UK Government

Analytical Note on Alternative Low Carbon Heating Technology Costs

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Executive Summary

Heat pumps are already proven to work at scale and, along with heat networks, will be the primary low-carbon technologies for decarbonising home heating over the next 10 years. However, the government recognises that heat pumps and heat networks may not be suitable for all buildings and is committed to ensuring that consumers have access to a range of low-carbon heating alternatives.

The Government has issued a consultation to explore the role of alternative clean heat solutions, providing an opportunity to improve the understanding of different low carbon heating options – other than standalone heat pumps and heat networks – their benefits to consumers, and operational limitations. This analytical note accompanies the consultation and outlines the Department's evidence base, assumptions, and modelling of the cost of alternative low carbon heating technologies. The cost analysis is split into two sections:

- The total capital costs and average annual running costs of alternative heating technologies under scope of the consultation, demonstrating the cost faced by households to install and run different systems in defined housing archetypes.
- The levelised cost of heat (LCOH) of the same technologies, demonstrating the discounted lifetime cost of installing and running those systems.

LCOH is a metric which describes the discounted lifetime cost of the purchase, installation, maintenance, and operation of a heating appliance expressed in pence per kilowatt hour (p/kWh) of heat. Sensitivity analysis has been conducted to understand how the LCOH results vary based on factors including system efficiency, energy price, load shifting, and installation year.

To illustrate how heating costs vary across different building types, three housing archetypes have been defined for cost analysis: a smaller mid-terrace on gas house, a larger detached on gas house, and a larger detached off gas house.

This analysis is based on the best technical evidence the Department currently has available. However, as the picture on these technologies is regularly evolving and given the modelling simplifications involved in assessing the costs of these technologies, the results should be considered illustrative. The cost analysis of all low carbon heating systems has been carried out using the Department's National Buildings Model (NBM), which simulates building energy use, costs, and emissions under different policy incentives.

LCOH results for heating systems under scope of this analysis illustrate that low temperature air source heat pumps (LTASHP) – across all three defined housing archetypes – have the lowest LCOH based on the central modelling assumptions, mainly driven by their high efficiency.

In comparison, direct electric (DE) heating systems including electric boilers, infrared panel heaters, and convective panel heaters, have the highest LCOH across the three housing archetypes. This is a result of assumed lower efficiencies compared to heat pump technologies and lack of thermal storage capability, meaning these systems are unable to take advantage of cheaper off-peak electricity prices. While the LCOH results are specific to the illustrative archetypes defined in this document, this should not be interpreted as reflecting the wider housing stock.

The role of low and high temperature air source heat pumps (HTASHP) in decarbonising the wider housing stock has been investigated by examining two property characteristics, peak heat loss and electrical supply constraints, facilitated by analysis within the NBM. The results illustrate that 98% of GB fossil fuel heated homes would have sufficient thermal insulation and electrical supply to have thermal comfort provided by a heat pump operating at low or high flow temperatures.

Introduction

This analytical note provides an examination of outputs from the Department's National Buildings Model (NBM) to better understand the capital and running costs of alternative heating systems in different housing archetypes – where suitable for installation. This includes a summary of the levelised cost of heat (LCOH) for alternative heating technologies across three distinct housing archetypes (exploring different sizes, typologies, and heating fuels).[1]

The purpose of this document is to outline both the Department's methodology and existing assumptions towards the cost analysis and present the illustrative results. Technical assumptions within this note are based on best current government and industry evidence. It is likely that future research and industry feedback following consultation may influence current assumptions and therefore change the results presented in this document. By outlining the Department's technical evidence, we are providing an opportunity for stakeholders – through the consultation – to review and help develop the evidence base across several areas.

Alternative Heating Technologies

Property Archetypes

The cost of installing, maintaining, and running a low carbon heating system typically varies across different property archetypes, with factors such as the overall heat loss, floor area, and number of bedrooms all determining heating costs. The same logic applies to the feasibility of heating systems that can be installed in a property. Certain housing archetypes make some heating systems more cost-effective to install and operate, with factors like property size and heat demand influencing overall cost and feasibility.

Because of this, the cost analysis of alternative heating systems is presented by specific housing archetypes. A total of three archetypes have been defined, with more detail covered in Table 1 below. These include:

- a smaller, mid-terraced, gas heated house,
- a larger, detached, gas heated house,
- a larger, detached, oil heated house.[2]

[1] LCOH estimates the average cost of providing 1kWh of heating over the lifetime of a heating system.

[2] A property filter has been applied to the NBM results based on the English Housing Survey (EHS) average household size per built form. Properties lower than or equal to the average floor area have been defined as 'smaller', whilst those greater than the average have been defined as 'larger'. More on EHS property sizes can be found here: English Housing Survey 2018: size of English homes - fact sheet - GOV.UK

Table 1: Three defined property archetypes to present the costs of alternative heating technologies[3]

	Average annual heat demand (kWh)[4]	Floor area (m^2)	Main fuel type
Mid-terrace house	6,400	<90	Gas
Detached (on-gas) house	17,600	>150	Gas
Detached (off-gas) house	21,800	>150	Oil

The smaller mid-terraced on gas house archetype may face space constraints when considering low carbon heating options but has a relatively low annual heat demand in comparison to the other archetypes. This will also influence the sizing of heating systems, and the scale of installation and running costs. In contrast, the larger detached on and off gas house archetypes have higher average annual heat demands due to larger floor areas, which again affects heating system sizing and running costs. However, both these archetypes are likely to have larger back plots, allowing the installation of heating systems that require more outdoor space.

These archetypes have been defined to illustrate the differences in costs faced by different households when installing low-carbon heating systems. As such, they do not represent the full GB housing stock, instead are used to present total capital costs, average annual running costs, and the LCOH for technologies – under scope of the consultation – suitable for installation.

Levelised Cost of Heating for Alternative Heating Technologies

Since heat demand varies across archetypes (see Table 1), and heating technologies differ in lifetime, capital cost, and running cost, it is useful to compare the LCOH across systems. LCOH is a metric which describes the discounted lifetime cost of the purchase, installation, maintenance, and operation of a heating appliance expressed in pence per kilowatt hour (p/kWh) of heat. LCOH calculations annualise the total costs to make heating technologies with different lifetimes comparable. A full breakdown of the assumed lifetime of heating technologies under scope and their relevant efficiencies can be found in Annex B. The

[3] Data produced using DESNZ National Buildings Model (NBM).
[4] Average annual heat demand includes both space and domestic hot water (DHW) demand.

following sections provide a summary of the individual components that feed into the overall LCOH calculations.

Capital Cost

Capital cost examines the costs incurred when installing a new heating system. This includes the cost of the appliance, labour costs from installation, and ancillary costs (where applicable).[5] A breakdown of the capital cost components for each technology under scope of this analysis can be found in Table 2 below.

Capital costs within this analysis do not factor in government subsidies that may be available. For instance, the Boiler Upgrade Scheme (BUS) currently offers £7,500 towards an air source heat pump (ASHP) or ground source heat pump (GSHP), or £5,000 towards a biomass boiler (subject to eligibility).[6]

The standard UK value added tax (VAT) rate of 20% has been applied to all non-heat pump technologies under consideration, excluding biomass boilers.[7,8] Both heat pump and biomass boiler systems that are installed in all residential properties benefit from zero rate of VAT.[9] For hybrid heat pump technologies, only the heat pump capital cost element of the total capital cost has a 0% VAT rate applied.

When calculating the capital cost for each heating system, a number of property-based assumptions are considered within the NBM that influence the total value. This includes:

- the peak heat loss of a property (to determine heating system sizing and ensure thermal comfort can be met in cold weather),
- the size of a property (to determine aspects such as labour costs and ancillary equipment), and
- whether a property has an existing central heating system (to determine new or upgraded radiator requirements).

The evidence base used in developing the appliance cost analysis is derived from the Eunomia study on the Cost of Domestic and Commercial Heating Appliances.[10] The study was undertaken on behalf of the Department to understand the variations in costs of heating appliances, based on the unit capital costs, labour costs, and ancillary costs. The results from the Eunomia report act as a benchmark for heating system costs within the NBM, which are

[5] Ancillary cost could include aspects such as the installation of a hot water cylinder, upgrading heat emitters, and installing heating controls.
[6] Boiler Upgrade Scheme: https://www.gov.uk/apply-boiler-upgrade-scheme
[7] https://www.gov.uk/vat-rates.
[8] Whilst a 20% VAT rate has been applied to non-heat pump related technologies (excluding biomass boilers), certain energy goods are subject to lower tax rates. More information on the VAT rate of specific goods and services can be found at: https://www.gov.uk/guidance/rates-of-vat-on-different-goods-and-services.
[9] More information on VAT exemption for specific energy-saving materials and heating equipment can be found at: https://www.gov.uk/guidance/vat-on-energy-saving-materials-and-heating-equipment-notice-7086.
[10] Eunomia (2023), Cost of Domestic and Commercial Heating Appliances. Available at: https://eunomia.eco/reports/title-the-cost-of-heating-appliances-a-comprehensive-uk-database/.

used to determine the scale of costs based on the individual characteristics of the sampled GB properties.

It is important to note that unlike heat pumps – an established low carbon heating technology that has been rolled out at scale in many countries – several of the alternative systems presented are much newer technologies with less developed evidence bases. As a result, departmental assumptions for some non-heat pump systems reflect the early stages of these heating systems, which will look to be improved upon through consultation, and when greater empirical evidence is presented. Because of this, the results presented below should be interpreted as an illustration of costs based on current departmental assumptions.

Table 2: Summary of the capital cost components accounted for within cost analysis of different low carbon heating technologies

	Summary of capital cost components
Low temperature air source heat pump (LTASHP)	Capital cost includes the installation of the heat pump unit and additional ancillary equipment required (inc. controls, buffer, hot water storage cylinders, and necessary radiator upgrades to support low temperature heating).
High temperature air source heat pump (HTASHP)	The same as assumed for a LTASHP but no radiator upgrades accounted for as a HTASHP is assumed to operate at a similar flow temperature to the system being replaced (a gas or oil boiler).
Low temperature ground source heat pump (LTGSHP)	The same as assumed for a LTASHP but includes the capital cost for the ground collector. Modelling assumes 80% of installations are vertical boreholes and 20% horizontal arrays. *Note: the ground collector has an assumed lifetime of 60-years, and this is accounted for as residual asset in the LCOH calculations.*
Shared ground loop (SGL) GSHP	The same as assumed for a LTGSHP but the capital cost for a shared ground collector is pro-rated across 20-100 connected properties by the capacity of the heat pump in each property.[11] *Note: the shared ground collector has an assumed lifetime of 60-years, and this is accounted for as a residual asset in the LCOH calculations.*

[11] The cost of the shared ground collector is modelled as a capital cost component; however, the capital cost and any financing cost could be applied as an annual service charge and therefore be included as part of the annual running cost.

