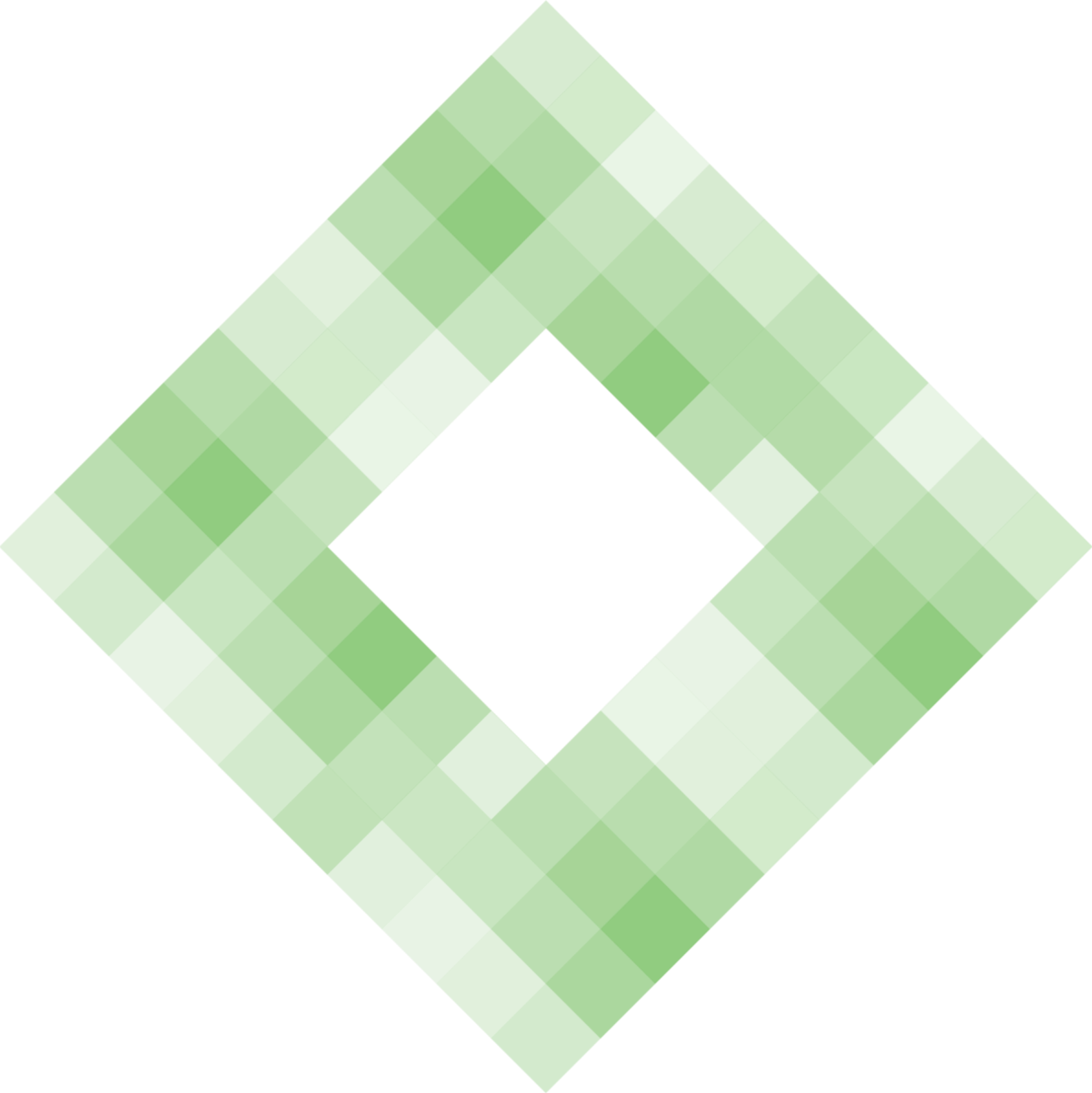
Belgian residential property low-carbon heating analysis

August 2021

Report prepared for Primagaz, Benelux



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Contents

DISCLAIMER

Study commissioned by Primagaz and supported with analysis from Gemserv – Low Carbon Business Unit.
The report aims to provide a cost comparison between various low-carbon heating systems, applicable for off-grid homes in Belgium. Data values are available in the annex with sources quoted in the reference section. Primagaz provided (bio)propane tank rental cost figures and assisted with developing 'consumer journey' assumptions.

