Comparison of heat decarbonisation options for a typical rural UK village

The Kehelland village project

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Representing the best in liquid fuels

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Contents

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1. Introduction

Kehelland is a village in Cornwall and typical of many in the UK. It is off the gas grid, rural and coastal, with unique individual homes. Most of the village currently uses kerosene heating oil as the primary heating source.

Many villagers were keen to explore alternative options to kerosene heating oil to decrease their domestic emissions. As such, they joined a demonstration scheme organised by UKIFDA and OFTEC and a UKIFDA member, Mitchell & Webber.

Under the scheme, the homes and premises of those taking part were converted to use a renewable liquid fuel called Hydrotreated Vegetable Oil (HVO) in 2021. UK government data show that HVO provides up to an 88% reduction in carbon emissions compared to kerosene heating oil.

This report offers a unique insight into the decarbonisation choices of 17 homes in Kehelland which could be typical of many thousands of rural homes across the UK if government policy was extended to allow renewable liquid heating fuels.

2. Key policy requirements

Converting existing oil heating systems to run on HVO is straightforward and inexpensive. However, the cost to the consumer of HVO at the time of this project was over twice that of kerosene heating oil. At this level, the cost is likely to be a significant barrier to consumer uptake. The modelling undertaken has identified two policy changes requiring no additional government costs (see below). With these, HVO becomes the lowest cost, least disruptive decarbonisation option for the homes in Kehelland.

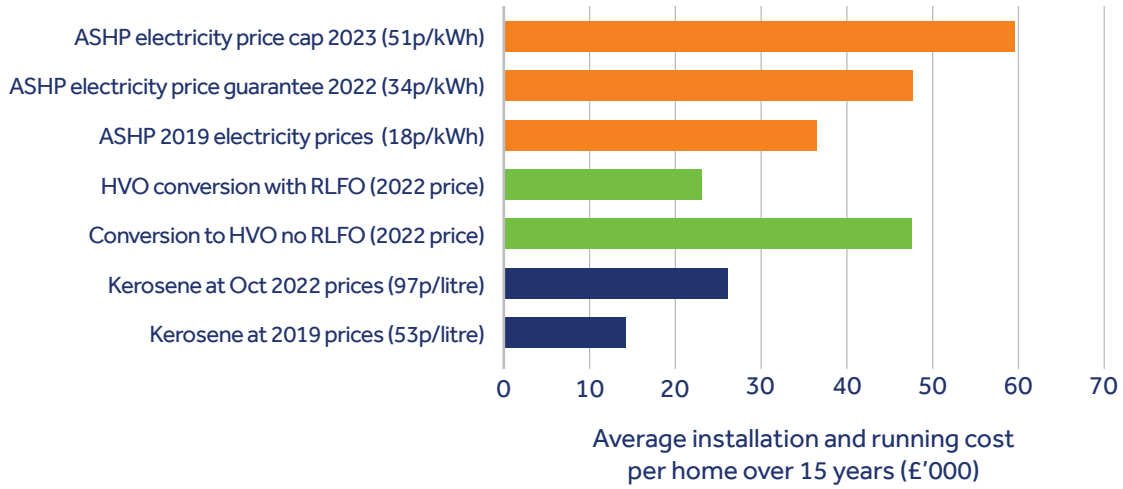
The two policy changes are:

1. Bring the fuel duty rate of HVO for heating in line with that of kerosene heating oil.
2. Create a mechanism (termed in this report as the Renewable Liquid Fuel Obligation - RLFO) which would extend or mirror for home heating the current provisions within the Renewable Transport Fuel Obligation (RTFO) which creates a price reduction for HVO to end users of vehicles, mobile machinery and aircraft.

3. Key findings

Shown here are the top level key findings across the 17 homes modelled.