Air to air HP (AAHP) + point of use hot water system or hot water cylinder for domestic hot water (DHW)	Capital cost includes the heat pump unit, decommissioning of the existing wet central heating system, and additional ancillary equipment required (inc. controls, wiring and a separate hot water heater – point of use system in smaller properties or an immersion heater in larger properties)[12]
Dry core storage boiler (assumes can provide space heat and DHW)	Also known as a heat battery, able to store and supply heat to a wet central heating system and provide hot water. Capital cost includes the installation of the unit and additional ancillary equipment required (inc. controls, wiring)
Hydrotreated Vegetable Oil (HVO) boiler	The capital cost for a HVO boiler assumes the replacement of an existing oil boiler. Capital cost includes all installation costs including ancillary equipment (inc. controls, hot water storage cylinder, and HVO conversion*). Note: modelling assumes the existing fuel storage tank does not need replacing).*
Biomass boiler	The capital cost for a biomass boiler assumes the replacement of an existing oil boiler. Capital cost includes all installation costs including ancillary equipment (inc. controls, buffer, hot water storage cylinder, and feed store).
Electric combi boiler	Capital cost includes the installation of the unit and additional ancillary equipment required (inc. controls, wiring)
Storage heater + point of use hot water system or hot water cylinder for DHW	Capital cost includes the installation of units in each heated room, decommissioning of the existing wet central heating system, and additional ancillary equipment required (inc. controls, wiring and a separate hot water heater – point of use system in smaller properties or an immersion heater in larger properties).
Convective panel heater + point of use hot water system or hot water cylinder for DHW	The same as assumed for a storage heater.
Infrared panel heater + point of use hot water system or hot water cylinder for DHW	The same as assumed for a storage heater.

[12] Decommissioning cost of a wet central heating system is based on the evidence gathering report for electric heating options in off gas grid homes (BEIS, 2019). Link to report: https://assets.publishing.service.gov.uk/media/5d78ed6be5274a27c2c6d50c/Electric_heating_options_in_off-gas_grid_homes.pdf

Hybrid LTASHP + HVO boiler	Capital cost includes the installation of the heat pump unit, a separate HVO boiler, and additional ancillary equipment required (inc. a unified control, buffer, and hot water cylinder). Radiator upgrades are not accounted for, assuming the hybrid system operates at similar flow temperature to the previous system (gas or oil boiler).

Running Cost

Running cost refers to the cost incurred over a heating system's lifetime to provide space and hot water heating when needed, including fuel and maintenance costs. Fuel prices used in this analytical note are, where possible, derive from domestic retail prices in Government published Green Book data. All retail fuel prices (presented in Table 3) used in the running cost calculations for this analysis have been averaged and discounted over an 18-year period, based on the assumed lifetime of an ASHP.

Fuel types used by heating systems covered in this analytical note – but not currently included in the Green Book appraisal guidance – include solid biomass and hydrotreated vegetable oil (HVO). The assumed retail price for solid biomass is based on Standard Assessment Procedure (SAP) 10.2 data and is fixed across future years due to a lack of evidence on price projections.[13]

The HVO retail price is based on the best available industry evidence at the time.[14] Used cooking oil (UCO) derived HVO has been indexed to the future domestic kerosene Green Book retail price for the purposes of projecting a future HVO retail fuel price. This results in HVO having an average price ratio approximately 2.5 times higher than kerosene.[15]

Fuel costs for direct electric heating systems and heat pumps are calculated using the Green Book central domestic electricity retail price.[16] Electric heating systems based on thermal storage (storage heaters and dry core storage boilers) are assumed to make use of Economy 7 (E7) tariffs to charge their thermal stores overnight during cheaper off-peak periods.[17] For these technologies, a 30% reduction has been applied to the annual Green Book electricity retail price.[18] This assumes 80% of the total space and hot water heating provided by thermal energy storage systems will be delivered through the night rate, and the remaining 20%

[13] BRE Group (2021), The Government's Standard Assessment Procedure for Energy Rating of Dwellings, version 10.2 (17/12/2021). Available at: https://bregroup.com/expertise/energy/sap/sap10.
[14] HVO price data based on results from the Quantum Commodity Intelligence database.
[15] Based on the average price ratio over a two-year period between 2022-2024.
[16] Green Book supplementary guidance: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal.
[17] With E7, an energy supplier specifies seven off-peak hours – typically between 12am and 7am depending on location and supplier – during which electricity is cheaper. Households use a special two-rate meter to separately record peak and off-peak consumption. More information on E7 tariffs can be found in the Ofgem Economy 7 Consumer Guide.
[18] Based on the average variable night electricity unit price being approximately 57% less than the average fixed electricity cost for financial year 2024/25, and the average variable day electricity unit price being approximately 21% higher than the average fixed price (over the same financial year). More can be found in table 2.2.4 of the annual domestic energy price statistics.

through the day rate.[19] A full breakdown of the average retail price assumptions of the different fuel types used for the calculations within the note can be found in Table 3. The impact of time of use (ToU) tariffs on the running costs of heat pumps is considered as part of sensitivity analysis.

Assumptions on maintenance cost are also based on the Eunomia study. In the case of ASHPs, we expect that maintenance costs will fall as their deployment increases. As a result, by 2035 we assume the maintenance costs of an ASHP will be equivalent to a gas boiler. More information on the maintenance cost assumptions can be found in Annex B.

Table 3: Average retail price assumptions for electricity, HVO and solid biomass – (2024 prices, discounted over an 18-year period)

	Average retail fuel price 2025-2042 (p/kWh)
Electricity	19
Electricity E7 tariff	13
Hydrotreated Vegetable Oil (HVO)	11
Solid biomass	5

Levelised Cost of Heat (LCOH)

Given the range of heating technologies assessed within this analytical note and the varying capital and running costs associated with each system, it is important to use a comparative metric through the LCOH.[20] LCOH compares the average cost (p/kWh) per unit of heat generated over the lifetime of a heating system, accounting for the capital and running costs, as well as a property's heat demand.

The LCOH for this analysis is based on an 18-year appraisal period (assumed lifetime of an ASHP), meaning heating systems (or components) with different lifetimes are accounted for to allow for comparisons. For example, a biomass boiler – with an assumed lifetime of 15 years – would need replacing in year 16. Allowing for an 18-year appraisal period, the replacement system would still have 12 years of operation remaining. As a result, the residual asset is treated as a negative cost in the LCOH calculation, equivalent to 12/15 of the capital cost of the replacement system. Similarly, GSHPs have an assumed lifetime of 20 years, and the

[19] It is acknowledged that in practice, the housing archetype and the availability and capacities of hot water storage tanks will influence the rate at which thermal energy storage systems are able to take advantage of the night rate electricity prices.
[20] LCOH is a modification of Levelised Cost of Electricity (LCOE) from DESNZ (2023), Electricity Generation Costs, available at: Electricity generation costs 2023 - GOV.UK.

ground collector is assumed to last 60 years. Since both components outlast the 18-year appraisal period, they are treated as residual assets in the LCOH calculation. At the end of the period, 2/20 of the GSHP's value and 42/60 of the ground collector's value are accounted for as negative costs, reflecting their remaining operational years. A full summary of the LCOH formula can be found below, where:

- C_t = the capital cost of the appliance (year 1) along with any adjustment for replacements or residual assets in later years, depending on appliance lifetime
- O_t = the fuel and maintenance cost of a heating system in year t
- H_t = the annual heat demand of a property in year t
- t = the year in the appraisal, with the initial year, t=1 being 2025.
- n = the appraisal period (18 years based on the assume lifetime of an ASHP)
- r = discount rate of 3.5% (Green Book Social Time Preference Rate)

$$LCOH = \sum_{t=1}^{n} \frac{(C_t + O_t)}{(1+r)^{t-1}} / \sum_{t=1}^{n} \frac{H_t}{(1+r)^{t-1}}$$

Alternative Heating Technologies Cost Results

This section presents the results for the total capital cost, the average annual running costs, and the LCOH for alternative low carbon heating technologies, by the three distinct property archetypes.

Capital Cost of Low Carbon Heating Systems by Housing Archetype

The results in Table 4 below illustrate the difference in heating system capital costs based on property archetype. For systems that provide space heating only (such as storage heaters or infrared panel heaters), the capital cost also includes the cost of hot water provision, either through a point-of-use water heater or a hot water tank, depending on property size. This ensures all heating systems considered provide both space and hot water heating.

For electric heating systems – both direct electric and thermal energy storage – the capital costs shown in Table 4 do not account for the potential cost of upgrading from a single-phase to a three-phase electricity supply. This upgrade may be required to meet peak heating demand during very cold weather, particularly when combined with other household electricity needs. The need for such an upgrade depends on the efficiency of the appliance and the property's peak heat demand. This issue is more likely to affect the larger housing archetypes installing non-heat pump electric heating systems, due to their lower efficiencies and higher electricity draw. Where a three-phase upgrade may be required, this has been denoted by cells highted in grey.

In addition, some heating systems have not been costed as they are considered unsuitable for certain housing archetypes. Where this is the case, "N/A" has been applied. The following bullet points outline the rationale for excluding costs associated with these technologies:

- A shared ground loop (SGL) is a form of ground source heat pump (GSHP) technology that enables multiple GSHPs to be linked to a single ground loop array.[21] Whilst individual GSHPs are viewed as suitable for larger properties with sufficient outdoor space, SGL systems may be suitable for a concentration of multiple smaller properties (e.g. blocks of flats) that struggle with space constraints. The larger housing archetypes would likely face prohibitive costs from sharing a communal loop array given the potential distance between properties, especially in sparse rural settings. For this reason, SGL costs have not been determined for these properties.
- A biomass boiler is not deemed suitable for the smaller mid-terraced, or larger detached on-gas property archetypes, based on the recommendation within the 2023 Biomass Strategy that this fuel type should be prioritised to help decarbonise off gas homes that are not readily suitable for heat pumps.[22] Within the strategy, HVO has been acknowledged as possibly providing a convenient route to decarbonising some off gas properties and as such, the cost analysis for a HVO boiler and hybrid ASHP/HVO boiler system is presented for the larger detached off gas housing archetype only.

Table 4: Total heating system capital cost in modelled fossil fuel heated GB properties by archetype (2024 prices)[23,24]

	Smaller mid-terraced on-gas house	Larger detached on-gas house	Larger detached off-gas house[25]
LTASHP	£9,300	£15,100	£16,900
HTASHP	£9,300	£15,200	£17,100
LTGSHP	N/A	£36,300 *(includes £16,300 for groundwork)*	£39,400 *(includes £19,000 for groundwork)*

[21] Under a traditional GSHP arrangement, each property has its own separate ground loop or borehole.
[22] DESNZ (2023), Biomass Strategy, available at: https://www.gov.uk/government/publications/biomass-strategy.
[23] Values in table 4 rounded to the nearest 100.
[24] Capital costs derived from the Eunomia study (2021) have been inflated to 2024 prices. For certain heating technologies – including ASHPs, GSHPs, biomass boilers, and hybrid ASHP systems – a specific inflator has been developed based on Microgeneration Certification Scheme (MCS) price analysis. For all other heating technologies, the standard Green Book inflator has been applied.
[25] Capital costs include decommissioning of fuel storage tanks (for the oil heated housing archetype) for the relevant technologies. This cost is applied for all technologies except for a HVO boiler and HVO hybrid ASHP in the large detached off gas housing archetype, as the oil storage tank can be used for HVO storage.

