,746
Annual domestic hot water demand (kWh)	67,958
Peak hourly space heating demand (kWh)	93.6
Peak hourly hot water demand (kWh)	19.0
Peak hourly heating demand (kWh)	108.5

## Local Heat Network ASHP Appraisal

The local heat network ASHP option for the K/L Block archetype has been modelled as a block-scale energy centre supplying space heating and domestic hot water via a low-temperature communal distribution network. The system is assessed on a per-block basis (typically 24 dwellings) and can be scaled to serve larger blocks or clusters where appropriate.

Table 0-26 - Air-source heat pump parameters

PARAMETER	VALUE
Generated heat	206 MWh
Electricity demand	76 MWh
Full load hours	1,254 h/year
Nominal heating power	164 kW <sup>th</sup>
Nominal electric capacity	41 kW <sup>el</sup>
SCOP	2.7

**External and plant arrangements:** ASHP units and associated plant (buffer vessels, pumps, controls, and electrical infrastructure) would be located externally at ground or roof level, subject to site-specific spatial, acoustic, and planning constraints. Where K/L blocks include ground-floor commercial units or constrained courtyards, plant location and noise mitigation would require careful consideration.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas boiler would be replaced with a low-temperature HIU with an integrated domestic hot water thermal store, incorporating heat metering, controls, and differential pressure regulation. The HIU would interface directly with the existing wet radiator system, which would be retained where suitable, with emitter or control upgrades potentially required to support lower flow temperatures. The use of a store-based HIU enables efficient operation with ASHP- or GSHP-led energy centres while limiting primary network temperatures. All gas-fired plant would be decommissioned as part of the transition.

**Pipework quantity and assumptions:** Indicative communal heat network pipework quantities have been estimated for the K/L Block archetype using available floor plans, site photographs, and conservative routing assumptions appropriate to a low-temperature communal heat network. The K/L Block is appraised on a per-block basis, with a typical block comprising 21 dwellings (generally 4-5 storeys, with external access walkways). Where blocks vary in length or are combined into larger terraces, the same per-block pipework quantities can be scaled proportionally. The methodology assumes a central vertical riser located within the enclosed stair core or internal service zone, horizontal distribution runs along each floor via internal corridors or ceiling zones adjacent to the external walkways, and individual branch connections to Heat Interface Units (HIUs) within each dwelling. External walkways introduce longer horizontal runs than for core-access blocks, which is reflected in the estimates below.

Table 0-27 - Indicative communal heat network pipework quantities

PARAMETER	VALUE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 4-5 storeys, incl. plant room allowances	~30
Horizontal floor distribution	Floor-level distribution runs serving 21 flats across 4 floors, incl. fittings allowance	~180
Branches to dwellings (HIUs)	Runs from floor distribution to HIU within each flat (21 flats)	~150
Plant room pipework & headers	Allowance for headers, isolation valves, metering and connections	~25
Total estimated pipework length		~385 m

For the Local Heat Network ASHP option, the pipework quantities above are directly applicable without modification. The ASHP plant is assumed to be located within a block-level or site-level energy centre, with flow and return pipework distributed via the internal riser and floor-level routes described. Operating temperatures compatible with low-temperature heat networks are assumed, and no additional internal pipework is required beyond the communal distribution network described above.

### Local Heat Network GSHP Appraisal

The local heat network GSHP option for the K/L Block archetype has been modelled as a block-scale ground-source energy hub supplying space heating and domestic hot water via a low-temperature communal distribution network. The system is assessed on a per-block basis (typically 24 dwellings) and can be scaled proportionally for larger blocks or clusters where suitable land for ground arrays is available.

Table 0-28 - Energy hub parameters

PARAMETER	VALUE
Extraction rate	75 kW <sup>th</sup>
Generated heat	206 MWh
Heat pump capacity	109 kW <sup>th</sup>
Electricity demand	64 MWh
SCOP	3.2

Heat is supplied from a vertical borehole array of 8 probes at 200 m depth, providing a total probe length of 1600 m over an indicative area of 512 m<sup>2</sup>. Ground temperatures support stable operation within acceptable limits in the first year of operation.

Table 0-29 - Borehole calculation results

PARAMETER	UNITS	VALUE
Borehole arrangement	---	2 x 4 (8)
Probe length	m	200
Total probe length	m	1600
Min. inlet temp. borehole	°C	-3.7
Borehole field area	m <sup>2</sup>	512
Length of the probe field	m	16
Width of the probe field	m	32
Specific heat extraction	W/m	46.619
g-function value	---	14.171
Undisturbed ground temperature	°C	14.05
Min. temperature borehole inlet in 1st year	°C	5.41

**External and plant arrangements:** External works would include borehole drilling and installation, manifold and ground loop pipework, and an energy hub housing the heat pump, buffer vessels, pumps, and controls. The requirement for sufficient land to accommodate the borehole field is the principal site-specific dependency for this option, alongside programme and ground investigation requirements.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas boiler would be replaced with a low-temperature HIU with an integrated domestic hot water thermal store, incorporating heat metering, controls, and differential pressure regulation. The HIU would interface directly with the existing wet radiator system, which would be retained where suitable, with emitter or control upgrades potentially required to support lower flow temperatures. The use of a store-based HIU enables efficient operation with ASHP- or GSHP-led energy centres while limiting primary network temperatures. All gas-fired plant would be decommissioned as part of the transition.

**Pipework quantity and assumptions:** Indicative communal heat network pipework quantities have been estimated for the K/L Block archetype using available floor plans, site photographs, and conservative routing assumptions appropriate to a low-temperature communal heat network. The K/L Block is appraised on a per-block basis, with a typical block comprising 24 dwellings (generally 4-5 storeys, with external access walkways). Where blocks vary in length or are combined into larger terraces, the same per-block pipework quantities can be scaled proportionally. The methodology assumes a central vertical riser located within the enclosed stair core or internal service zone, horizontal distribution runs along each floor via internal corridors or ceiling zones adjacent to the external walkways, and individual branch connections

to Heat Interface Units (HIUs) within each dwelling. External walkways introduce longer horizontal runs than for core-access blocks, which is reflected in the estimates below.

Table 0-30 - Indicative communal heat network pipework quantities

PARAMETER	BASIS OF ESTIMATE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 4-5 storeys, incl. plant room allowances	~30
Horizontal floor distribution	Floor-level distribution runs serving 6 flats per floor across 4 floors, incl. fittings allowance	~180
Branches to dwellings (HIUs)	Runs from floor distribution to HIU within each flat (24 flats)	~150
Plant room pipework & headers	Allowance for headers, isolation valves, metering and connections	~25
Total estimated pipework length		~385 m

For the Local Heat Network GSHP option, the internal building distribution pipework quantities are also directly applicable and unchanged. Additional pipework is required between the borehole field and the energy hub, including buried ground loop headers and internal connections to the heat pump plant. These source-side pipework elements are specific to the GSHP option and are excluded from the building distribution quantities presented above and are considered separately at this stage of appraisal.

### City-wide District Heat Network (DHN)

To connect K/L Blocks to the city-wide DHN, it is anticipated that the technical works set out in Table 0-31 will be required and must be led by the building owner or manager. This information is the basis for cost estimation for all building-side installation works and therefore the financial viability of this option.