Average cost of decarbonisation options for homes in Kehelland village compared to existing heating (kerosene)



Key findings include:

- HVO conversion with the benefit of the RLFO is the cheapest decarbonisation option over 15 years.
- HVO conversion has the lowest upfront investment requirement.
- HVO has the lowest cost per tonne of carbon saved under all scenarios.
- Under all scenarios at 2019 kerosene heating oil prices, all decarbonisation options are more expensive than the existing kerosene heating oil.
- Without government policy changes, HVO would be uneconomic compared to the do-nothing option.
- ASHP results are very sensitive to the electricity price. At today's electricity price, the ASHP option over 15 years would be 1.5 times more expensive than HVO.

4. Summary of methodology

In this report the use of a HVO boiler was compared to the installation of an air source heat pump (ASHP). The report compares the upfront cost of installation and running costs over a 15-year period (the typical lifetime of a heating appliance).

Upfront costs of the HVO option were taken from the Kehelland project results. The ASHP upfront costs for each home were taken from the Department for Energy Security and Net Zero heat pump checker tool, which outlines the costs of the heat pump and those associated with any insulation required.

HVO running costs are predominantly the cost of the fuel. Historic information on HVO costs is limited and, in common with all commodities at present, is difficult to forecast. Therefore, the cost of HVO in October 2022 was taken across the 15-year window.

When considering ASHP running costs, the model included a reduction in energy consumption due to the insulation, boiler inefficiencies and the ASHP seasonal coefficient of performance. There has been significant volatility in electricity prices and very little forward visibility in recent years. Costs across the 15 years were modelled against three electricity price scenarios – the price in 2019, the price in 2023 without government intervention and the 2023 price with government intervention.

“HVO is a great option for our home and we’re so pleased we made the switch – we’re saving nearly five metric tonnes of carbon every year as a result!

We wanted to reduce our carbon emissions but the cost of installing a heat pump would have been very high for us. The simple switch in fuel was so easy.”

– Dave Biggs Kehelland Resident

5. Summary of results

A number of different modelling scenarios were compared (see the rest of the report). This section outlines the top-level results across the 17 homes modelled.

	Kerosene at 2019 prices (53p/litre)	**Kerosene at Oct 2022 prices** (97p/litre)	**HVO conversion without RLFO 2022 prices**	**HVO conversion with RLFO 2022 prices**	**ASHP at 2019 electricity price** (18p/kWh)	**ASHP electricity price guarantee 2022** (34p/kWh)	**ASHP electricity price cap 2023** (51p/kWh)
Upfront costs (£)/home			500	500	23,940	23,940	23,940
Annual running costs /home (£)	957	1,751	3,140	1,516	838	1,583	2,375
Total cost / home over 15 years	**14,348**	**26,260**	**47,604**	**23,240**	**36,511**	**47,686**	**59,559**
Cost of carbon saved £/tonne			1,042	509	700	914	1,142

This report reveals there is a requirement for government to act.

The results of this project clearly reveal that all decarbonisation options are more expensive over a 15-year period than the cost of kerosene heating oil at pre-pandemic, pre-Ukraine invasion prices (2019).

Of the decarbonisation options there is a cost advantage, particularly upfront, to the consumer moving to a HVO based solution which employs a new policy that extends the RTFO benefits to a wider RLFO at no cost to the Government.

Additional carbon reduction and fuel usage savings can be achieved by fitting insulation measures, but the payback periods extend beyond 15 years.

It's clear from our findings that to support the rollout of heat pumps off the gas grid at scale, significant additional government financial support will be needed to cushion consumers from the full upfront conversion cost once any recommended insulation measures are also included. By contrast, the financial support required to deploy HVO requires no state funding while providing consumers with a welcome additional choice and a more easily adopted and cheaper solution.

5. Summary of results (Cont)

There are other considerations not included for review in this report which strengthen the case for the HVO option:

1. The transition from kerosene home heating oil to a renewable liquid fuel takes one hour when compared to potentially weeks of disruption for a heat pump installation once the various retrofitting actions are assessed and implemented, which may include planning permission requirements (many kerosene oil heated homes reside in conservation areas) and review of the electricity grid (many rural areas will require significant upgrades).