SGL GSHP	£15,000 *(includes £3,700 for the property pro-rata share of the groundwork)*	N/A	N/A
AAHP + point of use hot water system or hot water cylinder for DHW	£6,800	£19,000	£23,000
Dry core storage boiler (assumes can provide space heating and DHW)[26]	£10,200	£10,700	£12,800
HVO boiler	N/A	N/A	£8,100
Biomass boiler	N/A	N/A	£26,200
Electric combi boiler	£4,600	£5,100	£7,200
Storage heater + point of use hot water system or hot water cylinder for DHW	£6,900	£10,000	£12,100
Convective panel heater + point of use hot water system or hot water cylinder for DHW	£5,600	£7,800	£9,900
Infrared panel heater + point of use hot water system or hot water cylinder for DHW	£6,500	£9,400	£11,600
Hybrid LTASHP + HVO boiler	N/A	N/A	£17,800

Running Cost of Low Carbon Heating Systems by Housing Archetype

As highlighted in the previous section, the heat demand of a property has a direct influence on a heating system's capital cost, with the same principle applying to the running cost. Table 5 below illustrates the average annual running costs for each alternative heating system by housing archetype. As with Table 4, where "N/A" is denoted, technologies are unlikely to be suitable, and costs have not been presented.

[26] Capital cost for dry core storage boilers in the mid-terraced on-gas housing archetype are based on a Tepeo designed heat battery with a separate hot water heater, whilst the capital costs in the detached housing archetypes are based on the Eunomia study with heat battery models which are capable of space and hot water heating.

Heat pump running costs in Table 5 do not account for possible reductions through a time of use (ToU) tariff and shifting demand from peak to off-peak periods (e.g. pre-heating hot water or certain rooms during off peak periods). The illustrative effect that this could have on running costs is covered in more detail in the sensitivity analysis section.

Table 5: Average annual running cost in modelled GB properties by archetype (2024 prices, discounted over an 18-year period)[27,28]

	Smaller mid-terraced on-gas house	Larger detached on-gas house	Larger detached off-gas house
LTASHP	£600	£1,400	£1,700
HTASHP	£600	£1,450	£1,750
LTGSHP	N/A	£1,150	£1,400
SGL GSHP	£600	N/A	N/A
AAHP + point of use hot water system or hot water cylinder for DHW	£850	£1,900	£2,300
Dry core storage boiler	£1,000	£2,550	£3,150
HVO boiler	N/A	N/A	£2,850
Biomass boiler	N/A	N/A	£1,750
Electric combi Boiler	£1,300	£3,450	£4,250
Storage heater + point of use hot water system or hot water cylinder for DHW	£1,000	£2,550	£3,150
Convective heater + point of use hot water system or hot water cylinder for DHW	£1,300	£3,450	£4,250

[27] Values in table 5 rounded to the nearest 50.
[28] Energy prices averaged and discounted over an 18-year period between 2025 and 2042.

Infrared panel heater + point of use hot water system or hot water cylinder for DHW	£1,300	£3,450	£4,250
Hybrid LTASHP + HVO boiler[29]	N/A	N/A	£2,100

LCOH of Low Carbon Heating Systems by Housing Archetype

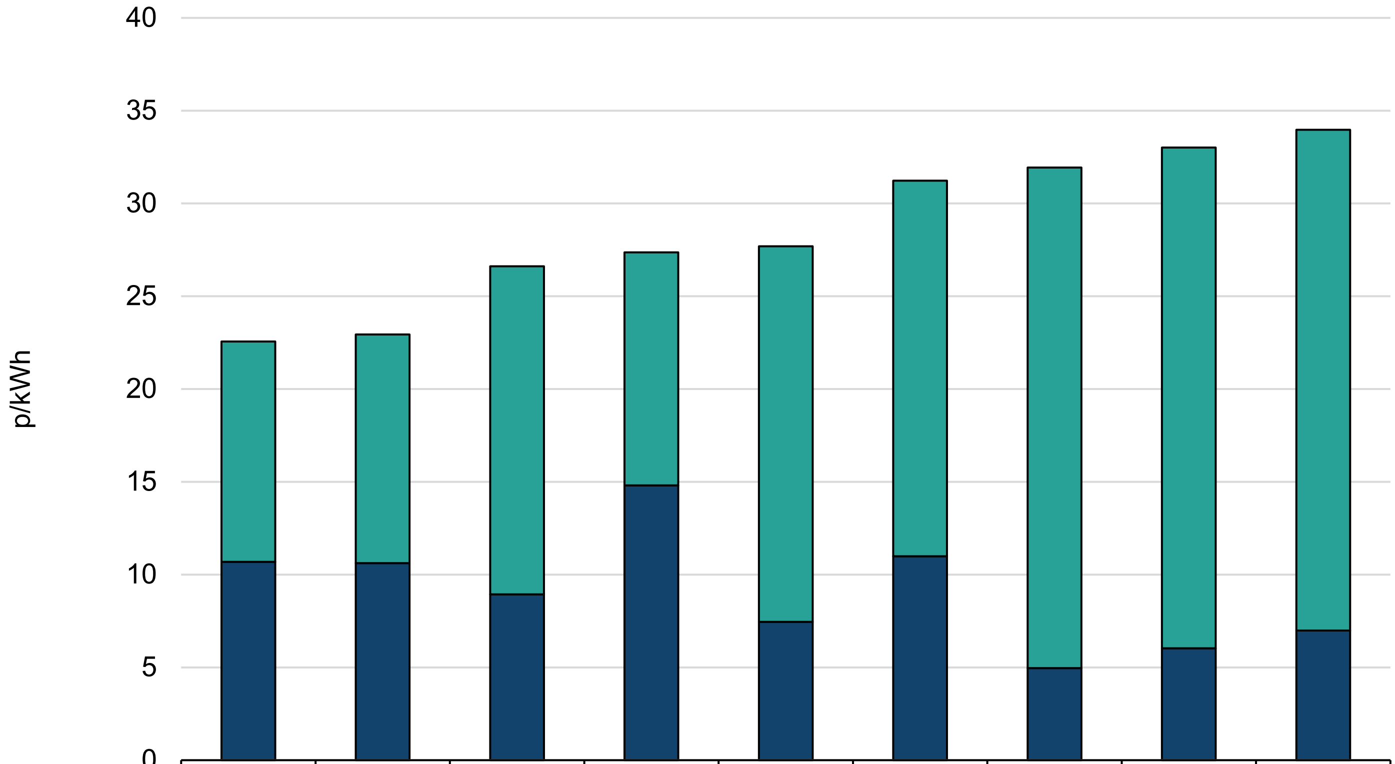
The following section presents the LCOH results for heating systems by the three defined housing archetypes. LCOH results are based on an 18-year appraisal period (assumed lifetime of an ASHP), and so capital and running costs for the residual lifetime of heating systems that are +/- 18 years have been considered to allow for equal comparisons. The results in Chart 1 present the LCOH for heating technologies in the smaller mid-terraced on-gas house archetype.

A LTASHP has the lowest LCOH (22.6p/kWh) relative to the other heating technologies considered, mainly driven by its high system efficiency (286%).[30] HTASHP are seen to have similar LCOH to LTASHP, with the balance of costs depending on the extent to which savings on ancillary works (like emitter upgrades) offset higher running costs from higher flow temperatures. DE heating systems have the highest LCOH, including infrared panel heaters (34.0/kWh), driven by the lack of thermal storage capability and the inability to take advantage of cheaper electricity prices. The efficiency of DE heating systems (100%) is also assumed to be substantially lower than that of an ASHP.

Select heating systems with a lower LCOH, in comparison to all systems, include AAHP, SGL, storage heaters, and dry core storage boilers. Storage heaters and dry core storage boilers – with their thermal storage capabilities – can take advantage of off-peak electricity prices, resulting in lower running costs when compared to DE heating systems.

[29] For hybrid HP systems, departmental modelling assumes an 80/20 ratio of work for space heating (80% of heating by a heat pump and the remaining 20% by the second heating system) and 100% of the hot water heating provided by the secondary heating system. This results in a total heating ratio of 64/36. In practice this split can be defined by the user and so the efficiency may vary depending on this.
[30] Whilst the results from the Electrification of Heat Demonstration Project concluded LTASHPs operate at 278% in 2022, departmental modelling assumes future gains in system efficiency, reaching 286% by 2025.

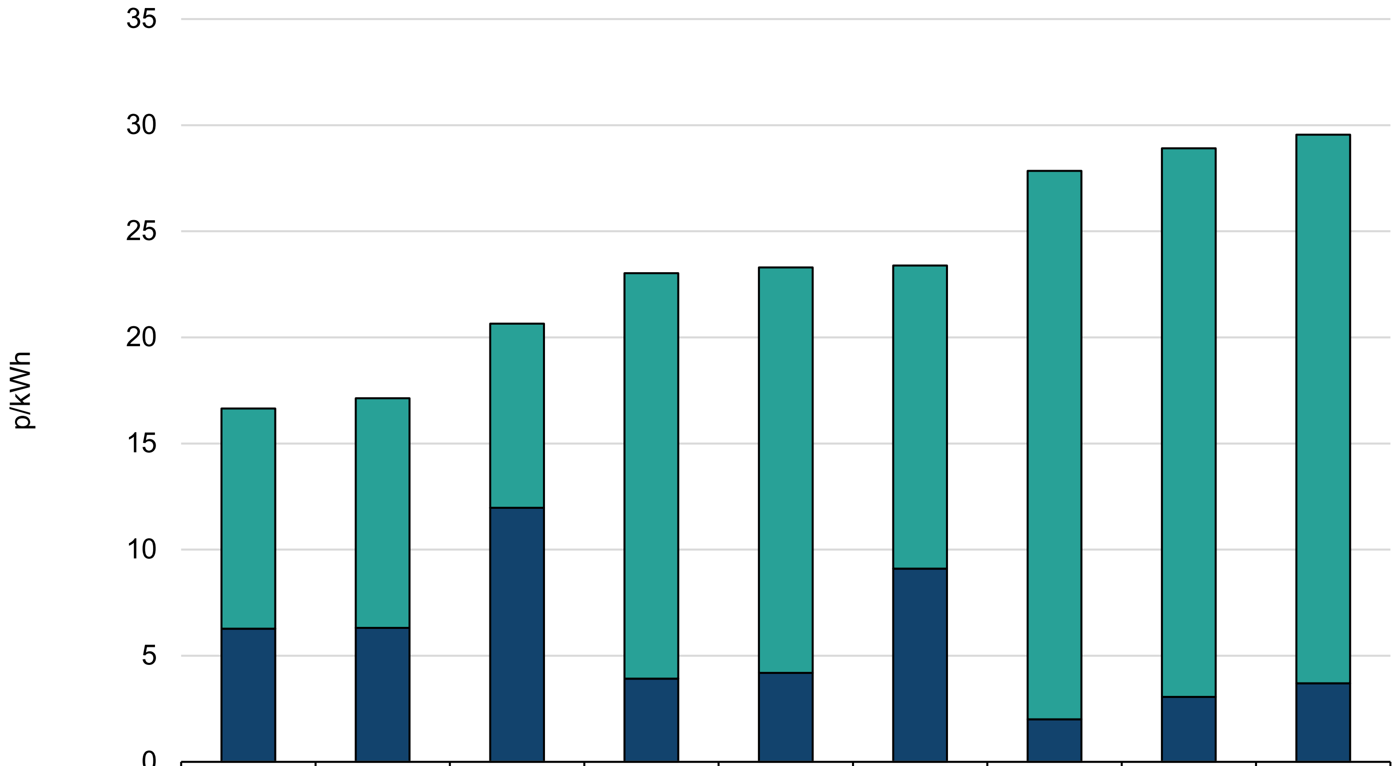
Chart 1: LCOH results for alternative heating systems in modelled GB properties for a smaller mid-terraced on-gas house archetype (2024 prices)