Table 0-31 - City-wide DHN technical requirements for K/L Block

WORKS REQUIRED	QUANTITY	METRIC
Number of properties	21	Number
District heat supply and return	40	Meters
Plantroom:		
Expansion vessels	2	Number vessels
Heat Meter	1	Number and type
Heat network substation		
Plate heat exchanger	1	Number exchangers

WORKS REQUIRED	QUANTITY	METRIC
Primary heat meter	1	Number and type of meter
Heat distribution system		
Flow and return distribution pipework (risers and laterals)	385	Meters
In-dwelling equipment		
Heat Interface Unit (HIU)	21	Number

### Site 7: Easiform (6771) Block (Archetype)

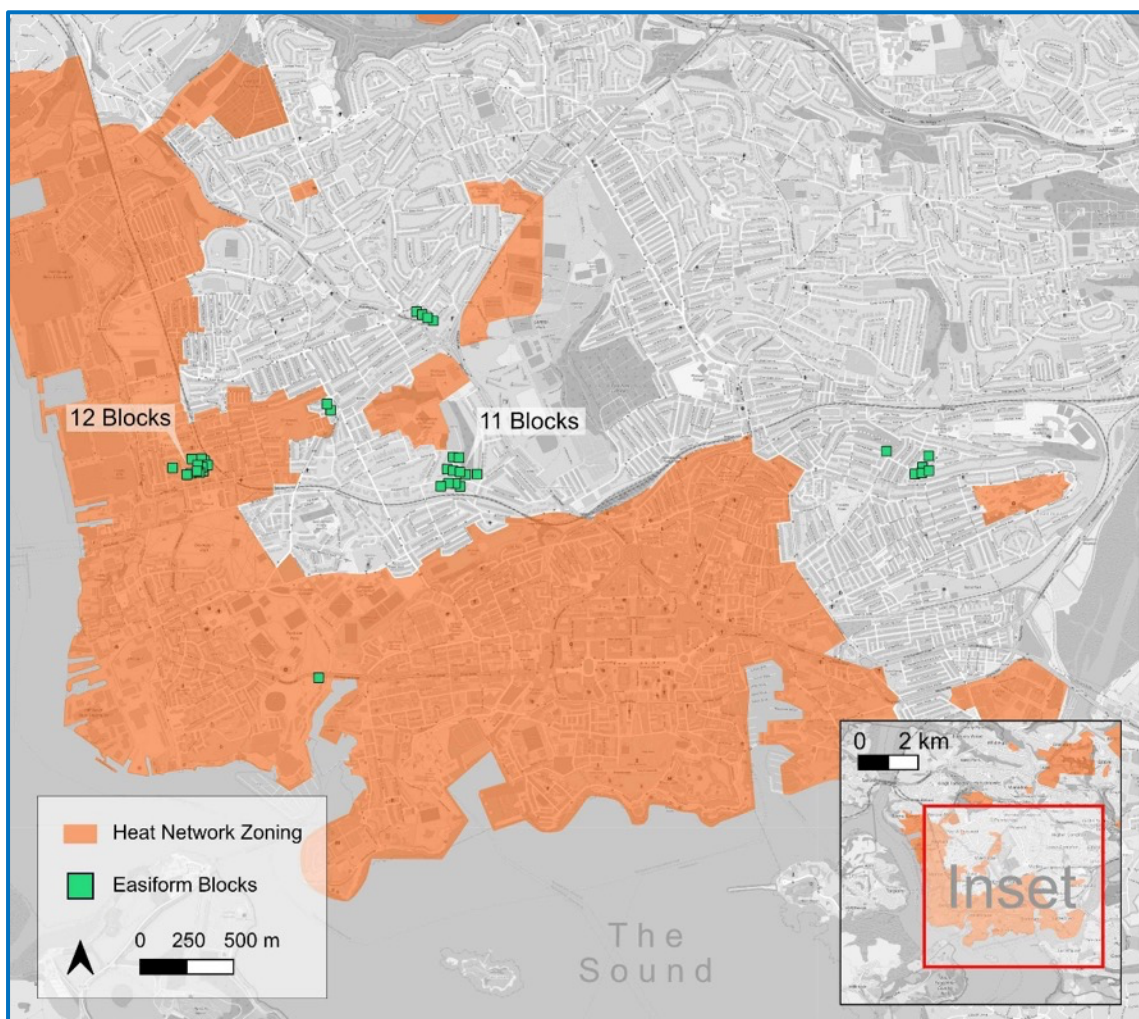


Figure 0.5 - Location of Easiform Blocks and Plymouth City HNzs

### Energy Demand and Data Inputs

Based on the building typology, scale, and spatial context, the following heat decarbonisation options have been included or excluded from the technical appraisal for the Easiform archetype.

Table 0-32 - Heat decarbonisation options appraised for Easiform block archetype.

OPTION	APPRAISED	RATIONALE
City-wide District Heat Network (DHN)	Yes	A proportion of Easiform blocks are located within planned heat network zones, making DHN connection a viable option in appropriate locations.
Local Heat Network - ASHP Energy Centre	Yes	Block- or cluster-scale ASHP energy centres are technically feasible and compatible with existing wet heating systems.
Local Heat Network - GSHP Energy Centre	Yes	GSHP systems are feasible in principle for this typology, subject to confirmation of available land for borehole arrays at site level.
Distributed ASHPs (individual flats)	Yes	The low-rise form and individual flat layouts make distributed ASHPs technically feasible for this typology, subject to site-specific constraints.

Gas boiler replacement is excluded in line with policy direction, while direct electric heating is retained as a counterfactual for financial comparison.

Energy demand for the Easiform archetype has been derived from a comprehensive set of detailed model runs representing variation across the stock. The modelling captures differences in:

- Floor level (ground, mid, top);
- Terrace versus end position;
- Insulation levels;
- Orientation (grouped to  $\pm 22.5$  degrees).

In total, 204 individual model runs were undertaken to represent variation across 430 dwellings within the Easiform stock. The resulting archetype represents a worst-case but realistic Easiform block, suitable for technical feasibility assessment and scalable to larger or smaller blocks.

Table 0-33 - Heating options appraisal demand inputs

PARAMETER	INPUT VALUE
Total number of flats	6
Total annual energy demand (kWh)	67,162
Annual space heating demand (kWh)	45,113
Annual domestic hot water demand (kWh)	22,049
Peak hourly space heating demand (kWh)	32.4
Peak hourly hot water demand (kWh)	6.2
Peak hourly heating demand (kWh)	37.2

These demand inputs form the basis for system sizing, network compatibility checks, and comparative appraisal of low carbon heat options for the Easiform block typology.

### Local Heat Network ASHP Appraisal

The local heat network ASHP option for the Easiform (6771) archetype has been modelled as a block-scale energy centre supplying space heating and domestic hot water via a low-temperature communal distribution network. The system is assessed on a per-block basis (typically 6 dwellings per stair core / block configuration) and can be scaled to serve larger Easiform arrangements (e.g. 12-18 dwellings) where blocks comprise multiple stairwells or are configured in clusters.

Table 0-34 - Air-source heat pump parameters

PARAMETER	VALUE
Generated heat	67 MWh
Electricity demand	24.9 MWh
Full load hours	1,217
Nominal heating power	55 kW <sup>th</sup>
Nominal electric capacity	14 kW <sup>el</sup>
SCOP	2.7

**External and plant arrangements:** ASHP units and associated plant (buffer vessels, pumps, controls, and electrical infrastructure) would be located externally at ground or roof level, subject to site-specific spatial, acoustic, and planning considerations. For Easiform blocks, locating plant to minimise noise impact on nearby ground-floor flats and communal access routes would be a key design consideration.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas boiler would be replaced with a compact, low-temperature HIU incorporating an integrated domestic hot water thermal store, with heat metering and dwelling-level controls. The HIU would supply space heating and hot water via plate heat exchangers and interface with the existing wet radiator system, which would be retained where suitable. Store-based HIUs are appropriate for this low-rise typology and support efficient operation at reduced network temperatures. All gas-fired plant would be decommissioned as part of the works.