2. The HVO option has the real backing of customers – with 88% in a recent study wanting to convert to HVO.

3. Independent research confirms that, as uptake grows, there will be enough renewable liquid fuels, including HVO, to cover the requirement for home heating and other sectors. This has recently been aided by the Department for International Trade removing fuel import tariffs associated with our previous membership of the EU, allowing HVO from the US (the largest global producer) access to the UK tariff-free.

“It is vital that we look to new, greener technologies to heat our homes if we are going to be able to stay on track to hit net-zero by 2050, but this is a challenge in rural areas, which often rely on oil boilers.

Finding a way to allow them to convert their boilers at reasonable cost to a fuel with a lower carbon footprint may well be part of the solution in the medium term. So I’m very pleased to see that my constituency is leading the way with this nationally-leading trial of HVO..”

– The Right Hon George Eustice MP

6. Typical homes in Kehelland

6. Typical homes in Kehelland (Cont)

Cost to convert to an ASHP £26,985

Cost to convert to an ASHP £16,310

Methodology report

1. Scenarios

This report compares two decarbonisation options available to the residents of Kehelland other than their current heating fuel (kerosene):

- **A.** Kerosene heating oil – the currently used fuel.
- **B.** Replacing kerosene heating oil with a renewable liquid fuel (HVO).
- **C.** Replacing the current oil boiler with an air source heat pump (ASHP).

Within these options different implementation scenarios have been modelled.

The current cost of HVO is significantly more expensive than the counterfactual kerosene heating oil, so the HVO option is modelled with and without government policy intervention. The modelled policy intervention assumes kerosene heating oil users have the same benefits that transport and aviation HVO users currently receive under the Renewable Transport Fuel Obligation (RTFO) and a zero duty rate, as is currently the case for kerosene heating oil.

To model the heat pump installation the Government's heat pump checker tool[i] was used. This recognises that the installation of a heat pump is likely to require significant upgrading of the home's fabric. This upgrading also brings heating demand reduction benefits which have been modelled for the ASHP and HVO replacement options.

Then each scenario was run under three different pricing environments.

This methodology report outlines the various data points used and the references.

[i] https://www.gov.uk/check-heat-pump

2. Consumption

2.1 Kerosene heating oil

The 17 homes in Kehelland have been using kerosene heating oil for many years and this provided the project with an opportunity to assess fuel consumption information over a 6 to 20 year timeframe. The average annual usage for these properties is 1,805 litres of heating oil. These figures have been converted to kWh using government conversion factors[ii] (gross calorific value of 10.29 kWh/litre) to give a consumption figure of 18,573 kWh per home before boiler efficiencies are considered.

2.2 HVO

The consumption of HVO is broadly similar to kerosene with a slight difference in conversion factor (gross 9.93 kWh/litre),[iii] providing an HVO consumption as a direct replacement of 17,921 kWh per home.

2.3 Impact of insulation

The details of each home were entered into the Government heat pump checker tool (www.gov.uk/check-heat-pump). The vast majority of the recommendations for fabric improvement included either cavity wall insulation or solid wall insulation, along with some loft insulation improvement. The average cost of the recommended improvements for the 17 homes was averaged and used for the cost comparisons.

The scope of this report does not include a building-by-building estimate of the impact on heating demand of the recommended fabric improvements. However, from the Government's National Energy Efficiency Data Framework (NEED),[iv] the consumption reduction for a gas home that installed solid wall insulation is estimated to be 18% and for loft insulation 4%. Therefore, for the purposes of this report we have included a reduction in heat demand of 22% for the insulation measures. It is recognised that not all homes will have the full suite of improvements, so this is a conservative approach.

2.4 Heat pump consumption

Heat pump electricity demand has been calculated by taking the base consumption per home (18,573 kWh) and adjusting for an oil boiler efficiency of 90%, thus reducing the heat requirement to 16,714 kWh per home. A 22% reduction due to insulation brings this down further to 13,037 kWh per home.

Finally, a seasonal coefficient of performance of 2.8 was used which brings the final heat pump consumption to 4,656 kWh per home.