	LTASHP	HTASHP	AAHP	SGL	Storage heater	Dry core storage boiler	Electric combi boiler	Convective heater	Infrared panel heater
Run. costs	11.9	12.3	17.7	12.6	20.2	20.2	27.0	27.0	27.0
Capex	10.7	10.6	8.9	14.8	7.5	11.0	5.0	6.0	7.0
Total LCOH	22.6	22.9	26.6	27.4	27.7	31.2	31.9	33.0	34.0

The LCOH for alternative heating systems within the larger detached on-gas house archetype is presented in Chart 2. As seen in the LCOH analysis for the smaller mid-terraced housing archetype, a LTASHP has the lowest LCOH (16.6p/kWh) and an infrared panel heater represents the highest LCOH (29.6p/kWh).

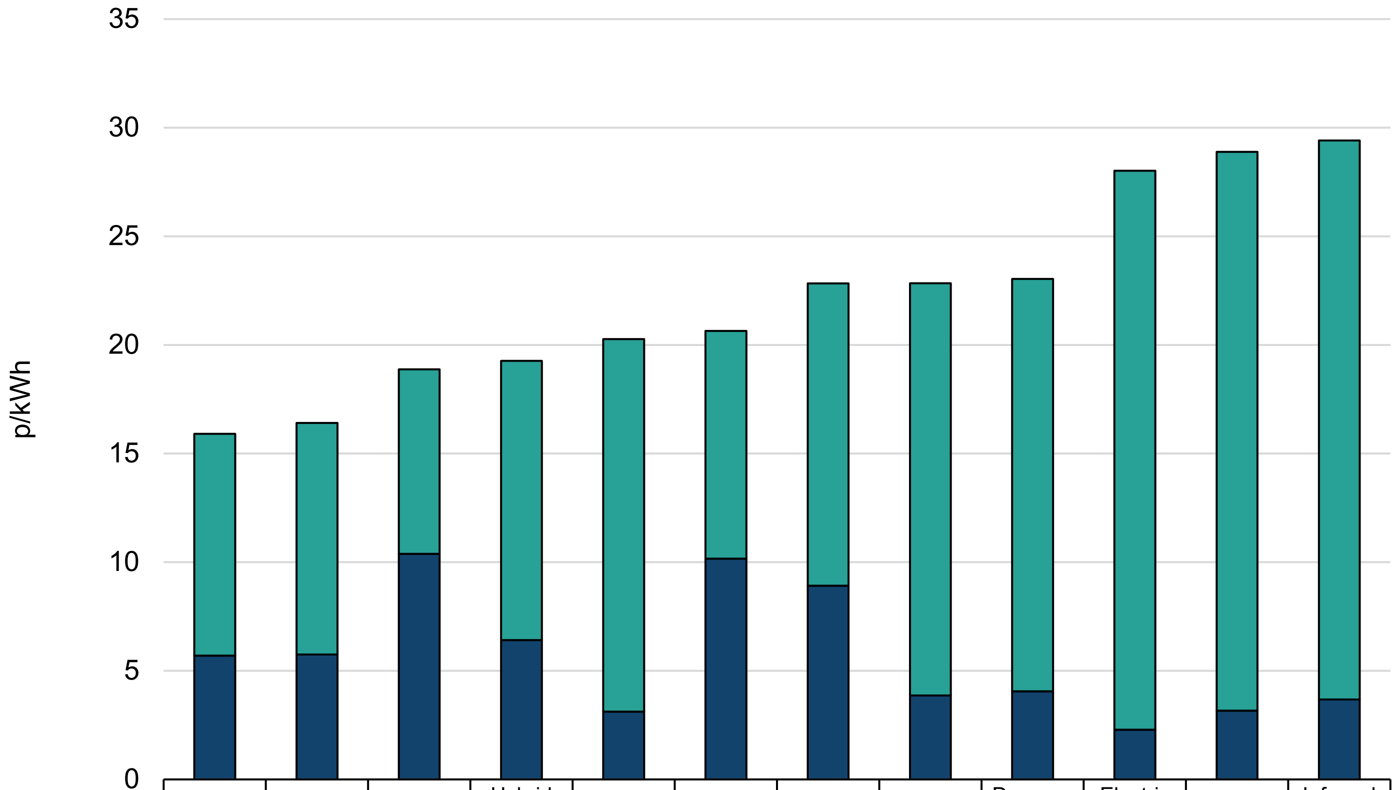
Chart 2: LCOH results for alternative heating systems in modelled GB properties for a larger detached on-gas house archetype (2024 prices)



	LTASHP	HTASHP	LTGSHP	Storage heater	Dry core storage boiler	AAHP	Electric combi boiler	Convective heater	Infrared panel heater
Run. costs	10.4	10.8	8.7	19.1	19.1	14.3	25.8	25.8	25.8
Capex	6.3	6.3	12.0	3.9	4.2	9.1	2.0	3.1	3.7
Total LCOH	16.6	17.1	20.6	23.0	23.3	23.4	27.9	28.9	29.6

For the larger detached off-gas house archetype, the heating systems with the lowest and highest LCOH are the same as the other housing archetypes, a LTASHP (15.9p/kWh) and infrared panel heater (29.4p/kWh) respectively. A greater range of technologies are presented for the detached off gas house archetype, as it is likely that heating systems including HVO boilers, biomass boilers, and hybrid heat pump systems working in conjunction with HVO boilers, would be suitable.

Chart 3: LCOH results for alternative heating systems in modelled GB properties for a larger detached off-gas house archetype (2024 prices)



	LTASHP	HTASHP	LTGSHP	Hybrid LTASHP + HVO	HVO boiler	Biomass boiler	AAHP	Storage heater	Dry core storage boiler	Electric combi boiler	Convective heater	Infrared panel heater
Run. costs	10.2	10.7	8.5	12.9	17.1	10.5	13.9	19.0	19.0	25.7	25.7	25.7
Capex	5.7	5.7	10.4	6.4	3.1	10.2	8.9	3.9	4.1	2.3	3.2	3.7
Total LCOH	15.9	16.4	18.9	19.3	20.3	20.6	22.8	22.8	23.0	28.0	28.9	29.4

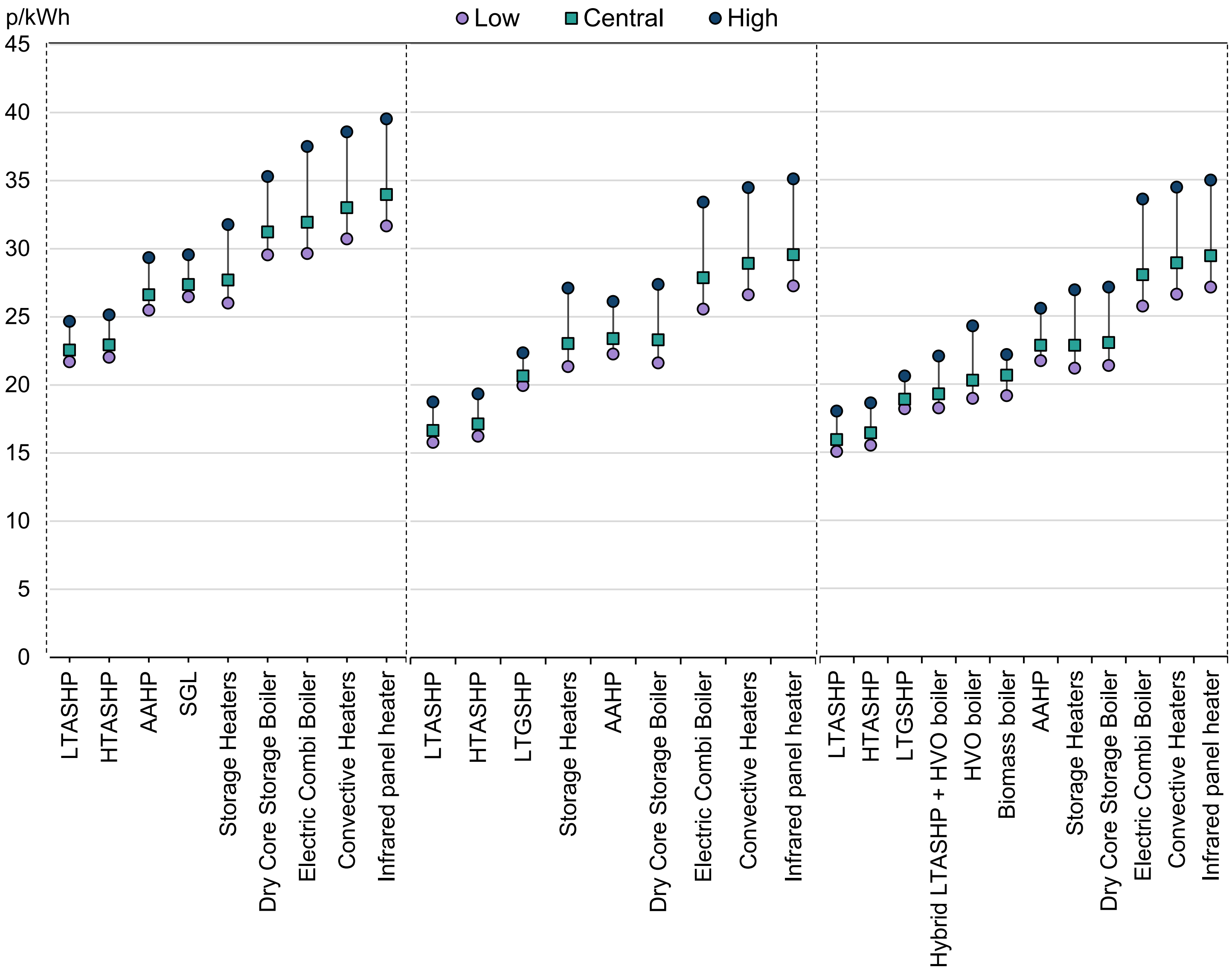
Sensitivity Analysis

Sensitivity analysis has been conducted to assess how variations in key assumptions – such as fuel costs, system efficiencies, and load shifting – affect the LCOH of heating technologies across the three archetypes. Given that heat pumps are expected to play a central role in the decarbonisation of heating, we anticipate future reductions in capital costs and improvements in system performance. To reflect this, we have included an illustrative sensitivity analysis showing the potential impact on the LCOH for installing heating systems in future years.