Nothing in this document constitutes a valuation or legal advice. Any party that chooses to rely on this report (or any part of it) does so at its own risk. To the fullest extent permitted by law, Gemserv does not assume any responsibility and will not accept any liability, including any liability arising from fault or negligence, for any loss arising from the use of this document or its contents or otherwise in connection with it to any party. Details of principal sources are set out within the document, and we have satisfied ourselves, so far as possible, that the information presented in the report is consistent with other information which was made available to us by Gemserv clients in the course of our work.

Our work was completed in August 2021.

EXECUTIVE SUMMARY

This analysis compares the relative costs, the sustainability and the ‘consumer journey’ of various heating methods between three, off grid Belgium archetype properties.

The archetypes have been chosen to represent three different levels of heat demand, low, medium, and high consumption. The low and medium consumption archetypes are both modern properties and the higher demand archetype is an older, less thermally efficient property. The two more modern properties are assumed to begin with a new to medium aged condensing oil boiler whilst the older property is assumed to start with an old system boiler. The analysis outlined in this report, evaluates the attractiveness of transitioning to a new alternative heating system. The results also include a scenario where the properties begin with no current heating system.

The results of the analysis have shown that there is a general trade-off between the cost and the carbon intensity of heating systems. Biopropane consistently demonstrates to have the lowest levelized cost of all low-carbon heating systems with by far the lowest capital cost. This makes biopropane boilers the most financially feasible low-carbon option to consumers. Whilst lower-carbon systems exist, biopropane boilers provide an attractive compromise between cost and sustainability, with carbon emission factors far lower than both oil and conventional propane.

The ASHP Hybrids have been compromised in cost in part due to the high electricity prices in Belgium increasing the running cost of the systems.

TERMINOLOGY KEY

Heading Systems:

ASHP: Air Source Heat Pump – uses external ambient temperature with a refrigerant to heat the property. In this study the ASHP is used to power a central heating system (air/water as opposed to air/air). The ASHP is included in multiple hybrid systems, combined with either propane, biopropane or Solar PV.

Solar PV: Solar Photovoltaic Panels - convert solar radiation directly into electricity. Requires an upfront cost but beyond purchase they generate free electricity. Used in this study with an ASHP to reduce the electricity demand to the heat pump as well as generating savings through reduced grid demand to other electrical appliances.

Solar Thermal: Uses the sun's solar energy (even on overcast days) to directly heat water circulating in the panels and reduces hot water demand. Used in this study with a propane/biopropane condensing boiler, reducing the fuel consumptions and therefore fuel costs / emissions.

Oil Condensing Boiler: Being more efficient than system boilers, they are also more fuel economical and more sustainable. Their technology has improved over recent decades and have slowly displaced system boilers which are increasingly less common in newer buildings.

Oil System Boiler: A more traditional and less efficient design of oil boiler. Its operation is also more complex and instead of existing as a single system, it has multiple components including a water cylinder. This has implications in replacing them with new systems such as ASHP hybrid heating systems where some of the necessary components are already in place.

(Bio)propane Condensing Boiler AG/UG: Propane or biopropane condensing boilers with above ground (AG) or underground (UG) tank storage – similar to an oil boiler with ongoing fuel deliveries and permanent tank storage of the fuel being necessary. Propane provides a lower carbon and clean burning alternative to oil. Biopropane, being chemically identical to propane, is also clean burning, but due to its production process it has a lower carbon intensity. The (bio)propane tank storage can either be above ground (AG) or underground (UG) - above ground storage is cheaper but results in a potential eye-sore. Both AG and UG options are included in the analysis with an ongoing annual 'tank rental' cost.