[ii] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

[iii] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

[iv] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1008681/need-report-2021.pdf

3. Emissions

3.1 Kerosene emissions

Kerosene emissions (0.298kgCO2e/kWh) are based on gross Greenhouse Gas Reporting: Conversion Factors 2021, published by the UK government[v] and are consistent with those reported within the Standard Assessment process for energy rating of dwellings (SAP 10.2).[vi] The Standard Assessment Procedure (SAP) is the methodology used by the Government to assess and compare the energy and environmental performance of dwellings.

3.2 HVO emissions

HVO has been reviewed by the British Research Establishment[vii] for the purposes of the Standard Assessment Procedure (SAP 10.2) as having a carbon equivalent lifecycle emission not exceeding 0.036 kg CO2e per kWh when utilised for fixed combustion purposes. This is 88% lower than kerosene.

3.3 ASHP emissions

Electricity generation emissions, on a year-by-year basis, were taken from the Climate Change Committee (CCC) forecast as part of the 6th carbon budget.[viii]

4. Upfront costs

4.1 Upfront cost of HVO

The industry has been demonstrating a renewable liquid fuel called Hydrotreated Vegetable Oil (HVO) in 150 premises across the UK for the last 12 months. There is no need to modify or replace existing appliances or infrastructure apart from changing the kerosene heating oil boiler burning nozzle to one compatible with HVO and removing the kerosene heating oil from the storage tank. From this project we can confirm the upfront cost of conversion is £500 and takes about one hour.

For comparison purposes, a scenario was modelled which included installing a new HVO compatible boiler from day one at a cost of £2,500.

The new boiler efficiency gain was not modelled.

[v] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021

[vi] https://files.bregroup.com/SAP/SAP%2010.2%20-%2017-12-2021.pdf

[vii] https://files.bregroup.com/SAP/SAP%2010.2%20-%2017-12-2021.pdf

[viii] https://www.theccc.org.uk/publication/sixth-carbon-budget/

4. Upfront costs (Cont)

4.2 ASHP upfront costs

Heat pump installation costs were established by inputting the data from each house into the Government's heat pump suitability checker: [ix]

SITE	Heat Pump cost (£)	Thermal Store (£)	Radiators (no/£)	Insulation / Windows (£)	Total (£)
1	13000	3000	(8) 1800	225	18025
2	13000	3000	(7) 1575	225	17800
3	10500	3000	(10) 2250	9000	24750
4	10500	3000	(15) 3375	2100	18975
5	10500	3000	(7) 1575	9225	24300
6	10500	3000	(10) 2275	9000	24775
7	10500	3000	(9) 2025	9225	24750
8	13000	3000	(10) 2250	225	18475
9	10500	3000	(10) 2250	9225	24975
10	10500	3000	(12) 2700	9225	25425
11	9500	3000	(7) 1575	225	14300
12	13000	3000	(11) 2475	1225	19700
13	9500	3000	(5) 1125	1225	14850
14	9500	3000	(5) 1125	0	13625
15	13000	3000	(10) 2250	9225	27475
16	10500	3000	(7) 1575	14125	29200
17	10500	3000	(10) 2250	14125	29875
					371,275

From this, the average capital cost across the 17 homes was found to be £21,840.

[ix] https://www.gov.uk/check-heat-pump

4. Upfront costs (Cont)

4.2 ASHP upfront costs (Cont)

The following additional costs were added:

Item	Cost	Note
Coastal protection	**£350**[x]	Kehelland is 2km from the north coast of Cornwall. A report by Element Energy for the Scottish Government concluded: “*Homes located less than 5 km from the coastline were assigned ‘Coastal location’... additional costs were assumed for the use of air-source heat pumps, due to the necessary measures required to prevent accelerated corrosion of the heat exchanger. Additional costs are expected to arise from the capex premium for the installation of a ‘coastal’ model of heat pump or from the application of a corrosion protection coating on the heat exchanger of a conventional model.*[xi]”
Removal & disposal of old tank & oil	**£750**[xii]	
Redecoration	**£1000**[xiii]	

This brought the average cost of a heat pump installation to £23,940

No account was taken of the Boiler Upgrade Scheme (BUS) grant of £5,000 as this scheme is not open to all homes, with many of those modelled in this project requiring fabric improvements before a heat pump can be installed.