Fuel Prices

The LCOH analysis presented in this note uses central domestic retail fuel prices to estimate average fuel costs over an 18-year appraisal period for each heating system. Lower and higher fuel price assumptions have been tested to evaluate their impact on the LCOH for each heating system. Green Book energy price data includes high and low estimates of electricity retail prices. For HVO, rather than using the average weekly price ratio between 2022 and 2024, the minimum and maximum weekly price ratio observed over the same period have been used to establish a range which is then indexed against future Green Book kerosene retail prices.[31] This range is 2.3 (minimum price ratio) and 3.1 (maximum price ratio), compared to the central average of 2.5. Chart 4 below illustrates the total LCOH for each heating system by archetype, using the lower, central, and higher retail price estimates.

Chart 4: LCOH for heating systems based on low, central, and high retail fuel price assumptions by housing archetype (p/kWh) – smaller mid-terraced on-gas house (left), larger detached on-gas house (centre), larger detached off-gas house (right)



For heat pump and thermal energy storage systems, the effect of higher and lower energy price assumptions typically drives an LCOH variation of ~5p/kWh. The larger difference for direct electric (DE) systems is partly driven by the high retail price assumptions for electricity in the near term. High Green Book electricity retail price assumptions between 2025 and 2027 are 63% higher than the centrally assumed retail price (over the same period), whilst the low electricity retail price assumption is only 18% lower than the centrally assumed retail price for comparison. Overall, the ranking of LCOH across all systems does not change significantly

[31] Weekly HVO/kerosene price ratio average over a minimum 4-month period to account for larger price fluctuations.

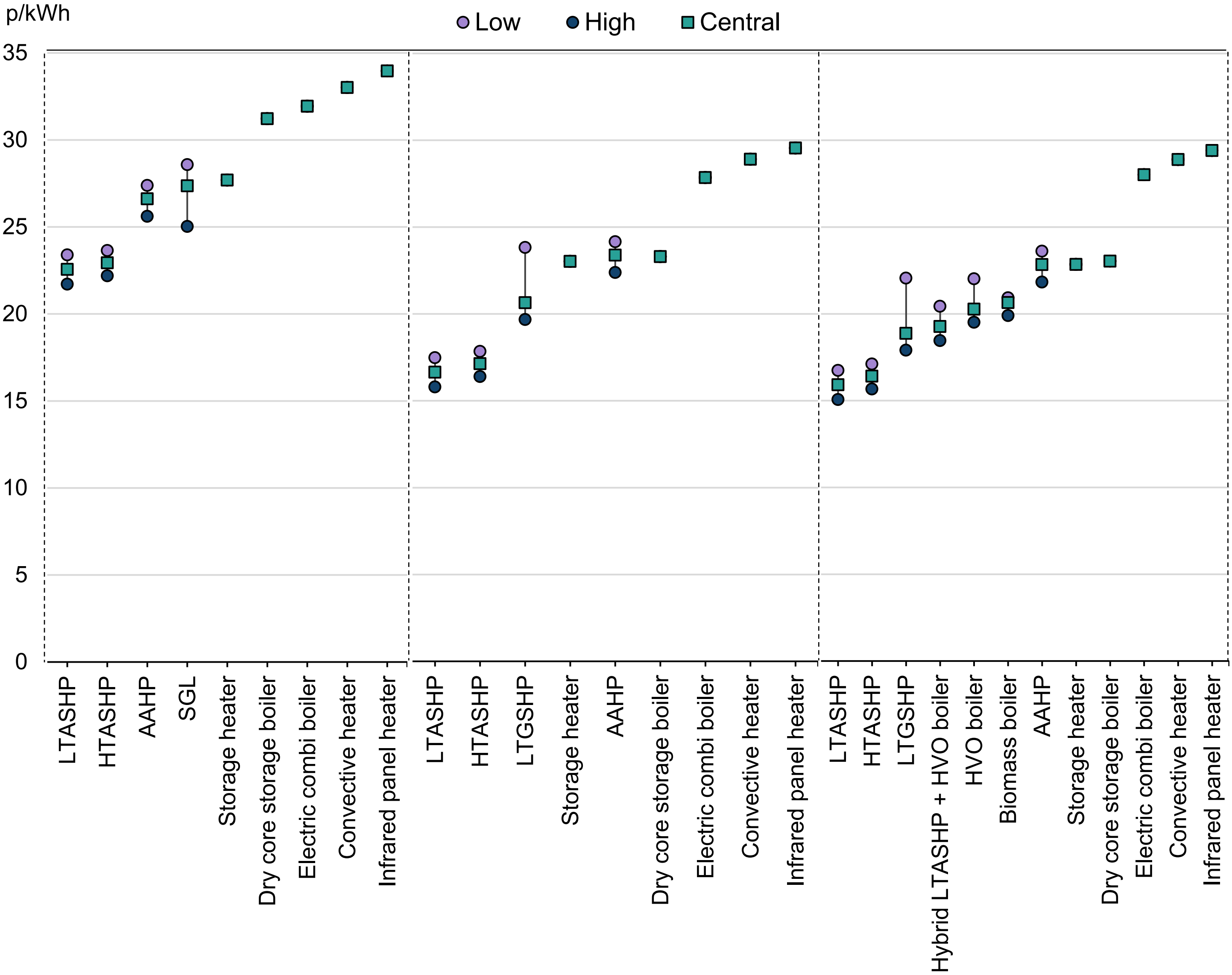
when accounting for low and high energy prices. Across all three housing archetypes, LTASHPs have the lowest LCOH under the low energy price assumptions and infrared panel heaters have the highest LCOH under the high energy price assumption.

System Efficiency

This sensitivity explores the impact of varying assumptions around system efficiency which would impact appliance fuel demand and running costs. For some technologies like heat pumps, recent field trials have shown that these can display a broad range of in situ efficiencies, so it useful to see how this might affect LCOH. We don’t assume any variation in efficiency for non-heat pump electric heating systems as these are assumed to be operating close to 100% efficiency. Details and sources for the efficiency ranges for different heating technologies are set out in Annex B.

The results in Chart 5 below illustrates the effect of high and low heating system efficiency assumptions on the LCOH. This doesn’t have a significant impact on the LCOH ranking across heating technologies, with ASHPs still having the lowest LCOH.

Chart 5: LCOH for heating systems at low, central, and high system efficiency by archetype (p/kWh) – smaller mid-terraced on-gas house (left), larger detached on-gas house (centre), larger detached off-gas house (right)



Load Shifting

Properties with electric heating systems (including heat pumps) can reduce their heating bills by using E7 or other ToU tariffs, shifting demand from expensive peak periods to cheaper off-peak times. Thermal energy storage systems can achieve this by charging during off-peak periods, while homes with heat pumps can shift their demand by timing hot water heating with off peak periods or reducing heat pump operation during peak times – relying on the building's thermal mass to maintain comfort. There are a variety of time-based tariffs available, and the level of load shifting is likely to vary across consumers. Because of this, a sensitivity test has been conducted to investigate how different levels of load shifting may impact the LCOH of heat pump technologies and thermal energy storage systems.

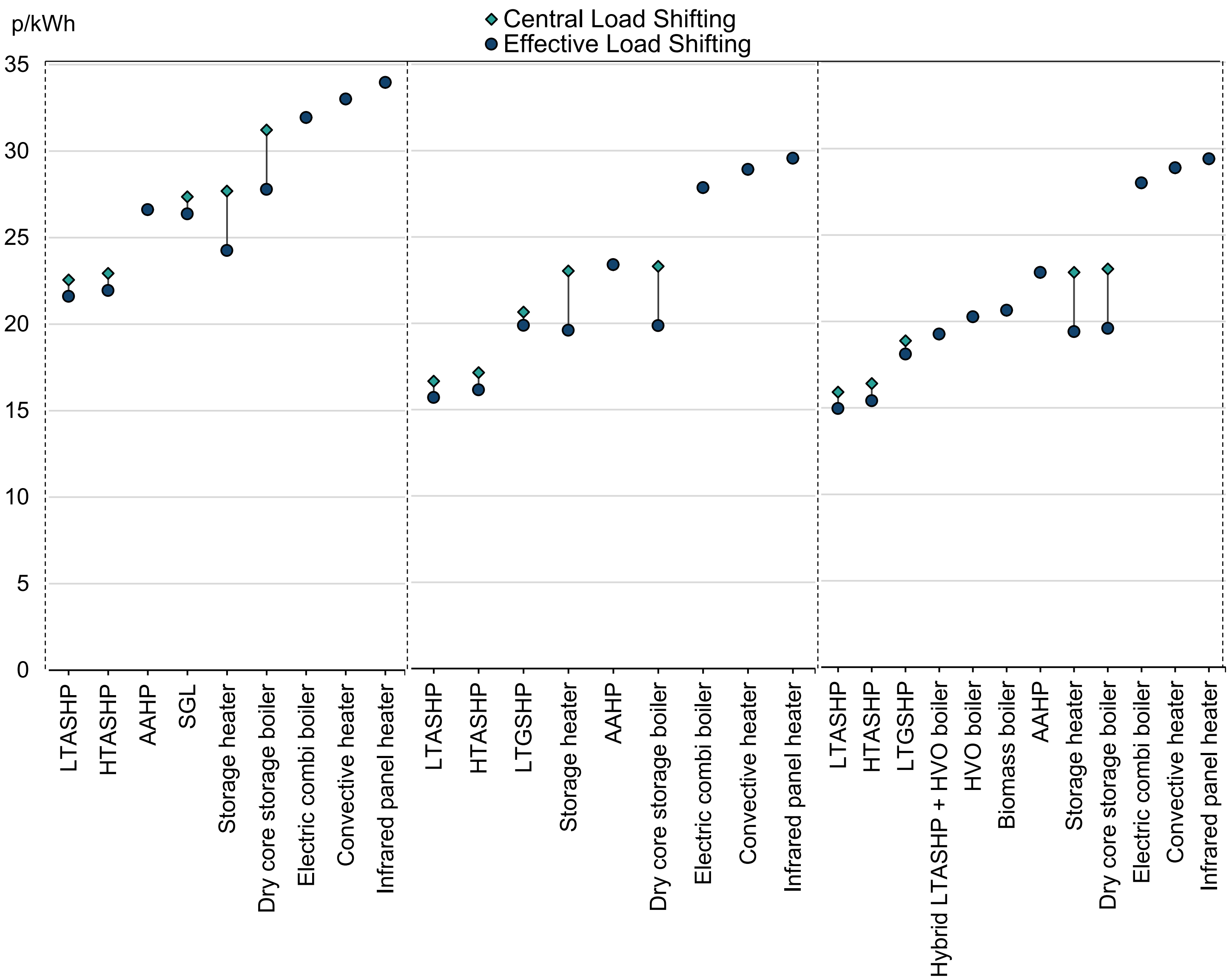
In the central scenario for heat pump technologies, it is assumed that the customer is on a standard electricity tariff, meaning there is no running cost benefit for load shifting. The 'effective' load shifting sensitivity assumes that the consumer is on a ToU tariff and actively engages in load shifting, leading to a 10% reduction in running costs. This conservative estimate is based on internal DESNZ modelling using the CODE dataset, incorporating existing tariff structures and assumed load shifting behaviour by consumers.[32,33] Future tariffs – particularly those designed to support heat pump usage and load shifting behaviours – could enable greater reductions in running costs. In the central scenario for thermal energy storage systems, it is assumed that 80% of heating demand is met during off-peak hours and 20% during peak hours, based on E7 tariff pricing. The 'effective' scenario assumes that all electricity demand for space and hot water heating can be shifted to the off-peak period.