Biomass Auto-feed Wood Pellet Boiler: Biomass boilers operate by burning a form of biomass, of which many options exist. This study considers a wood pellet fuel source which has distinct emission factors compared to other forms of biomass such as burning logs or wood chips, for example. This study also chooses an auto-feed system which automatically feeds the burner with the fuel source. This is more expensive than a manual feed system but far more convenient to the consumer.

Other Terminology:

CapEx: The CapEx, or the capital expenditure, includes all of the upfront costs to the consumer. This includes the cost of the new heating system as well as the cost of the installation. A tank removal + remediation cost of the (assumed) existing oil boiler system is also necessary. Additionally, for the ASHP hybrid systems replacing condensing oil boilers, an additional cost of a new water cylinder is necessary. This cost is not necessary for the replacing of an oil *system* boiler (archetype 3), where a water cylinder will already exist.

OpEx: The OpEx, or the operational expenditure, includes all of the ongoing costs to the consumer. This is dominated by the fuel cost of the heating system which depends on the property's energy demand, the efficiency of the system and the fuel source type. An additional ongoing cost includes the expected required maintenance of the system. For the (bio)propane boilers and hybrid systems, the cost of the storage tank is paid via a rental system, and so forms part of the OpEx cost. For the Solar PV hybrid system, the free, domestically generated electricity acts as a *negative* fuel cost as it reduces the fuel cost of grid electricity.

Levelized Cost: The levelized cost combines the CapEx and the OpEx along with the heating system lifetime and a 'discount rate', to produce a value that is representative of what the consumer pays over the system's total lifetime. This cost is therefore reflective of the overall financial attractiveness of the system to the consumer.

REPORT FORMAT

The report begins with a Background section which sets the study in context. Following this is a short introduction which explains the study approach and the scope of the analysis as well as introducing the archetypes which are considered.

The results of the analysis are then presented within two tables for each archetype. The first table contains all of the key cost information including the total upfront costs (CapEx), total ongoing annual costs (OpEx), and the levelized cost of the system. The second table contains the emissions resulting from the operation of the heating systems, including CO2eq emissions alongside emissions which cause air pollution. Each archetype section concludes with a summary of the key results from the two tables. The archetype information is then followed by a ‘consumer journey’ section which is universal to all three archetypes and compares the time involved with each of the heating system options.

Following the Analysis Results section is a Discussion of Results which collates the results from all three archetypes to provide a discussion on the key themes of the cost, the sustainability, and the consumer journey between the heating systems. The results are then displayed visually in an infographic which illustrates the pros and cons of each system via a traffic light colour coding system.