**Pipework quantity and assumptions:** Indicative communal heat network pipework quantities have been estimated for the Easiform (6771) block archetype using the available typical flat plan and photographic evidence, supported by conservative routing assumptions appropriate to a low-temperature communal heat network. Easiform blocks are typically three storeys with six dwellings per block (two flats per floor) served from a single enclosed, unheated stairwell. The Easiform archetype is appraised on a per-block basis, with pipework quantities scalable in proportion where multiple blocks are served from a shared energy centre. The methodology assumes a centrally located vertical riser within the stair core, short horizontal distribution runs

on each floor serving two flats, and individual branch connections to Heat Interface Units (HIUs) within each dwelling. External pipework is minimised, with internal routes prioritised through communal spaces where practicable.

Table 0-35 - Indicative communal heat network pipework quantities

PARAMETER	VALUE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 3 storeys, incl. plant room allowances	~15
Horizontal floor distribution	Short floor-level distribution/manifold runs to 2 flats per floor (3 floors, incl. fittings allowance)	~60
Branches to dwellings (HIUs)	Short runs from floor distribution to HIU within each flat (6 flats)	~45
Plant room pipework & headers	Allowance for headers, isolation valves, metering and connections	~15
Total estimated pipework length		~135 m

For the communal ASHP option, the internal pipework quantities are directly applicable without modification. The ASHP plant is assumed to be located within a block-level or nearby site-level energy centre, with low-temperature flow and return pipework distributed via the central riser and short horizontal routes described. No additional internal distribution pipework beyond that identified above is required.

### Local Heat Network GSHP Appraisal

The local heat network GSHP option for the Easiform (6771) archetype has been modelled as a block-scale ground-source energy hub supplying space heating and domestic hot water via a low-temperature communal distribution network. The system is assessed on a per-block basis (typically 6 dwellings per stair core / block configuration) and can be scaled proportionally for larger Easiform arrangements (e.g. 12-18 dwellings) where sufficient land is available for expanded borehole arrays.

Table 0-36 - Energy hub parameters

PARAMETER	VALUE
Extraction rate	26 kW <sup>th</sup>
Generated heat	67 MWh
Heat pump capacity	38 kW <sup>th</sup>
Electricity demand	21 MWh
SCOP	3.2

Heat is supplied from a vertical borehole array of 2 probes at 200 m depth, providing a total probe length of 400 m over an indicative area of 128 m<sup>2</sup>. Ground temperatures support stable operation within acceptable limits in the first year of operation.

Table 0-37 - Borehole calculation results

PARAMETER	UNITS	VALUE
Borehole arrangement	---	1 x 2 (2)
Probe length	m	200
Total probe length	m	400
Min. inlet temp. borehole	°C	-3.19
Borehole field area	m <sup>2</sup>	128
Length of the probe field	m	8
Width of the probe field	m	16
Specific heat extraction	W/m	64.00
g-function value	---	7.787
Undisturbed ground temperature	°C	14.05
Min. temperature borehole inlet in 1st year	°C	2.30

**External and plant arrangements:** External works would include borehole drilling and installation, manifold and ground loop pipework, and an energy hub housing the heat pump, buffer vessels, pumps, and controls. The key dependency for this option is the availability of suitable land for the borehole field at each site, alongside ground investigation and programme considerations.

**Internal distribution and dwelling interfaces:** Within each flat, the existing gas boiler would be replaced with a compact, low-temperature HIU incorporating an integrated domestic hot water thermal store, with heat metering and dwelling-level controls. The HIU would supply space heating and hot water via plate heat exchangers and interface with the existing wet radiator system, which would be retained where suitable. Store-based HIUs are appropriate for this low-rise typology and support efficient operation at reduced network temperatures. All gas-fired plant would be decommissioned as part of the works.

**Pipework quantity and assumptions:** Indicative communal heat network pipework quantities have been estimated for the Easiform (6771) block archetype using the available typical flat plan and photographic evidence, supported by conservative routing assumptions appropriate to a low-temperature communal heat network. Easiform blocks are typically three storeys with six dwellings per block (two flats per floor) served from a single enclosed, unheated stairwell. The Easiform archetype is appraised on a per-block basis, with pipework quantities scalable in proportion where multiple blocks are served from a shared energy centre. The methodology assumes a centrally located vertical riser within the stair core, short horizontal distribution runs

on each floor serving two flats, and individual branch connections to Heat Interface Units (HIUs) within each dwelling. External pipework is minimised, with internal routes prioritised through communal spaces where practicable.

Table 0-38 - Indicative communal heat network pipework quantities

PARAMETER	BASIS OF ESTIMATE	INDICATIVE LENGTH (m)
Vertical risers (flow & return)	Central riser pair serving 3 storeys, incl. plant room allowances	~15
Horizontal floor distribution	Short floor-level distribution/manifold runs to 2 flats per floor (3 floors, incl. fittings allowance)	~60
Branches to dwellings (HIUs)	Short runs from floor distribution to HIU within each flat (6 flats)	~45
Plant room pipework & headers	Allowance for headers, isolation valves, metering and connections	~15
Total estimated pipework length		~135 m

The pipework quantities above represent the internal communal distribution network and are directly applicable to the GSHP option. Additional pipework is required between the borehole field and the block-level energy hub, including buried ground loop headers and internal connections to the heat pump plant. These source-side pipework elements are GSHP-specific and are excluded from the internal building distribution quantities presented above.

### Distributed ASHP Appraisal

The distributed ASHP option for the Easiform (6771) archetype has been appraised as a dwelling-level retrofit, with an individual air-source heat pump installed to serve each flat. This approach reflects the suitability of the Easiform typology for distributed solutions due to its low-rise form and relatively straightforward flat layouts.

The appraisal was undertaken at flat archetype level, with representative archetypes modelled for ground, mid and roof floors, and for end versus mid-terrace positions. An average flat archetype can be used to determine typical unit sizing requirements, while the number of each archetype within a given block can be used to scale outputs to the block level (e.g. 6-flat blocks versus larger 12-18 flat configurations).

The results show that ground-floor end flats have the highest heat demand and therefore require the largest ASHP units, with nominal heating capacities of up to 9.6 kW<sup>th</sup> and annual heat generation of approximately 12 MWh. This reflects increased heat losses from greater exposed façade area and ground contact. In contrast, mid-floor mid-terrace flats exhibit the lowest heat demand, requiring ASHP units of approximately 7.2 kW<sup>th</sup> with annual heat generation of around 7.9 MWh. Roof flats and end flats on upper floors sit between these extremes, reflecting

increased exposure relative to mid-terrace units but reduced losses compared with ground-floor dwellings. The assumed SCOP is 2.7.