Chart 6 below illustrates the effect of the central and effective load shifting assumptions on the LCOH. The LCOH is higher in the central scenario across all heating systems considered. For heat pump technologies, this is driven by higher running costs on a standard tariff compared a time-based tariff with load-shifting behaviour. Similarly, the higher LCOH in the central scenario for storage heaters and dry core storage boilers is due to consumers making suboptimal use of E7 type tariff pricing. For AAHP, DE, biofuel, and hybrid systems, the LCOH for both the central and effective load shifting assumptions are the same, as these technologies have no modelled load shifting capabilities.

[32] DESNZ (2021). Cost Optimal Domestic Electrification (CODE): research study. Available at: Cost Optimal Domestic Electrification (CODE) - GOV.UK.

[33] External research provides savings from load shifting of similar magnitude e.g. L. Bernard, A. Hackett, R. Metcalfe, A.R. Schein 2025, Decarbonizing Heat: The Impact of Heat Pumps and a Time-of-Use Heat Pump Tariff on Energy Demand. Available at: 70c132aeeb97e9d127046b8f12f6277f9f84b68d.pdf.

Chart 6: LCOH for heating systems based on the central and effective load shifting assumptions by archetype (p/kWh) – smaller mid-terraced on-gas house (left), larger detached on-gas house (centre), larger detached off-gas house (right)



Future Heat Pump Capital Cost

Heat pumps are expected to play a central role in the decarbonisation of home heating, with significant growth in deployment expected over the next decade. This increased uptake is expected to drive down capital costs through economies of scale and technological innovation.

To assess the potential impact of future reductions in ASHP capital costs, the sensitivity analysis in Chart 7 below examines how lowering the upfront costs of LT and HTASHPs influences their relative LCOH compared to alternate technologies. The modelling assumes a reduction in heat pump capital costs of 33% for LTASHP and 38% for HTASHP between 2021 and 2035. The ASHP cost reduction percentages are based on internal analysis of the Eunomia report and the Delta-LCP white paper on cost cutting potential of installed heat pumps.[34,35] Only the LTASHP aspect of the hybrid system for the large, detached archetype has had a capital cost reduction factor applied.

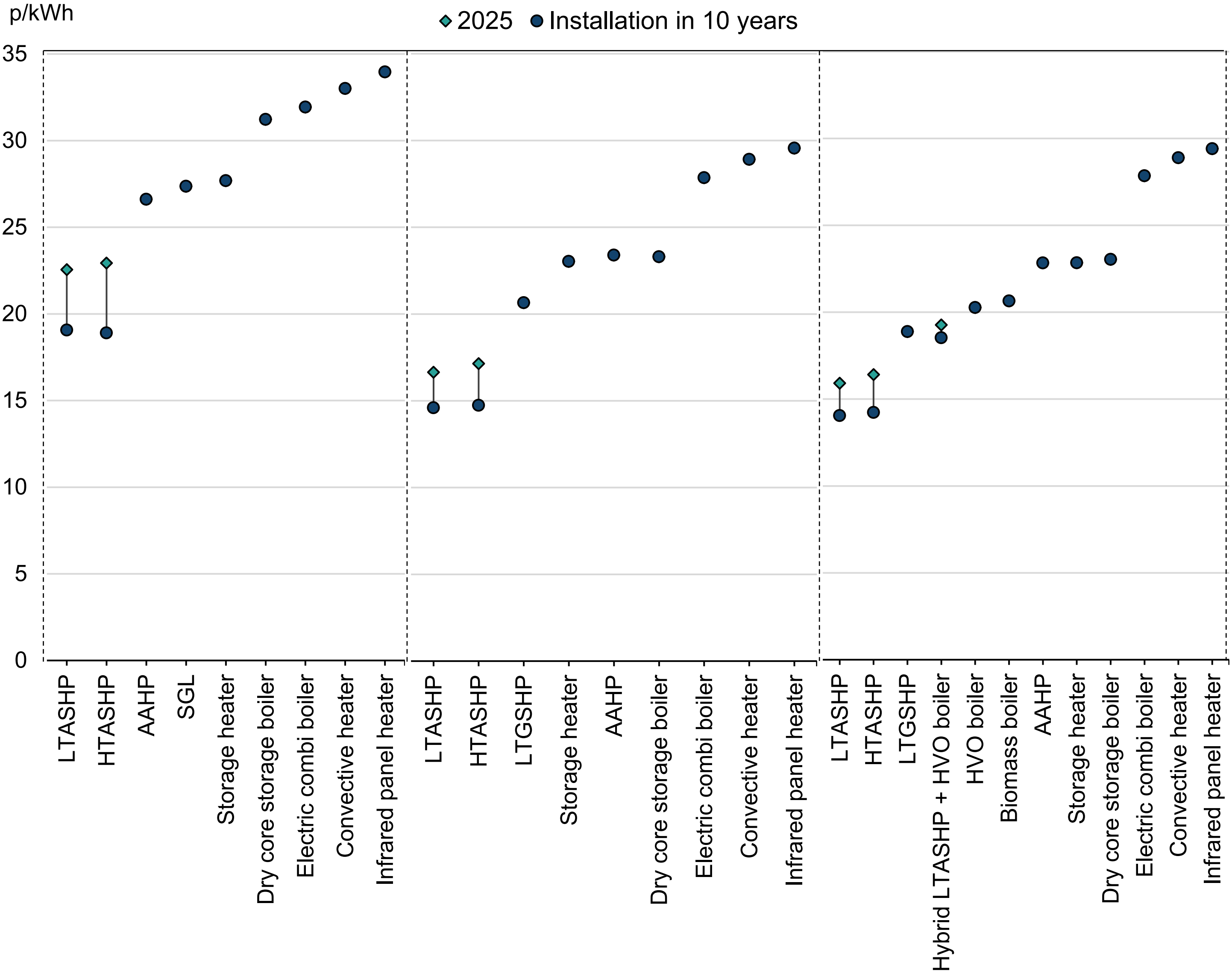
While other appliances may also experience future reductions in capital costs, we currently have insufficient evidence to quantify these impacts.[36] Additionally, some alternative heating technologies (including storage heaters, panel heaters, and AAHPs) already have significant levels of deployment, so they are unlikely to experience the same degree of future cost reduction potential as ASHPs.

[34] Eunomia (2023). Cost of Domestic and Commercial Heating Appliances. Available at: https://eunomia.eco/reports/title-the-cost-of-heating-appliances-a-comprehensive-uk-database/.

[35] LCP Delta (2025). What is the potential for cutting the cost of an installed heat pump? Available at: https://www.lcp.com/en/energy-transition.

[36] No capital cost reductions have been assumed for other technologies as these other systems are already mature, or the scale of future deployment is limited. However, there is a great deal of uncertainty around such assumptions.

Chart 7: LCOH for heating systems installed in 2025 and future years by archetype (p/kWh) – smaller mid-terraced on-gas house (left), larger detached on-gas house (centre), larger detached off-gas house (right)



Carbon Impacts from Fuel

Although carbon impacts from fuel consumption are not included in the heating system cost analysis within this document, it is important to note that each fuel type has an associated carbon emission factor ($kgCO_2e/kWh$). This can be used to assess the carbon intensity of a heating system when accounting for its efficiency. The carbon intensity of heating can be calculated by dividing the emission factor of the fuel type by the efficiency of each relevant heating system.

Emission factors for electricity and oil are sourced from the Green Book, which accounts for the projected decarbonisation of the power sector through to 2050.[37] For electricity, a present carbon impacts value (2025) and future carbon impacts value (2035) has been calculated. As emission factors for biomass and HVO are not included in the Green Book, SAP data is used to estimate the carbon impacts of heating systems using these fuels. For solid biomass, SAP data presents an emissions factor of 0.053 $kgCO_2e/kWh$. HVO, when derived from UCO, has a lifetime emissions factor of 0.036 $kgCO_2e/kWh$, which is approximately 90% less than domestic heating oil.[38,39,40]

The results in Table 6 demonstrate that, over the long term, emissions from electric heating systems are expected to decline in line with the decarbonisation of the electricity grid. By 2035, air source and ground source heat pumps are projected to have the lowest emissions factors among all heating systems considered in this analysis. Although other non heat pump electric heating systems use the same energy type, the higher efficiency of heat pumps leads to lower electricity consumption—and therefore lower emissions.

Table 6: Present and future carbon intensity of heating by alternate heating technologies (kgCO2e/kWh)

	Emissions (2025)	Emissions (2035)
LTASHP	0.074	0.009
HTASHP	0.077	0.009
LTGSHP	0.060	0.007
SGL GSHP	0.077	0.009
AAHP	0.103	0.012
Electric combi boiler	0.211	0.025
Storage heater	0.222	0.026
Dry core storage boiler	0.222	0.026
Infrared panel heater	0.211	0.025

[37] Green Book supplementary guidance. Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal.
[38] BRE Group (2021). The Government's Standard Assessment Procedure for Energy Rating of Dwellings, version 10.2 (17/12/2021). Available at: https://bregroup.com/expertise/energy/sap/sap10.
[39] Ibid.
[40] The emissions factor of solid biomass can vary significantly based on type of feedstock. The emissions factor presented is based on wood pellets bought in bulk supply for main heating.

Hybrid ASHP at low temp. + HVO boiler	0.097	0.019
Point of use hot water system for DHW	0.222	0.026
HVO boiler	0.043	
Biomass boiler	0.076	

Limitations

As with most surveys and data modelling, there are certain limitations that impact the quality of the data collected and resultant findings. This section outlines some of the key limitations associated with the analysis presented in this analytical note.

Survey Data Quality

Since the NBM relies on household survey data from 2016/17 for England, 2017/18 for Wales, and 2018 for Scotland, properties built after these surveys – or those that have undergone energy efficiency (EE) retrofits – are modelled using generic assumptions rather than actual survey data. The results, however, are unlikely to be sensitive to changes from any new build properties or retrofit measures.

Survey Sampling and Sample Size

Given the size and variety of the GB housing stock, it is likely that the sampling frame (the total list of those within a population that can be sampled) may be incomplete and therefore introduce coverage error. Coverage error occurs when a sampling frame does not sufficiently cover the population required, therefore excluding some properties from being sampled. This type of error can introduce bias into survey estimates. While coverage error is a recognised limitation, it is a common challenge when surveying large and diverse populations – such as the GB housing stock.