[x] https://householdquotes.co.uk/air-source-heat-pump-prices/
[xi] https://www.gov.scot/publications/technical-feasibility-low-carbon-heating-domestic-buildings-report-scottish-governments-directorate-energy-climate-change/
[xii] https://www.checkatrade.com/blog/cost-guides/cost-removing-domestic-oil-tank/
[xiii] Internal estimate

5. Ongoing costs

5.1 HVO price

The HVO price was taken as the price paid at the onset of the project in October 2022 (£1.74 per litre) and was used throughout the three price models and held constant over the 15-year period.

The current cost of HVO and other renewable liquid fuels is significantly higher than kerosene heating oil under normal market conditions, and this will act as a barrier to consumer uptake.

The Department for Transport incentivises the use of the same fuel in transport and aviation through the Renewable Transport Fuel Obligation (RTFO) scheme, which reduces the cost significantly to the end user (by up to c80p per litre). Replicating the RTFO model for renewable liquid fuel heating users as a Renewable Liquid Fuel Obligation (RLFO) would reduce the cost significantly to rural homes and businesses. **There is no cost to the Government for this action.**

Counterintuitively, HVO for home heating currently attracts a fuel duty administered by the Treasury (c10p per litre), whereas kerosene heating oil does not. Removal of this anomaly would also reduce the cost to rural customers, and again at **no cost to the Government** (because HVO is currently not used commercially for heating purposes and generates no tax revenue).

The HVO RLFO scenarios take these cost reductions into account.

5.2 Electricity and kerosene prices

Commodity prices have moved significantly over the last 18 months, making it impossible to provide a robust ongoing forecast of either electricity prices or kerosene prices. To overcome this, three price scenarios have been modelled to illustrate a representative range. For electricity prices, 2019 has been used as the low-cost case, i.e. prior to the pandemic and invasion of Ukraine[xiv], the Government price guarantee announced in September 2022[xv] was chosen as the mid-case, and the most recent price cap announcement by OFGEM (February 2023)[xvi] as the high-point.

Kerosene prices have been taken as close to the electricity timescales as possible using ONS data.[xvii]

Prices	2019	October 2022	February 2023
Electricity (p/kWh)	18	34	51
Kerosene (p/litre)	53	97	75