Table 0-39 - Distributed ASHP parameters for each Easiform flat archetype

FLAT ARCHETYPE	GENERATED HEAT	ELECTRICITY DEMAND	FULL LOAD HOURS	NOMINAL HEATING POWER
GROUND_FLOOR_end_1	12.1 MWh	4.5 MWh	1,260 h/year	9.6 kW <sup>th</sup>
GROUND_FLOOR_end_2	11.9 MWh	4.4 MWh	1240 h/year	9.6 kW <sup>th</sup>
GROUND_FLOOR_mid	11 MWh	4.1 MWh	1,247 h/year	8.8 kW <sup>th</sup>
MID_FLOOR_end_1	9.2 MWh	3.4 MWh	1,092 h/year	8.4 kW <sup>th</sup>
MID_FLOOR_end_2	9 MWh	3.3 MWh	1,067 h/year	8.4 kW <sup>th</sup>
MID_FLOOR_mid	7.9 MWh	2.9 MWh	1,904 h/year	7.2 kW <sup>th</sup>
ROOF_end_1	10.7 MWh	4 MWh	1,165 h/year	9.2 kW <sup>th</sup>
ROOF_end_2	10.5 MWh	3.9 MWh	1,142 h/year	9.2 kW <sup>th</sup>
ROOF_mid	9.3 MWh	3.4 MWh	1,162 h/year	8.0 kW <sup>th</sup>

**External and plant arrangements:** Each flat would require an external ASHP unit located on an external wall or suitable ground-level position, subject to acoustic, planning, and space constraints. The distributed approach increases the number of external units and associated electrical connections relative to centralised options.

**Internal distribution and dwelling interfaces:** Under the distributed ASHP option, HIUs would not be required. Each flat would be served by an individual air-source heat pump system comprising an external unit and internal hydraulic components (hydrobox and domestic hot water cylinder or integrated cylinder unit). The system would connect directly to the existing wet radiator distribution, with emitter and control upgrades potentially required to support low-temperature operation. Existing gas boilers would be removed as part of the retrofit.

**Pipework quantity and assumptions:** Indicative pipework quantities for the distributed ASHP option have been estimated for the Easiform (6771) block archetype using the available typical flat plan and conservative routing assumptions. Under this option, no communal LTHW distribution network is required; instead, each dwelling is served by an individual ASHP and associated internal hydraulic kit (or monobloc connections), with pipework largely confined to each flat and short external runs local to the dwelling. The Easiform archetype is appraised on a per-flat basis, with block-level quantities derived by multiplying by the number of dwellings (typically six flats per block). Pipe routes are assumed to follow existing service zones (kitchen/bathroom proximity and radiator positions), minimising disruption to habitable rooms.

Table 0-40 - Indicative communal heat network pipework quantities

PARAMETER	BASIS OF ESTIMATE	INDICATIVE LENGTH (m)
Internal dwelling flow & return (to emitters)	Replacement/upgrade of in-flat wet distribution from hydraulic interface to existing/new radiators (typical 2-bed flat)	~25 m per flat
Primary connection from ASHP to dwelling hydraulic kit	Short run from external unit location to internal hydraulic components (varies with mounting position)	~5 m per flat
Condensate drain	Gravity drain from outdoor unit to nearest suitable discharge point	~3 m per flat
External pipework (flow/return or refrigerant line set)	Local external routing along façade to serve the dwelling unit (allowance only)	~7 m per flat
<b>Total indicative pipework (per flat)</b>		<b>~40 m per flat</b>
<b>Total indicative pipework (per 6 flat block)</b>		<b>~240 m per block</b>

These quantities are indicative and are most sensitive to the chosen external unit location (rear/side elevation, ground-mounted vs wall-mounted, and proximity to the kitchen/services zone). Where internal distribution is retained in good condition, the internal pipe allowance may reduce; however, allowances have been kept conservative at feasibility stage to reflect likely upgrades for low-temperature operation (e.g. radiator changes and associated pipe alterations). Electrical containment/cabling is not included here and should be allowed separately for each dwelling.

### City-wide District Heat Network (DHN)

To connect Easiform Blocks to the city-wide DHN, it is anticipated that the technical works set out in Table 0-41 will be required and must be led by the building owner or manager. This information is the basis for cost estimation for all building-side installation works and therefore the financial viability of this option.

Further information on the connection requirements and all installation works required to connected to the PCC heat network is provided in **Appendix B - City-wide Heat Network Technical Review**.

Table 0-41 - City-wide DHN technical requirements for Easiform Block

WORKS REQUIRED	QUANTITY	METRIC
Number of properties	6	Number
District heat supply and return	60	Meters
Plantroom:		
Expansion vessels	2	Number vessels
Plate heat exchanger	1	Number exchangers
Primary heat meter	1 (Ultrasonic automatic reader)	Number and type
Heat network substation		
Flow and return distribution pipework (risers and laterals)	135	Meters
In-dwelling equipment		
Heat Interface Unit (HIU)	6	Number

# APPENDIX B - CITY-WIDE HEAT NETWORK

## TECHNICAL REVIEW

Analysis of all connection guides for the proposed Plymouth Heat Network<sup>9</sup> was conducted to develop an understanding of the technical requirements and specifications required to connect to the heat network. Individual analysis of specific property requirements is set out in the property / archetype analysis within this chapter, with this section providing context of the full connection requirements and criteria as set out by PCC.

In summary, **connection approval is contingent on the block of flats consistently achieving the specified low return temperatures under normal operation.** Failure to demonstrate compliance may result in refusal of connection or the requirement for remedial works.

In terms of progressing connections, the below next steps are defined by PCC:

Based on the guidance set out in this document your design team (led by a Chartered Engineer and/or someone qualified as a CIBSE Heat Network Consultant) should draw up designs and specifications for the heating and hot water systems within the building and submit these, along with your predicted peak demand and annual energy consumption for your building. Your initial data should be collected and the Data Transfer Form in Annex A should be completed to the best of your knowledge and submitted to the supplier. In addition to the form there will need to be an exchange of drawings detailing the plantroom design, the routes for external pipework and a schematic of the secondary side mechanical design.

### 5DHC and conventional heat network

A conventional heat network supplies buildings with medium-temperature hot water (typically up to 65 °C), so building systems can use traditional communal heating layouts provided they strictly control return temperatures (normally  $\leq 35$  °C) and use instantaneous DHW. In contrast, a 5th Generation District Heating and Cooling (5DHC) network operates at ultra-low temperatures (approximately 2 - 25 °C) and does not directly provide usable heating or hot water; instead, buildings must use local heat pumps or HIU boosters to raise temperatures for space heating and DHW. As a result, 5DHC designs demand much lower space-heating flow temperatures ( $\sim 45$  °C), very low return temperatures ( $\leq 25$  °C), low-temperature emitters, and highly optimised controls, but they also enable integrated heating and cooling and greater long-term decarbonisation.

Conventional heat networks are generally better suited to existing residential blocks and simpler new-build flats, as they can accommodate more traditional communal heating layouts, standard

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<sup>9</sup> Connecting to the Plymouth 5DHC Network (

HIUs, and familiar radiator systems while still delivering carbon and air-quality benefits, provided return temperatures are well controlled. 5DHC is most suitable for new-build or large, masterplan residential schemes, where low-temperature emitters, fabric-first design, and centralised plantrooms can be integrated from the outset.

5DHC also has the ability to provide cooling. As detailed in Appendix D, overheating is already an issue in some flats. This merits further consideration prior to finalising investment decisions.