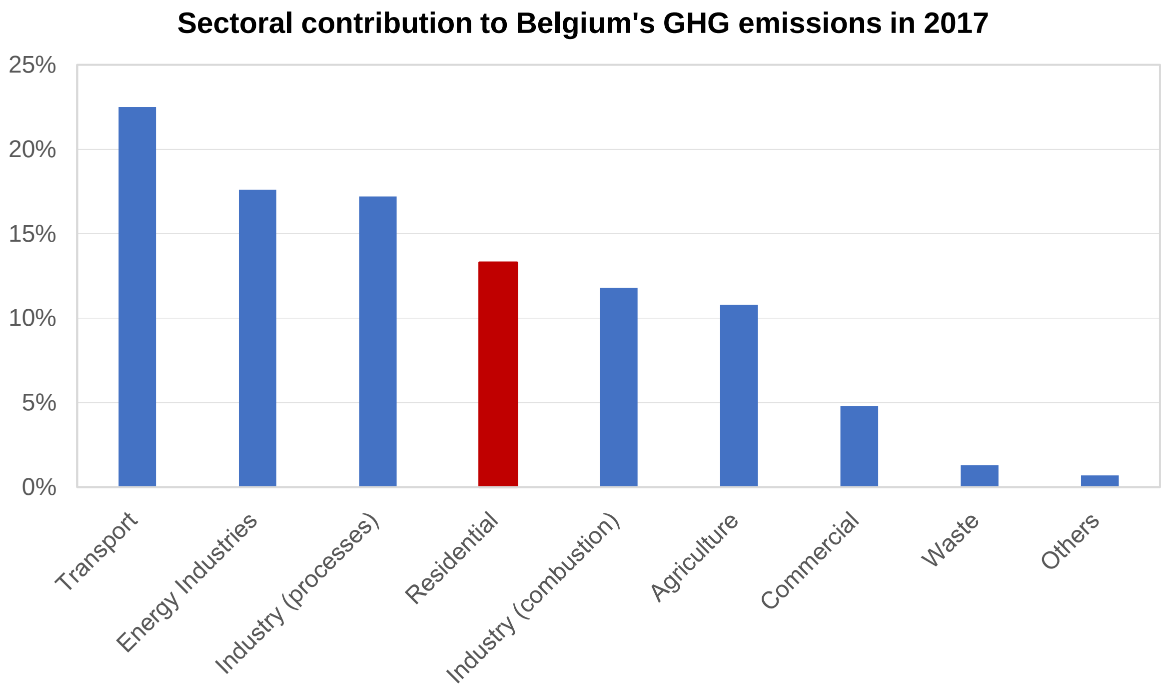
The Conclusion then summarises the results for each of the heating system options separately.

Following the References section, the Appendix contains more specific cost information that is not included in the results tables.

BACKGROUND

Belgium's climate change targets

As a country, Belgium has an emission reduction target of 35% by 2030 (compared with 2005 levels), before reaching net-zero in 2050[1]. The residential sector makes up 13.3% of existing emissions, as seen below:



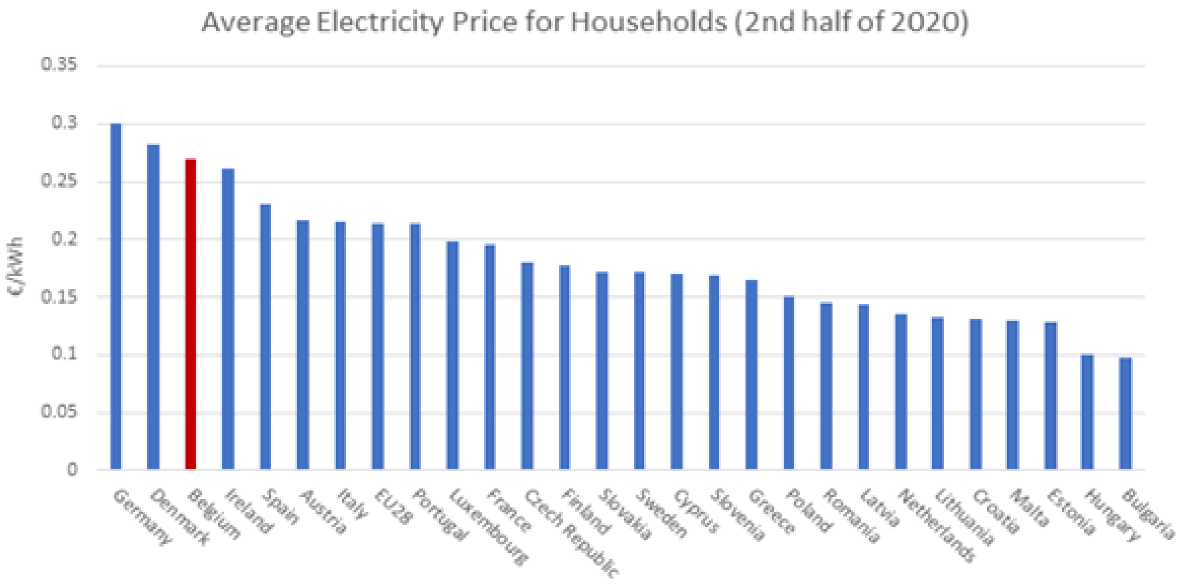
Source: Belgium's greenhouse gas inventory 1990-2018[2]