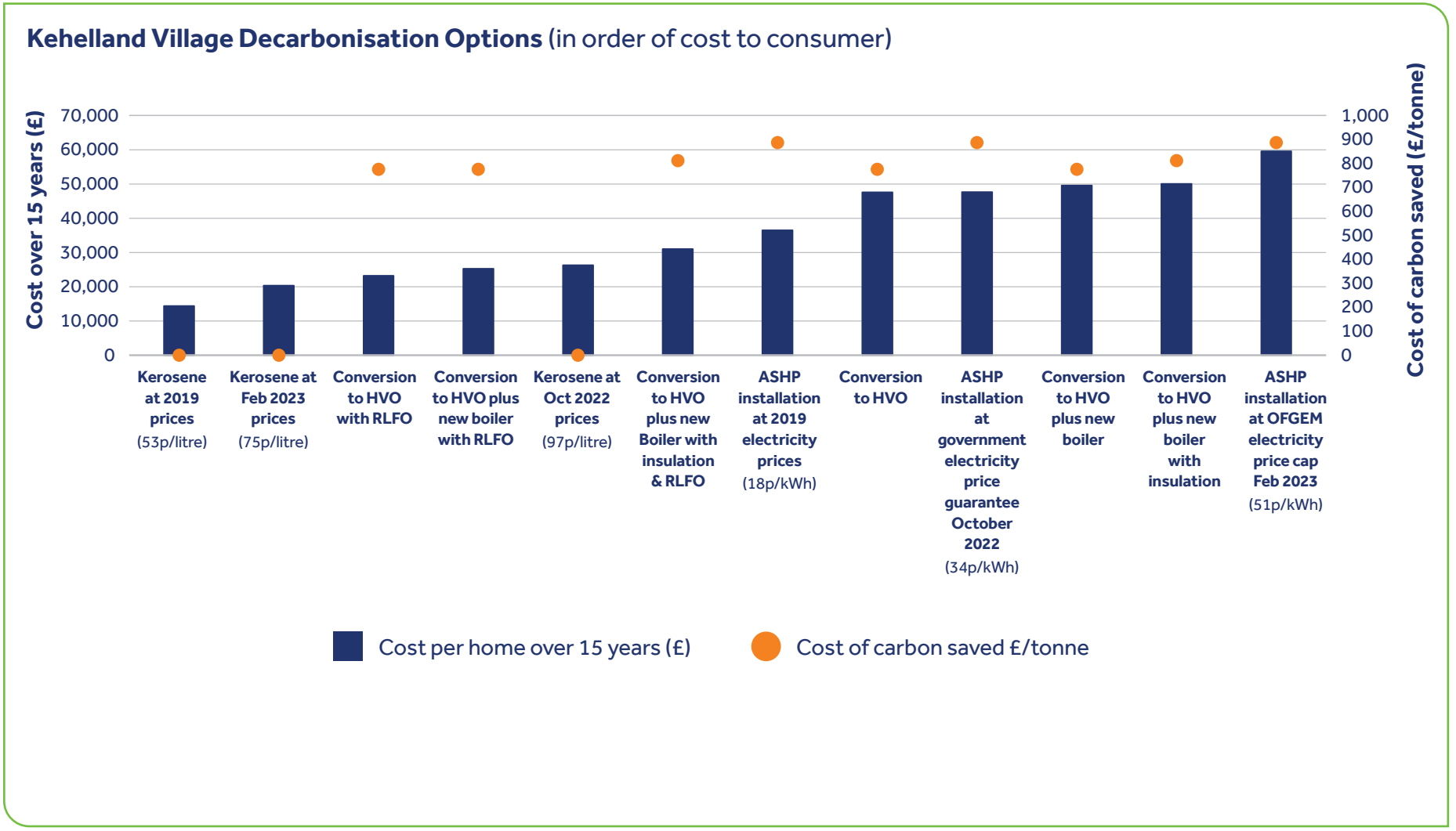
[xiv] https://www.gov.uk/government/statistical-data-sets/annual-domestic-energy-price-statistics
[xv] https://www.gov.uk/government/publications/energy-bills-support/energy-bills-support-factsheet-8-september-2022
[xvi] https://www.ofgem.gov.uk/publications/ofgem-announces-latest-quarterly-price-cap-update
[xvii] https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/kj5u/mm23

6. Results

The tables on this page and the next show the modelled combined total cost and emissions data for the 17 Kehelland homes in the three modelled scenarios.

	Kerosene			Conversion to HVO						Installation of an ASHP		
	2019 prices (53p litre)	**Oct 2022 prices** (97p litre)	**Feb 2023 prices** (75p litre)	**No policy input**	**With RLFO**	**New boiler no RLFO**	**New boiler with RLFO**	**New boiler with insulation no RLFO**	**New boiler with insulation & RLFO**	**2019 electricity price** (18p/kWh)	**October 2022 government electricity price guarantee** (34p/kWh)	**Feb 2023 OFGEM electricity price cap** (51p/kWh)
Upfront costs	-	-	-	8,500	8,500	42,500	42,500	225,775	225,775	406,975	406,975	406,975
Annual running costs (£)	16,261	29,761	23,011	53,385	25,772	53,385	25,772	41,640	20,102	14,247	26,912	40,368
Total cost over 15 years	**243,914**	**446,409**	**345,161**	**809,274**	**395,081**	**843,274**	**429,081**	**850,379**	**527,308**	**620,686**	**810,652**	**1,012,491**
Cost per home over 15 years	14,348	26,259	20,304	47,604	23,240	49,604	25,240	50,022	31,018	36,511	47,685	59,558
Carbon emissions over a 15 year period (tonnes)	941	941	941	165	165	165	165	128	128	54	54	54
Cost of carbon saved £/tonne				1,042	509	1,086	553	1,047	649	700	914	1,142

6. Results (Cont)



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