**When considering heating requirements only, conventional heat networks are preferred for all sites and archetypes considered in this study.**

## Installation requirements

Based on the analysis provided in Section 4.3.3, technical requirements to connect to PCC's conventional heat network would include:

### Individual properties (Direct Connection)

1. **District heat supply and return** pipework up to the building point of entry.
2. **Plantroom equipment**, including expansion vessels; pressure relief valves; water treatment equipment; isolation valves; monitoring and metering equipment; electrical supply and system control panels.
3. **In-dwelling equipment**: Heat Interface Unit (HIU) for each dwelling (including space heating plate heat exchanger (if indirect); instantaneous DHW plate heat exchanger (including temperature sensors); flow and temperature control valves; heat meter (dwelling-level billing); Strainers and isolation valves); two-port control valves.

### Communal Systems (Indirect Connection, e.g., block of flats)

1. **District heat supply and return** pipework up to the building point of entry.
2. **Plantroom equipment**: Expansion vessels; Pressure relief valves; water treatment equipment; isolation valves; monitoring and metering equipment; electrical supply and system control panels.
3. **Heat network substation**: Plate heat exchanger(s); Primary-side control valves; Differential pressure control (PICV or DPCV arrangement); Primary heat meter; Strainers and filters; Instrumentation (temperature and pressure sensors).
4. **Heat distribution system**: Flow and return distribution pipework (risers and laterals); Pipework insulation designed to limit overall secondary heat losses; Differential pressure control valves (DPCVs) on risers or zones; Isolation valves to risers and branches; Air vents and drain valves at high and low points.
5. **In-dwelling equipment**: Heat Interface Unit (HIU) for each dwelling (including space heating plate heat exchanger (if indirect to dwelling); instantaneous DHW plate heat exchanger (including temperature sensors); flow and temperature control valves; heat meter (for dwelling-level billing); Strainers and isolation valves); heat emitters (low temperature radiators, or underfloor heating); thermostatic radiator valves (flow-regulating or return-temperature-limiting) and two-port control valves.

## DHN Technical Requirements

The below specific design requirements and criteria are set out in relation to conventional heat network connections at residential properties in Plymouth.

### General Requirements

The property(s) shall be designed either as individual connections or as a communal heating system (e.g., for a block of properties) for direct connection to the Plymouth Heat Network, with the connection strategy confirmed at an early design stage in consultation with PCC. Individual dwelling boilers or direct electric resistance heating shall not be installed.

The system shall be designed, commissioned, and operated in accordance with the CIBSE / ADE Heat Networks Code of Practice CP1.2 and the Heat Network Technical Assurance Standards with particular emphasis on achieving and maintaining consistently low return temperatures to maximise network efficiency.

### Temperature Limits

The heating system shall be designed to operate with a maximum network flow temperature of 65°C at the point of supply. The secondary system shall be configured such that the return temperature at the point of return does not exceed 35°C under any operating condition, including low-load and part-load scenarios. Domestic hot water shall be provided by point-of-use instantaneous systems, with no primary-side stored hot water, achieving 50°C at the outlet within one minute in accordance with BS 8558<sup>10</sup>.

### Heat Interface Units (HIUs)

Each dwelling shall be served by a dedicated HIU suitable for residential heat network applications. Direct-connection HIUs shall be prioritised wherever static pressure and ownership arrangements permit, with indirect connections (i.e., using a heat exchanger between DHN and internal systems) permitted only where justified.

HIUs shall be specifically selected and configured to operate efficiently across the full range of design and part-load conditions and shall incorporate control strategies that limit excessive flow rates and prevent elevated return temperatures, particularly during low demand periods.

### Distribution System

The internal heat distribution system, including risers and lateral pipework, shall be designed for variable flow operation. Differential pressure control shall be provided to maintain stable operation and effective balancing across all dwellings.

Common headers and low-loss headers shall be avoided, as these can lead to uncontrolled flows and elevated return temperatures. Pipework shall be sized to maintain the required temperature differential at both peak and low load conditions, and overall heat losses from secondary pipework shall be minimised through route optimisation and enhanced insulation design.

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<sup>10</sup> BS 8588:2015 - *Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages.*

## **Emitters, Valves and Controls**

Space heating within dwellings shall be provided by low-temperature emitters, such as underfloor heating or appropriately sized low-temperature radiators, to support the achievement of low return temperatures. All heating circuits shall use two-port control valves only; three-port valves shall not be installed.

Thermostatic radiator valves shall be flow-regulating or return-temperature-limiting, and emitter layouts shall allow accurate commissioning and balancing. Uncontrolled bypasses shall not be installed. Any keep-warm functions shall be minimised, fully temperature controlled, and demonstrated not to compromise return temperature performance.

## **Domestic Hot Water (DHW)**

Domestic hot water shall be generated instantaneously within each dwelling via the HIU using plate heat exchangers. Centralised stored hot water systems and calorifiers with internal heating coils shall not be used unless expressly agreed with Plymouth City Council. Legionella control measures shall be compatible with instantaneous DHW systems and shall not rely on elevated return temperatures or continuous circulation.

## **Plantroom, Metering and Pressure**

A dedicated plantroom or substation shall be provided with clear demarcation between PCC-owned supplier equipment and the developer's secondary systems. Heat metering shall be installed at both building and dwelling level and shall be compatible with the Council's automatic meter reading (AMR) system.

The secondary system shall be designed for a maximum operating pressure of 10 bar(g) and shall include appropriate expansion vessels, pressure relief, filtration, flushing, and water treatment provisions.

## **Commissioning and Handover**

The system shall be fully commissioned in accordance with CP1 / CP1.2 and the Plymouth Heat Network technical guidance. Commissioning shall prioritise verification of return temperatures under low-load and typical occupancy conditions, not solely peak demand.

All HIU settings, control parameters, and balancing data shall be documented and locked where appropriate. Complete as-built drawings, commissioning records, and operation and maintenance manuals shall be provided at handover to support efficient long-term operation of the network connection.

# APPENDIX C - BASELINE METHODOLOGY

## Baseline Data Collection

Scene prepared a Request for Information (RFI) to collate and analyse all relevant and available information and datasets held by PCH, PCC, and open databases.

For the blocks this comprised:

- Address, including GIS mapping.
- Block characteristics, including number of flats, number of stories, and estimation of common area per floor.
- Heating and ventilation characteristics, including common areas.
- Floor to floor height
- Available reference drawings

For the flats this comprised:

- Energy performance certificates (EPCs)
- Stock condition survey, including boiler age, boiler capacity and any planned fabric improvement measures.
- Building schematics, block and flat-level plans, including heating and hot water schematics for floor types
- Floor to ceiling heights

## Literature Review

We conducted a structured review of relevant technical, academic, and policy material, to inform our modelling assumptions and ensure the project aligns with local and national strategy and objectives, as reported in Chapter 2.

### Site Visit and Initial Assessment

Scene undertook a site walkover (21 October 2025) of each of the block types, alongside PCH staff. The site visit included a meeting with PCC and PCH and a site inspection to validate block schematics and characteristics and infill any data gaps not provided through the RFI.

### GIS mapping

We used GIS mapping to appraise the spatial location of all PCH blocks, overlaying AZP zones, grid infrastructure, and relevant cultural or environmental heritage designations. The constraints assessment identified that there are no cultural, technical or planning-related constraints affecting specific blocks, and flats in general.