Since 1990 there has been a 21.9% reduction in overall GHG emissions, with the residential sector falling by 26.5%. This comes despite a significant rise in the number of households (20% since 1995). Furthermore, the housing stock has been described as having a high proportion of old buildings. Moving forwards, Belgium's political context has resulted in devolution of emission reduction targets to its three distinct regions (Flemish, Walloon, and Brussels). All three regions have proposed residential emission reduction targets of around 40% by 2030.

The importance of the heating oil transition

Heating oil makes up 48% of Belgium's residential heat emissions, despite only accounting for 38% of relevant fuel consumption. Of the approximately 1.8 million oil-heated households, the vast majority are in the regions of Flanders and Walloon. This can be chiefly explained by the concentration of detached and semi-detached, older properties in these regions. Heating oil itself is relatively cheap, at 5.8 € cents/kWh, compared to an EU average of 7.5 € cents/kWh.[3] Given the country's reliance on nuclear power (53% of electricity generation), and plans to close these facilities, presenting a climate-viable alternative is of utmost environmental importance.

The cheap cost of heating oil adds to a slew of potential transitionary problems - particularly considering Belgium’s relatively expensive cost of electricity. With one of the highest costs in the EU28, at around 27 € cents/kWh. Given that over half of their electricity supply is due to be removed due to denuclearisation, there is no clear pathway for the rapid and significant price reductions required to bring costs in line with heating oil.



Source: Eurostat – Electricity Price Statistics[4]

The full extent of the challenge emerges when considering the types of houses and consumers who will be expected to swap oil for electricity. Off-grid housing in Belgium disproportionately tends towards older, and larger buildings. It follows that these are likely to host lower income households (in general), posing relatively price-sensitive demand curves. There is a genuine risk that the resulting income effect could reduce the general consumption and quality of life for those worst-off. Even if there is a dramatic bridging of prices between heating oil and electricity – the fact remains that many of the older properties discussed may be unsuitable for a heat pump. Alternative methods of decarbonisation may be required in these cases – either by grid expansion, alternative renewables, or biopropane adoption.

STUDY APPROACH

This report displays information on the cost, sustainability and 'consumer journey' of transitioning to various new heating systems for three different archetypes.

The three archetypes included represent three different levels of heating demand – low, medium and high. The details of these properties are included below. Key information relating to the thermal properties of these archetypes have been taken from an archetype database (TABULA – co-funded by the Intelligent Energy Europe programme) and then entered into a model which calculates the key cost and sustainability outputs of various heating system options, for each archetype. These outputs also depend on key input data relating to the heating systems and the fuel costs, which have aimed to be Belgium specific and as up to date as possible. Alongside this report exists an Excel tool which allows the user to alter key input pricing data with the outputs updating automatically.

The key cost outputs include: total capital expenditure, total annual operational expenditure and levelized cost. (A more detailed break-down of this cost information is included in Table 1 and in the Appendix.)

The key sustainability outputs include: CO2eq emissions – 2020 and CO2eq emissions – 2030 (climate change relevant) as well as PM2.5, SOx and NOx (air pollution relevant).

Details on consumer journey are considered universal between all three archetypes and so these results are included afterwards.