Analysing smaller subgroups reduces the available sample size. If the sample becomes too small, it may no longer be representative of the broader population, potentially leading to biased or inconclusive survey results. All analysis conducted within this analytical note has been reviewed for sample counts, with any analysis below a certain sample size suitably flagged.

Simplified Assumptions

The E7 tariff price used for analysis within this document for thermal energy storage systems has been simplified. The modelling assumes that roughly 80% of a home's space and hot water heating demands are provided during cheaper electricity night rates, and the remaining 20% delivered during more expensive day rates. This assumption applies to all the defined housing archetypes and thermal energy storage-based systems. In practice, the typology of a home, as well as the type of thermal energy storage system installed, will determine the proportion of heating that could be provided during day and night electricity rates.

Whilst the carbon intensity of different heating systems has been examined in this analytical note, the air quality impacts that result from energy consumption have not been investigated. This is because there are significant evidence gaps concerning the air quality impacts from the use of solid biomass and HVO. As new evidence is presented, this is an area that will be developed further.

Evidence Gaps and Further Areas for Development

There are several evidence gaps within this analysis that will be addressed through consultation with industry stakeholders and future commissioned research. In doing so will help improve our understanding of the LCOH to consumers and the suitability of low carbon heating technologies across GB property archetypes.

Further insights into heat pump technologies are being sought through consultation, particularly regarding the extent of energy efficiency and radiator upgrades required for the installation of HTASHPs. Additionally, the in-situ performance of AAHPs, especially when integrated with hot water provision, is being explored. For direct electric systems, further evidence is being sought on the impact on costs and in-situ performance of combining these systems with thermal or electrical storage systems. Relatedly, while a sensitivity analysis has been conducted to explore the potential impact of load-shifting behaviour under ToU tariffs on the LCOH for consumers, further evidence is needed on the typical number of hours during which load-shifting is feasible, as well as the storage capacity required by a property relative to its heat demand.

For solid biomass heating systems, there is scope to improve our understanding of potential cost reductions and innovations to reduce the negative impacts on air quality, which may affect property suitability. Finally, for HVO boilers and hybrid ASHP systems, further evidence is being sought on the existing long run variable cost (LRVC) and retail cost of renewable liquid heating fuels (RLHF), including HVO and bioLPG, and how these are likely to change in the future. The consultation will also address the potential impact on costs and emissions of a proposed blend of RLHF and fossil fuels in HVO boilers and hybrid ASHP systems.

Annex

Annex A: Peak Heat Loss, Electricity Supply Capacity and the Impact of High Temperature Heat Pumps

While it's expected that heat pumps and heat networks will be the main technologies to decarbonise home heating, not all properties will be suitable for their installation. A range of factors might make ASHP installation challenging or unfeasible and while DESNZ is undertaking research to gather evidence on the broader issue of 'Complex to Decarbonise' homes, the NBM enables analysis of two specific factors – **Peak Heat Loss** and **Electricity Supply Constraints**.

Peak Heat Loss (W/m^2) reflects the fabric efficiency of a building and plays a key role in determining the appropriate sizing of a heat pump. It also influences whether a heat pump can maintain sufficient thermal comfort at a given flow temperature during cold conditions, as defined by Microgeneration Certification Scheme (MCS) design temperatures, which range from -2°C to -6°C depending on the region. Based on MCS Emitter Guidance, we assume that heat pumps operating at low flow temperatures (45°C) would be able to provide thermal comfort in homes with a peak loss of up to $100W/m^2$.[41] For heat pumps operating with high flow temperatures (65°C), this would increase to $150W/m^2$.

[41] MCS (2019). Heat Emitter Guide for Domestic Heat Pumps. Available at: https://mcscertified.com/wp-content/uploads/2021/10/MCS-021-.pdf.

Chart 8: Distribution of peak heat loss intervals in modelled fossil fuel heated GB properties on and off gas grid (W/m²)[42]

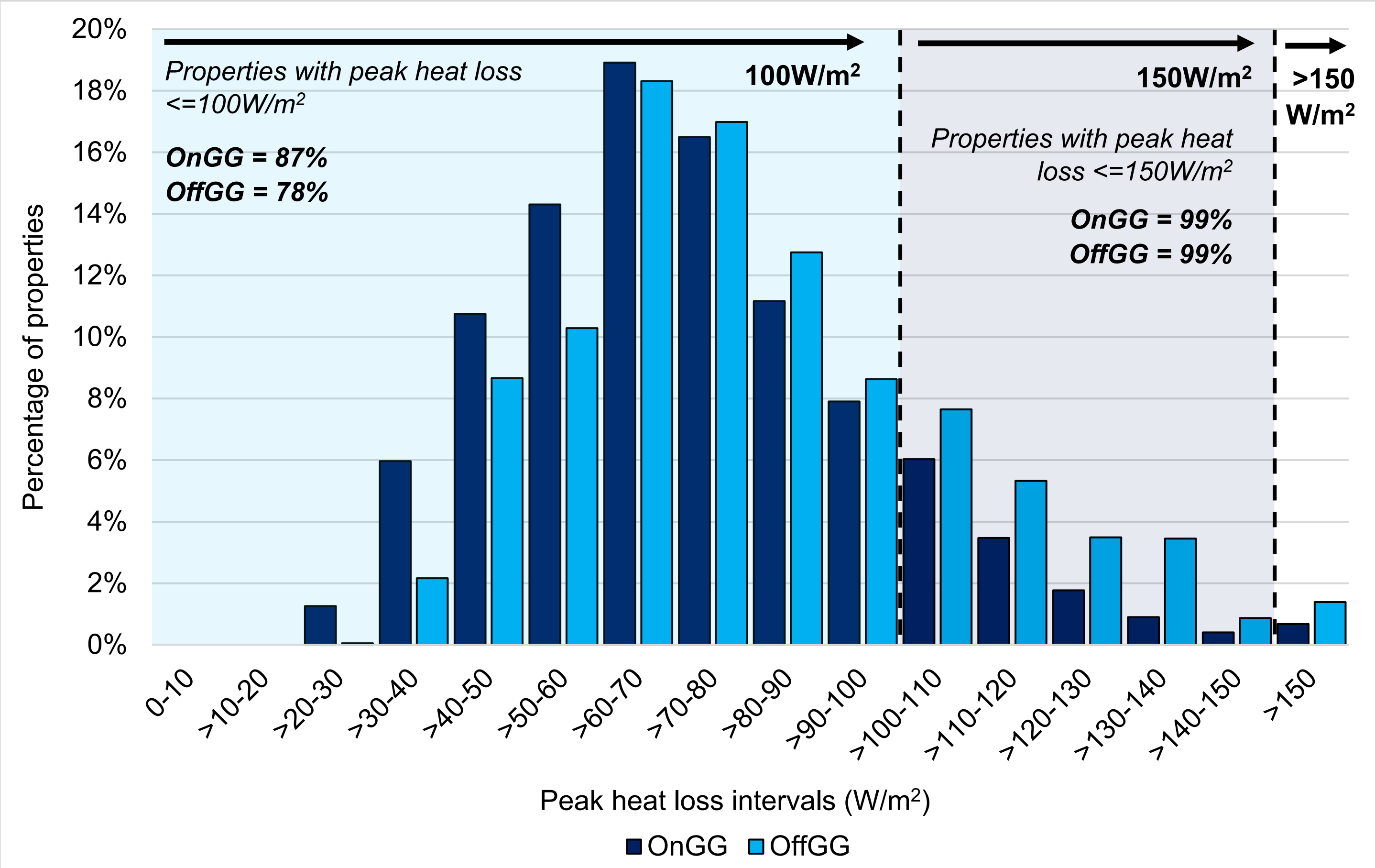


Chart 8 illustrates the distribution of fossil heated homes across GB by peak heat loss intervals as modelled in the NBM. The results indicate that approximately 87% of on-gas GB homes should be able to achieve sufficient thermal comfort with a heat pump operating at low flow temperatures. For off-gas fossil fuel heated homes, this proportion is lower at 78%, reflecting the tendency for these homes to be older and less fabric efficient. The results also highlight the potential role of high temperature heat pumps in supporting homes with higher peak heat losses, increasing the proportion of fossil fuel heated GB homes that could achieve sufficient thermal comfort by a heat pump to around 99%.

Electricity Supply Constraints relates to buildings peak electrical demand. This determines whether a heat pumps current draw during cold weather would be compatible with a single-phase electricity supply or whether a property would require upgrading to a three-phase supply (which can be disruptive and expensive). The peak current draw for a property is determined by its peak heat loss and the assumed performance of a heat pump during very cold temperatures (2.08 for a LTASHP and 1.67 for a HTASHP). While a single-phase electricity supply can support a current draw of up to 100A, many homes have fuse limits below this, but District Network Operators (DNO) can upgrade a home's fuse limit to 80A or 100A. Modelling of electrical supply constraints conservatively assumes heat pumps with a current draw of up

[42] Results in Chart 8 are from the Departments NBM.

to 60A could be supported by a home with a single-phase supply. This leaves a residual buffer of 20A to account for the electrical draw from other household appliances, e.g. washing machines, refrigerators, and other common appliances.[43]

Chart 9: Distribution of peak current draw by LT and HTASHP at worse-case coefficient of performance (COP) in modelled fossil fuel heated GB properties[44]