## Social, Economic and Technical Context

We recognise the PCH objective that heat decarbonisation must be of social and economic benefit to the residents. Therefore, we included an integrated review to ensure positive social justice outcomes are rooted in the final outputs:

- Social vulnerability indicators, such as fuel poverty metrics, tenancy types, Index of Multiple Deprivation (IMD) data, and household characteristics;
- Thermal comfort, including the health risks of both overheating and underheating. Projected heating degree days (HDD) and cooling degree days (CDD) across the project lifetime. Risk flags will be developed specific to the locations and aspects (e.g. top floors, south-facing, single aspect);
- The capacity of residents to adapt behaviour in response to new heating systems;
- The assessment criteria for low carbon heat options, likely including affordability, thermal comfort, usability, technical viability, financial viability, carbon impact, and futureproofing design.

## Archotyping and Baseline Modelling

We applied a robust classification method to group flats in each of the block types into a set of representative archetypes. This is founded on the building characteristics, spatial configuration, location and orientation of each flat within each block, to develop and define floorplate definitions, spatial arrangement, and building materials. A 3D geometry assessment for each archetype was developed as an input to the simulation framework. Key parameters for the flat archetypes include:

- Floor position - e.g. ground, mid-floor, top-floor, and if top-floor, the roof type;
- Flat geometry - exposure to external walls, party walls/floors/ceilings, unheated corridors;
- Orientation - flat's façade influences solar heat gains in the flat;
- Number of bedrooms - to be used as a proxy for occupancy;
- Treated floor area (TFA) and gross internal floor area (GIFA) - determining the space heating requirement;
- Glazing ratio - the ratio of windows and doors to the external wall surface area.

Each archetype is modelled using EnergyPlus, an industry-leading dynamic simulation engine developed by the US Department of Energy. This allows our modelling to develop high resolution data whilst dynamically accounting for occupancy patterns, internal gains, surface to zone heat transfer, window thermal balance, convective heat transfer, wall transfer functions, and the ventilation rate.

Our bottom-up, low information approach is designed specifically for real-world contexts where full datasets are rarely available. Our approach derives block-level outputs by scaling up simulated archetypal flats to the real block layouts. This approach offers some critical advantages:

1. High resolution data can dynamically capture variations in weather, occupancy, and system operations over time, and thus provides more accurate and sensitive assessment of LCHOs.

2. Supports modular scenario testing of LCHOs, with impact assessments for each archetypal flat/resident.
3. Takes account of the diversity of physical flat characteristics and occupancy patterns.
4. Provides more detailed and distributional insights into energy usage.
5. Avoids some systemic biases of top-down modelling and standardised assumptions.

# APPENDIX D - INTERNAL TEMPERATURE ANALYSIS

Internal temperature and space heating energy demand was modelled to assess the viability of low-temperature heating systems for the flat blocks.

The primary focus was for the 3 High Rise blocks in the Devonport area, to evaluate the feasibility of low-temperature radiator systems for the flats to replace the existing warm-air systems. But sample flats in the other block archetypes were modelled and included in the conclusions below.

The modelled space-heating demand differed significantly between the levels of the high-rise blocks, due to the uninsulated roof and the lowest-level having an uninsulated floor to an unheated ground-level below.

The modelled results indicate that low-temperature heating systems should be suitable for all mid-level flats within the High-Rise blocks but also show the top-level and lowest-level flats have significantly higher space-heating demands owing to their uninsulated roof and floor, respectively.

## Methodology and assumptions

Low-temperature heating systems were not directly modelled, instead two figures were extracted from the existing electric-heating scenarios:

- Peak hourly space heating demand (kWh) for the intermittent heating schedule (20° c evenings and weekend-daytime, 16° c setback)
- Peak daily space heating demand (kWh) for a continuous heating schedule (20° day-time, 16° c setback)

This was modelled for a subset of the flat archetypes, using the fabric-improved scenarios for all blocks except for the High-Rise blocks, which already have external wall insulation and do not have any proposed fabric improvement measures.

Potential heat output of low-temperature radiators:

- At a flow-temperature of 50° c (DeltaT 30) radiators should emit approximately 50% of their rated output for DeltaT 50.
- A Type-22 double-panel radiator sized 600mm x 1200mm would typically output 2000W at DeltaT 50, and so should output ~1000W at DeltaT 30.

## High Rise block flat peak space heating demands

High rise flat archetype	Continuous heating schedule Peak daily demand (kWh)	Intermittent heating schedule Peak daily demand (kWh)	Peak hourly demand (kWh)
Top level, 2 bedroom (60m <sup>2</sup> )	98.3	95.5	6.7
Top level, 1 bedroom, corner (50m <sup>2</sup> )	82.6	80.2	5.6
Mid-level, 2 bedroom (60m <sup>2</sup> )	22.9	24.2	2.4
Mid-level, 1 bedroom, corner (50m <sup>2</sup> )	20.0	20.9	2.0
Lowest level, 2 bedroom (60m <sup>2</sup> )	54.8	58	4.0
Lowest floor, 1 bedroom, corner (50m <sup>2</sup> )	47.9	50.1	3.4

This energy demand data can be used to provide an indicative power requirement for emitters, and the number of typical radiators required to meet that output (using Type-22 dual-panel 600x1200 radiators).

High rise flat archetype	Emitter power rating (Watts)		Radiator count
	Low	High	
Top level, 2 bedroom (60m <sup>2</sup> )	4,100	6,700	4 - 7
Top level, 1 bedroom, corner (50m <sup>2</sup> )	3,500	5,600	4 - 6
Mid-level, 2 bedroom (60m <sup>2</sup> )	1,000	2,400	1 - 3
Mid-level, 1 bedroom, corner (50m <sup>2</sup> )	900	2,000	1 - 2
Lowest level, 2 bedroom (60m <sup>2</sup> )	2,300	4,000	3 - 4
Lowest floor, 1 bedroom, corner (50m <sup>2</sup> )	2,000	2,400	2 - 3

This range was calculated from the peak hourly demand<sup>11</sup>, and highest daily demand, divided across 24 hours (for a low-temperature heating system). Power figures were rounded up to nearest 100w. This suggests that low flow temperature heating systems should be suitable for all of the mid-level flats within the high-rise blocks. For the lowest-level flats, the number or size of emitters will likely be higher than the mid-level flats but should still be achievable without insulating the floor to the ground-level.

For the top-level flats, the space heating demand is likely too high to be met by low flow temperature heating systems, without further insulation improvements to the roof. Modelling the top level flats with 50mm of ceiling insulation, and this produced significantly reduced space heating demands, closer to those of the lowest-level flats.

<sup>11</sup> These are not a substitute for room-by-room heat-loss calculations for a heating system design, and each room would likely require different sized radiators to properly balance heat-loss with output.

High rise flat archetype	Continuous heating schedule Peak daily demand (kWh)	Intermittent heating schedule Peak daily demand (kWh)	Peak hourly demand (kWh)
Top level, 2 bedroom (60m <sup>2</sup> )	51	51	4
Top level, 1 bedroom, corner (50m <sup>2</sup> )	44.4	43.2	3.3

High rise flat archetype	Emitter power rating (Watts)		Radiator count
	Low	High	
Top level, 2 bedroom (60m <sup>2</sup> )	2,200	4,000	3 - 4
Top level, 1 bedroom, corner (50m <sup>2</sup> )	1,900	3,300	2 - 3

## Overheating risks and impact of insulation improvements

Using the same subset of flat archetypes as the low-temperature heating modelling above, the hourly internal temperature data was analysed and the total number of hours and days where the temperature exceeded 26 °c and 27 °c were counted, for both baseline and fabric-improved flat configurations (26 °c being the NHS guideline for overheating risk (UK Health Security Agency, 2024) and ideally a building regulation). CIBSE TM59 guidelines determine that overheating occurs when indoor temperatures exceed 26 °c for more than 3% of annual occupied hours. The inability to cool down at night poses the highest risk to vulnerable residents.