Archetype 1 – Low-Consumption:

- Semi-detached single-family house
- Built since 2012
- Floor area: 199 m^2
- Usual refurbishments
- Current heating system: New Condensing Oil Boiler
- Energy demand: 44.7 kWh / m^2 * year
- Annual heating demand: **8,895 kWh / year**

1. Brand New Condensing Oil Boiler

   or

2. No current heating system

- Oil Condensing Boiler (from no heating system)
- Propane Condensing Boiler (AG/UG)
- Biopropane Condensing Boiler (AG/UG)
- Biomass Auto-feed Wood Pellet Boiler
- Hybrid – ASHP + Propane (AG/UG)
- Hybrid – ASHP + Biopropane (AG/UG)
- Hybrid – Solar Thermal + Propane (AG/UG)
- Hybrid – Solar Thermal + Biopropane (AG/UG)
- Hybrid – ASHP + Solar PV

Archetype 2 – Medium Consumption:

- Detached single family house
- Built between 2006-2011
- Floor area: 229 m^2
- Usual refurbishments
- Current heating system: 10-year-old Condensing Oil Boiler
- Energy demand: 78.4 kWh / m^2 * year
- Annual heating demand: **17,954 kWh / year**

1. Mid-life (10 year) Condensing Oil Boiler

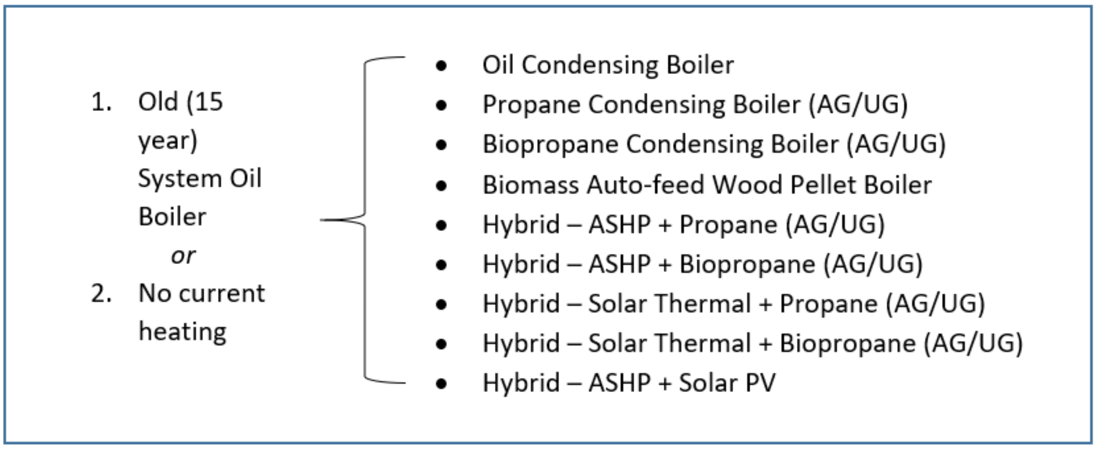
   or

2. No current heating system

- Oil Condensing Boiler
- Propane Condensing Boiler (AG/UG)
- Biopropane Condensing Boiler (AG/UG)
- Biomass Auto-feed Wood Pellet Boiler
- Hybrid – ASHP + Propane (AG/UG)
- Hybrid – ASHP + Biopropane (AG/UG)
- Hybrid – Solar Thermal + Propane (AG/UG)
- Hybrid – Solar Thermal + Biopropane (AG/UG)
- Hybrid – ASHP + Solar PV

Archetype 3 – High Consumption:

- Detached single Family House
- Built between 1946-1970
- Floor area: 200 m^2
- Usual refurbishments
- Current heating system: 15-year-old System Oil Boiler
- Energy needed for heating: 145 kWh / m^2 * year
- Annual heating demand: **29,040 kWh / year**



1. Old (15 year) System Oil Boiler

   or

2. No current heating

- Oil Condensing Boiler
- Propane Condensing Boiler (AG/UG)
- Biopropane Condensing Boiler (AG/UG)
- Biomass Auto-feed Wood Pellet Boiler
- Hybrid – ASHP + Propane (AG/UG)
- Hybrid – ASHP + Biopropane (AG/UG)
- Hybrid – Solar Thermal + Propane (AG/UG)
- Hybrid – Solar Thermal + Biopropane (AG/UG)
- Hybrid – ASHP + Solar PV

ANALYSIS RESULTS

The archetype result tables in this section contain information on the total capital expenditure, total operational expenditure and the levelized cost. These total costs are a sum of smaller contributing costs which are explained in table 1 below. More specific details of these costs are included in the appendix and in the additional Excel Input-Output Tool.