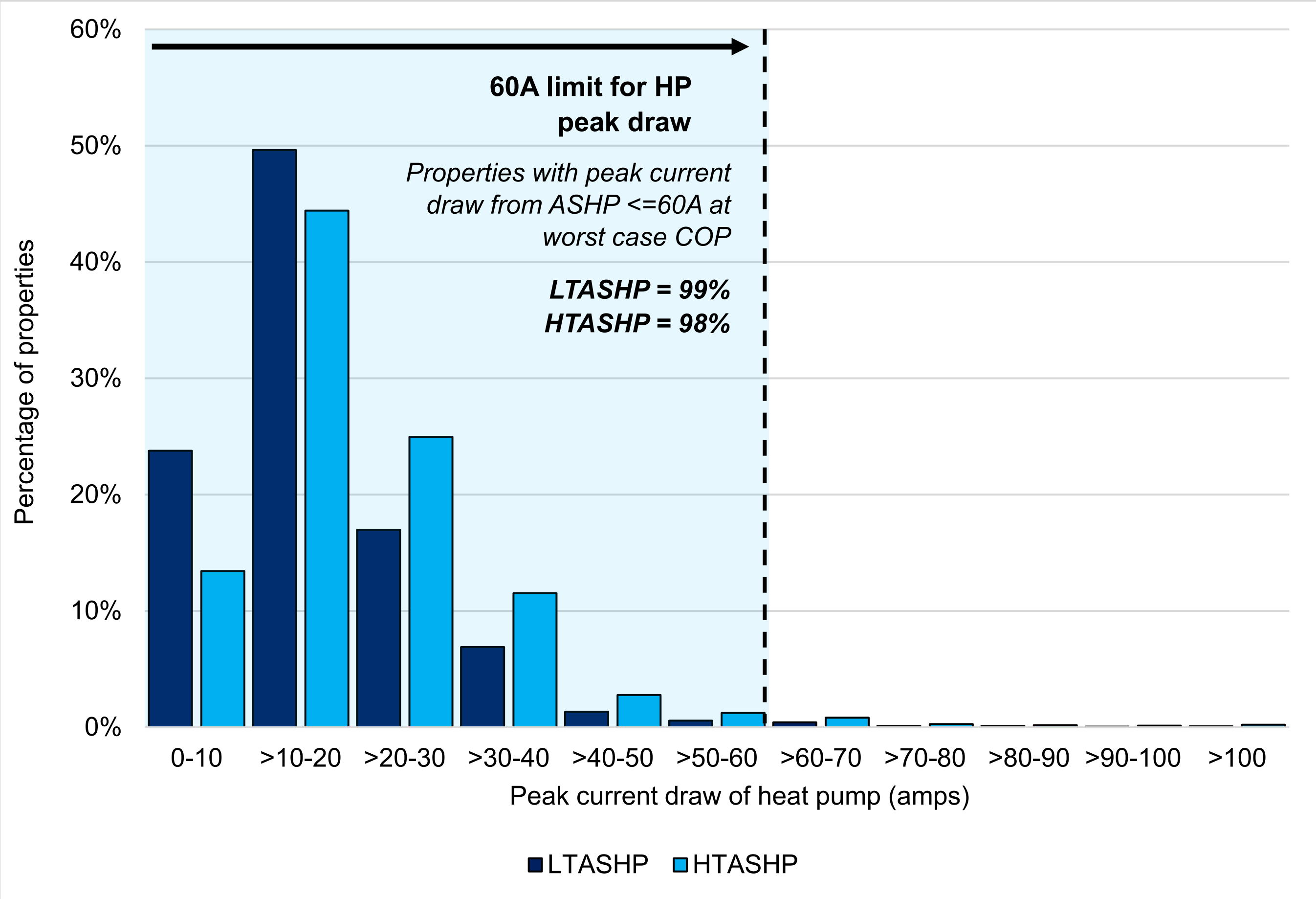


Chart 9 illustrates the modelled distribution of peak current draws from heat pumps operating at both low and high flow temperatures in fossil-fuel-heated GB homes, based on worst-case coefficient of performance (COP) assumptions. This represents the point where a heat pump will be performing at its lowest efficiency, predominantly during periods of extreme cold weather. The results illustrate that a single-phase supply would be sufficient for the vast majority of homes regardless of the flow temperature of the heat pump (99% for LTASHP and 98% for HTASHP), without considering fuse upgrades. There is a very small population of homes that would likely require three-phase connections due to the scale of their peak heat demand – these are typically extremely large homes with floor areas over 400m^2.

When considering the combined interaction between a home's peak heat loss and electrical supply, the modelling results from the NBM suggest that 98% of fossil fuel heated homes in GB

[43] Assumes that other significant electrical demand like charging electric vehicles (EVs) would be done flexibly and outside peak heat demand periods.
[44] Results in Chart 9 are from the Departments NBM.

would have sufficient thermal insulation and electrical capacity to maintain thermal comfort from a heat pump at low or high flow temperatures. When disaggregated, the results show that 99% of on-gas homes meet this criterion, compared to 93% of off-gas homes.

It is important to outline some of the key caveats associated with the modelling results. The percentage of homes outlined above that would meet the thermal insulation and electrical supply conditions for thermal comfort provided by a heat pump are based on modelled housing conditions. In practice, homes that do not meet the above conditions could opt to improve thermal insulation, which in turn would reduce the peak heat loss and potentially overcome the first of the two modelled conditions. In addition, some homes may already have a three-phase electrical connection, allowing these homes to accommodate heat pumps with a peak current draw beyond 60A, overcoming the second of the two modelled conditions.

Alternatively, homes that would not have sufficient thermal insulation or electrical supply to have thermal comfort provided by a heat pump, may opt for one of the alternative low carbon heating technologies covered within this analytical note.

Annex B: Supporting data tables

Table of departmental assumed efficiency and lifetime of alternative heating technologies

	Efficiency (%)[45]	**Lifetime (years)**
LTASHP	286%[46]	18
HTASHP	273%[47]	18
LTGSHP	353%[48]	20[49]
Ground collector	N/A	60

[45] The SPFH4 values for the Low-Temperature Air Source Heat Pump (LTASHP), High-Temperature Air Source Heat Pump (HTASHP), Ground Source Heat Pump (GSHP), and Shared Ground Loop (SGL) systems are derived from the cleansed dataset provided in the Electrification of Heat Demonstration Project (EoH).
[46] The published SPFH4 value in the EoH report is 2.78. This has been adjusted to reflect improved performance, resulting in an updated value of 2.86.
[47] This SPFH4 value of 2.73 is not the value published in the EoH report. Instead, it is calculated from the underlying cleansed dataset and re-weighted based on the market share of different models, making it more representative of average performance across the technology. Additional adjustment is made to reflect improved performance.
[48] The SPFH4 for GSHP due to there being a relatively small number of these technologies in the sample. The value of 3.53 is the median of the 7 installations included in the published cleansed dataset.
[49] For LTGSHP, the lifetime of the unit is different to the lifetime of the groundworks. Departmental modelling assumes a LTGSHP to have a unit lifetime of 20 years, and an assumed ground works lifetime of 60 years.

SGL GSHP		275%[50]	20
Hybrid LTASHP + HVO boiler	Combined efficiency	153%	-
	LTASHP	*286%*	*18*
	HVO boiler	*84%*	*15*
AAHP		204%[51]	15
Electric boiler		100%	20
Infrared panel heater		100%	20
Point of use hot water system and immersion heater for DHW		100%	20
Dry core storage boiler		95%[52]	20
Storage heater		95%[53]	20
HVO boiler		84%[54]	15
Biomass boiler[55]		70%	15

The efficiencies are used for calculating the fuel consumption. For modelling purposes, the annual heat demand values for dwelling heated by gas boilers are used as baselines. These are derived from metered data, with assumptions applied to end-use and efficiencies. [56] This

[50] The EoH report didn't estimate a specific SPFH4 for SGLs due to there being a relatively small number in the sample. The value of 2.75 is the median of the 16 installations from the published cleansed dataset. The SPF values reported are based on trial data and given that SGLs are a relatively novel application, it is possible that performance has improved since the trial was conducted.
[51] Space heating efficiency of 275% is assumed based on the results presented in the Renewable Heat Incentive Evidence Report, and the Delta-EE Report. This results in a combined efficiency of 204%, with a hot water heater having an assumed efficiency of 100% (assuming the proportion of space heating heat demand to hot water heat demand is 80/20).
[52] Dry core storage boilers, despite being conventional electric heating systems, have an assumed 95% efficiency due to a small proportion of heat generated that is not required.
[53] Ibid.
[54] We assume HVO boilers to have the same in situ efficiency as gas and oil boilers, with the efficiency of a gas boiler taken from: In-situ monitoring of efficiencies of condensing boilers and use of secondary heating trial: final report (2009) - GOV.UK.
[55] DESNZ (2019). Measurement of the in-situ performance of solid biomass boilers. Available at: https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance.
[56] DESNZ (2024). National Energy Efficiency Data Framework (NEED). Available at: https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework.

approach applies to all technologies except LTASHP, HTASHP, LTGSHP, and SGL, where heat demand (not fuel demand) is typically higher than for boilers. This is because these systems operate for longer periods due to their ability to run efficiently at lower flow temperatures, which requires more time to reach the desired room temperature—resulting in increased annual heat demand. To account for this, a 10% uplift has been applied to space heating demand, leading to an overall increase in total heat demand (including hot water) of approximately 8% for these technologies.[57]

Table of low, central, and high efficiency assumptions for non-direct electric heating technologies

	Efficiency		
	Low	**Central**	**High**
LTASHP[58]	263%	286%	314%
HTASHP[59]	255%	273%	295%
LTGSHP[60]	250%	353%	404%
SGL[61]	245%	275%	360%
AAHP[62]	192%	204%	222%
HVO boiler[63]	76%	84%	88%

[57] S.D. Watson, K.J. Lomas, R.A. Buswell, 2021, '*How will heat pumps alter national half-hourly heat demands?'* Empirical modelling based on GB field trials. Available at: https://www.sciencedirect.com/science/article/pii/S037877882100061X.
[58] The high and low efficiency values are based on the 25th percentile and 75th percentile SPFH4 values for LTASHP in the Electrification of Heat Demonstration Project. To account for ongoing new heat pump performance improvements over time, these have been increased by 1% a year from 2022 to 2025.
[59] The low and high efficiency values are calculated as the weighted averages of the 25th and 75th percentile SPFH4 values across different HTASHP models, assuming the same rate of improvement over time as applied to the central estimate.
[60] The low and high efficiency values are based on the minimum and maximum recorded SPFH4 values (based on just 7 installations in the Electrification of Heat sample).
[61] The low, central, and high efficiency values correspond to the 25th, 50th (median), and 75th percentiles of the recorded SPFH4 values from the Electrification of Heat Demonstration Project (based on 16 properties on 3 networks).
[62] Low and high values for AAHP space heating of 250% and 320% respectively. This results in a combined efficiency of 192% and 222% with a hot water heater with efficiency of 100% assuming the proportion of space heating heat demand to hot water heat demand is 80/20.
[63] No specific in situ performance of oil boilers have been sourced, they are assumed to be of similar efficiencies as gas boilers. Proxy values have been used from In-situ monitoring of efficiencies of condensing boilers and use of secondary heating trial: final report (2009) - GOV.UK.
Low is taken as the lowest in-situ efficiency of both combi and standard boilers. High is the highest efficiency of both.

Biomass boiler[64]		68%	70%	76%
Hybrid LTASHP + HVO boiler	LTASHP	263%	286%	314%
	HVO boiler	76%	84%	88%

Table of average annual heating system maintenance cost assumptions[65] (2024 prices)

	Cost (£)
AAHP	260
Biomass boiler	170
LTGSHP/SGL GSHP	130
Hybrid LTASHP + HVO boiler	130
ASHP[66,67]	190 *(2025)* 110 *(2035)*
All other heating systems	90

[64] The high and low values are the 25th percentile and 75th percentile efficiency values in the Technical report on the Measurement of in-situ performance of solid biomass boilers.
[65] Heating system maintenance cost assumptions are derived from the Eunomia Study on the Cost of Domestic and Commercial Heating Appliances, available at: https://eunomia.eco/reports/title-the-cost-of-heating-appliances-a-comprehensive-uk-database/.
[66] Maintenance cost for ASHP averaged over the assumed 18-year lifetime.
[67] In the case of ASHPs, we expect that maintenance costs will fall as their deployment increases. As a result, we assume that by 2035 the maintenance costs of an ASHP will be equivalent to a gas boiler.

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