Understanding the impact of overheating requires an analysis of not only the total hours in which internal temperatures are exceeded, but also the duration of each incidence. Forecasts should also take into account changing climate patterns on temperature. This level of analysis is beyond the scope of this study, but our initial analysis does provide an indication that overheating is definitely a risk (both for baseline and following fabric improvements), particularly in the high rise blocks where active cooling is likely to be required. Further work on assessing this risk and reviewing technical options to provide cooling is therefore recommended.

The conclusions of this analysis vary by archetype.

**High rise blocks** already have external wall insulation and have a relatively high glazing ratio of 0.25 for the 3 blocks in the Davenport area, and 0.2 for Woodlands Court. Adding roof insulation to the top level flats showed a small increase in the number of overheating incidents, as the majority of the solar gains already come from the windows and not the roof. (Not represented in the modelling is the shading on the block roofs, which likely further reduces solar gains from the roof and so roof insulation may result in a higher increase in overheating).

**Easiform blocks** also showed small increases in the number of overheating incidents from additional wall and roof insulation.

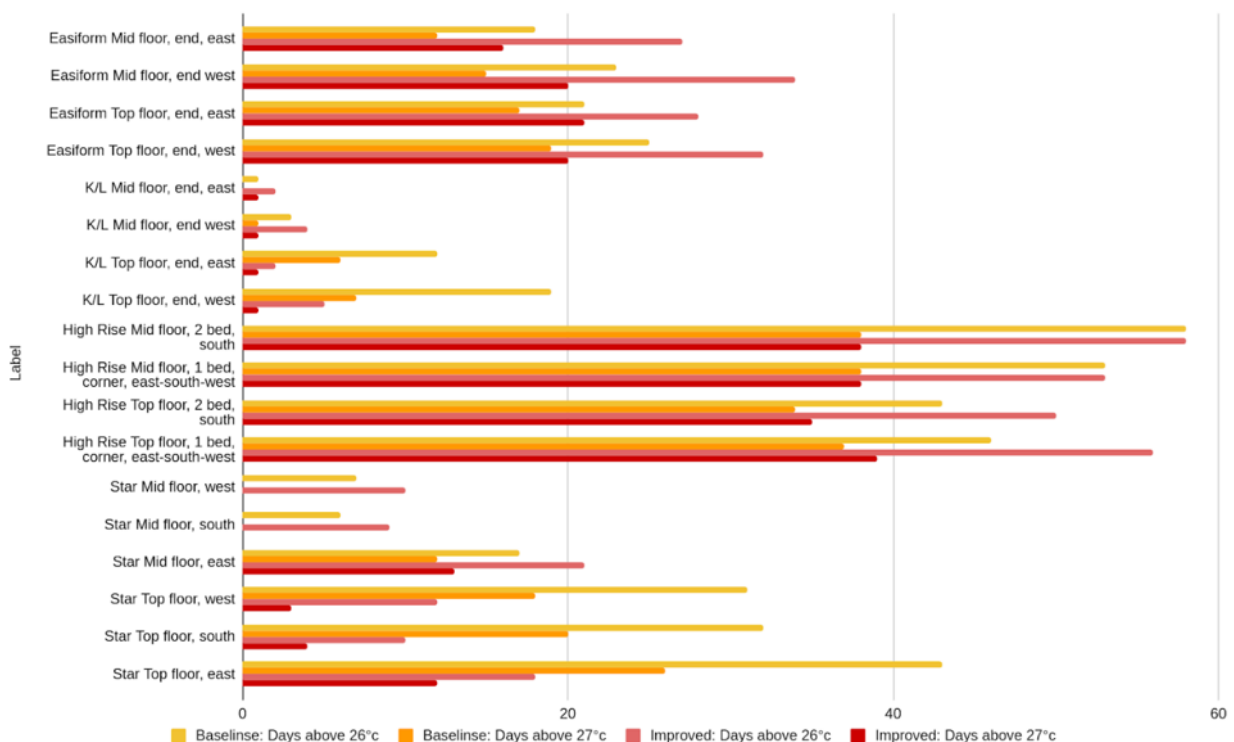
**K/L blocks** showed the lowest number of baseline overheating incidents, and the addition of wall and roof insulation reduced these further. They have a low glazing ratio of 0.12, which combined with their mostly dual-aspect reduces their total exposure to solar gains. (Note: Most

of the K/L blocks also have walkways which will cause shading to one exterior wall, reducing solar gains further. This w)

**Star blocks** also showed significant reductions in overheating incidents with wall and roof insulation, with the larger 3-bedroom flats eliminating overheating. Star blocks have a very low glazing ratio of 0.1, and 3 exterior walls, so a higher proportion of their solar gains are through the walls. Star blocks have a high variety of orientations, but 3 orientations were modelled: east, west and south facing. These were selected as they represent the highest solar gains for the 3-aspect geometry of these flats. The southern orientation was also the larger of the 3, representing the largest exterior wall area with the most exposure to the sun.

## Methodology and assumptions

The same Typical Meteorological Year (TMY) weather data as the rest of the modelling. A future climate-adapted scenario was not undertaken. Ventilation was not altered between these model runs. Active ventilation systems are not currently being considered for the flats, and increased passive ventilation would likely be insufficient given the ambient temperatures also regularly exceeded 26 °C.



## Baseline Overheating Analysis

Block type	Flat archetype	Maximum temperature (°c)	Hours above 26 °c	Hours above 27 °c	Days above 26 °c	Days above 27 °c
Easiform	Mid floor, end, east	28.7	111	57	18	12

Block type	Flat archetype	Maximum temperature (°c)	Hours above 26 °c	Hours above 27 °c	Days above 26 °c	Days above 27 °c
Easiform	Mid floor, end west	29.4	159	85	23	15
Easiform	Top floor, end, east	29.5	103	56	21	17
Easiform	Top floor, end, west	29.8	129	71	25	19
K/L	Mid floor, end, east	26.6	4	0	1	0
K/L	Mid floor, end west	27.5	13	4	3	1
K/L	Top floor, end, east	30.6	37	17	12	6
K/L	Top floor, end, west	31.1	58	21	19	7
High Rise	Mid floor, 2 bed, south	30.2	458	243	58	38
High Rise	Mid floor, 1 bed, corner, east-south-west	30.2	412	215	53	38
High Rise	Top floor, 2 bed, south	32.2	205	143	43	34
High Rise	Top floor, 1 bed, corner, east-south-west	32.6	222	159	46	37
Star	Mid floor, west	26.6	19	0	7	0
Star	Mid floor, south	26.4	13	0	6	0
Star	Mid floor, east	28.6	128	64	17	12
Star	Top floor, west	30.8	100	53	31	18
Star	Top floor, south	31.2	122	61	32	20
Star	Top floor, east	31.9	181	92	43	26

### Fabric-Improved Overheating Analysis

Block type	Flat archetype	Maximum temperature (°c)	Hours above 26 °c	Hours above 27 °c	Days above 26 °c	Days above 27 °c
Easiform	Mid floor, end, east	29.2	223	104	27	16
Easiform	Mid floor, end west	29.6	297	135	34	20
Easiform	Top floor, end, east	29.9	185	104	28	21
Easiform	Top floor, end, west	29.7	208	103	32	20
K/L	Mid floor, end, east	27.2	6	1	2	1
K/L	Mid floor, end west	27.7	18	4	4	1

Block type	Flat archetype	Maximum temperature (°c)	Hours above 26°c	Hours above 27°c	Days above 26°c	Days above 27°c
K/L	Top floor, end, east	27.8	9	3	2	1
K/L	Top floor, end, west	27.9	14	4	5	1
High Rise	Mid floor, 2 bed, south	30.2	458	243	58	38
High Rise	Mid floor, 1 bed, corner, east-south-west	30.2	412	215	53	38
High Rise	Top floor, 2 bed, south	33	298	205	50	35
High Rise	Top floor, 1 bed, corner, east-south-west	33.5	325	230	56	39
Star	Mid floor, west	26.8	50	0	10	0
Star	Mid floor, south	26.9	47	0	9	0
Star	Mid floor, east	28.5	186	74	21	13
Star	Top floor, west	27.4	50	5	12	3
Star	Top floor, south	27.2	45	4	10	4
Star	Top floor, east	28.6	130	58	18	12

# APPENDIX E - PREDICTED RdSAP SCORE IMPROVEMENTS

The predicted range of EPC score improvements for each block type, each relative to the modelled baseline scores.

	Easiform	High Rise	K/L	Star
Fabric improvements only	8 : 15	-	8 : 36	8 : 43
Fabric improvements + Counterfactual new gas boilers	12 : 19	2 : 6	11 : 40	11 : 47
Fabric improvements + ASHP (Distributed or Local network)	6 : 12	-	6 : 34	6 : 39
Fabric improvements + Local network GSHP	10 : 15	-	9 : 37	9 : 43
Fabric improvements + Heat Network	12 : 20	12 : 41	3 : 24	12 : 48

Ratios of EPC Bands for each block type, from the existing certificates.

		Easiform	High Rise	K/L	Star
A	92+	-	-	-	-
B	81-91	0.5%	6.4%	4.4%	2.0%
C	69-80	76.9%	66.2%	67.1%	66.1%
D	55-68	21.2%	24.8%	25.8%	29.1%
E	39-54	1.4%	2.6%	1.7%	2.0%
F	21-38	-	-	1.0%	0.8%
G	1-20	-	-	-	-

Predicted EPC Bands achievable with fabric improvements alone.

		Easiform	High Rise	K/L	Star
A	92+	-	-	-	-
B	81-91	B	-	B	B
C	69-80	C : B	-	C : B	C : B
D	55-68	C	-	C	C
E	39-54	D : C	-	D : C	D : C
F	21-38	-	-	D : C	D : C
G	1-20				

Predicted EPC Bands achievable with fabric improvements and counterfactual gas boiler upgrades.

		Easiform	High Rise	K/L	Star
A	92+	-	-	-	-
B	81-91	B	B	B	B
C	69-80	B	C : B	C : B	C : B
D	55-68	C : B	D : C	C : B	C : B
E	39-54	C	D	C	C

F	21-38	-	-	C	C
G	1-20	-	-	-	-

Predicted EPC Bands achievable with fabric improvements and distributed or local network air-source heat pumps, or local network ground-source heat-pumps.

		Easiform	High Rise	K/L	Star
A	92+	-	-	-	-
B	81-91	C : B	-	C : B	C : B
C	69-80	C : B	-	C : B	C : B
D	55-68	C	-	C	C
E	39-54	D : C	-	D : C	D : C
F	21-38	-	-	D : C	D : C
G	1-20	-	-	-	-

Predicted EPC Bands achievable with fabric improvements and the proposed heat network.

		Easiform	High Rise	K/L	Star
A	92+	-	-	-	-
B	81-91	A	A	A	A
C	69-80	B : A	B : A	B : A	B : A
D	55-68	B	B	B	B
E	39-54	C : B	C : B	C : B	C : B
F	21-38	-	-	C : B	C : B
G	1-20	-	-	-	-

## Methodology and assumptions

Predicting RdSAP score improvements is difficult from energy modelling results, as the models use dynamic weather data as well as different occupancy and heating schedules to RdSAP. However, RdSAP scores are a relatively simplistic calculation based on fixed fuel-costs, and energy-per-floor area for space heating, hot-water and lighting. A method of predicting RdSAP scores was developed, by calibrating modelled energy data to an existing EPC for a property, to predict the EPC score for the baseline, fabric-improved, and future heating system options.

### Heat pumps (ASHP, GSHP)

- RdSAP uses fixed 2012 energy pricing for calculating scores and does not factor in carbon emissions of heating systems. This often results in heat-pumps reducing an EPC score relative to a gas boiler.
- The SCOPs used in the RdSAP score prediction was the same as the rest of the technical modelling, 2.7 for distributed and local-network ASHP and 3.2 for local-network GSHP.

### DHN

- The proposed heat network was assumed to involve some form of heat recovery, which uses a lower cost and improves the RdSAP score.
- A distribution loss factor of 25% was used for the score prediction.

# APPENDIX F - REFERENCES

BEIS (2020) *Heat Pumps in Domestic Buildings: User Experience of Low-Carbon Heating*. Department for Business, Energy & Industrial Strategy, London.

BEIS (2021) *Improving Consumer Experiences of Heat Networks: Research into Resident Behaviours and Satisfaction*. Department for Business, Energy & Industrial Strategy, London.

CCC (2020) *Behaviour Change, Public Engagement and Net Zero*. Committee on Climate Change, London.

Department for Energy Security and Net Zero (2023) *Energy Security Bill factsheet: Low-carbon heat scheme*. Available at: <https://www.gov.uk/government/publications/energy-security-bill-factsheets/energy-security-bill-factsheet-low-carbon-heat-scheme>.

Energy Saving Trust (2013) *The Heat Pump Field Trials: Detailed Analysis of Performance, Controls and User Engagement*. Energy Saving Trust, London.

GBE. (2025). *Local Power Plan*. Retrieved from <https://www.gbe.gov.uk/local-power-plan>

GLA (2021) *Heat Pumps in London: Evaluation of Domestic Installations and Resident Feedback*. Greater London Authority, London.

Huebner, G., Cooper, J. and Jones, K. (2021) 'Domestic Heating Behaviours and the Transition to Low-Carbon Systems: A Review', *Energy Research & Social Science*, 76, p.102054.

KiWi Power & Innovate UK (2018) *Domestic Demand-Side Flexibility: Behavioural Insights from Heat Pump Households*. Innovate UK, London.

LSE (2022) *Adapting to Heat Pumps: Behavioural and Social Factors Affecting Performance*. Grantham Research Institute on Climate Change, London School of Economics.

Ofgem (2020) *Consumer Protection in Heat Networks: Findings from Behavioural Research*. Office of Gas and Electricity Markets, London.

Rosenow, J. and Lowes, R. (2020) *Social Housing and Heat Pumps: Lessons from European Deployment*. Regulatory Assistance Project (RAP), Brussels.

UKERC (2020) *Energy Behaviour and the Performance Gap in Low-Carbon Homes*. UK Energy Research Centre, London.

UK Health Security Agency (2024) *Supporting vulnerable people before and during hot weather: social care managers*. Available at: [Supporting vulnerable people before and during hot weather](#) (Accessed: 8 April 2026).