	CapEx Contributing Factors			
	Cost of System	**Cost of Installation**	**Tank Removal**	**Water Cylinder**
Applicable Heating Systems	All systems	All systems	All scenarios where the consumer starts with an oil boiler system.	All ASHP hybrid systems for archetypes beginning from no heating system or replacing a condensing oil boiler. Replacing a system oil boiler is exempt from this cost as they already contain a water cylinder.
Cost Details	The quoted price of the system by the manufacturer.	Sometimes contained within the total price of the system - otherwise exists as a separate fee.	**€1,410**	**€2,900**

Table 1a: contributing costs to the total capital expenditure.

	OpEx Contributing Factors			
	Fuel Cost	**Maintenance**	**Tank Rental**	**Microgeneration (Negative Costs)**
Applicable Heating Systems	All systems	All Systems	All systems which utilise propane or biopropane	ASHP + PV system
Cost Details	Fuel costs have been determined for each fuel source and expressed as a cost per kWh. The total fuel cost depends on the fuel source type, the efficiency of the system and the heating demand of the archetype.	The annual maintenance cost of each heating system is also included for each system.	Two tank rental fees have been included. One for above ground (AG) tank storage and one for underground (UG). **AG: €78 / year** **UG: €307 / year**	Specific to the ASHP + PV system, the PV panels act to reduce the grid electricity demand of the heat pump. However, additionally they also reduce electricity demand of other electrical appliances, therefore generating an additional cost saving. It is also assumed a proportion will generate a small income via a feed in premium. It is therefore necessary for these to be subtracted from the operational cost.

Table 1b: contributing costs to the total operational expenditure.

Archetype 1 - Low-Consumption:

Heating System	Replacing Oil Boiler (Tank Removal)			No Current Heating System		
	Total Upfront Cost (CapEx) (€)	Total Ongoing Annual Cost (OpEx) (€/yr)	Levelized Cost (€/MWh)	Total Upfront Cost (CapEx) (€)	Total Ongoing Annual Cost (OpEx) (€/yr)	Levelized Cost (€/MWh)
Oil (condensing - new) (no change)	0	1,049	83	NA	NA	NA
Oil (condensing – new) (new system)	NA	NA	NA	4,212	982	106
Propane Boiler (AG)	4,405	1,147	121	2,995	1,147	111
Propane Boiler (UG)	4,405	1,376	139	2,995	1,376	129
Hybrid - Solar thermal + Propane (AG)	12,057	1,012	163	10,647	1,012	153
Hybrid - Solar thermal + Propane (UG)	12,057	1,241	181	10,647	1,241	171
Hybrid - Solar thermal + Biopropane (AG)	12,057	1,133	172	10,647	1,133	162
Hybrid - Solar thermal + Biopropane (UG)	12,057	1,362	190	10,647	1,362	181
Hybrid - ASHP + Propane (AG)	9,675	1,284	168	8,265	1,284	158
Hybrid - ASHP + Propane (UG)	9,675	1,513	186	8,265	1,513	176
Hybrid - ASHP + Biopropane (AG)	9,675	1,314	170	8,265	1,314	160
Hybrid - ASHP + Biopropane (UG)	9,675	1,543	188	8,265	1,543	178
Hybrid – ASHP + Solar PV	11,680	**1,025**	151	10,270	**1,025**	142
Biopropane Boiler (AG)	**4,405**	1,293	**132**	**2,995**	1,293	**123**
Biopropane Boiler (UG)	**4,405**	1,522	150	**2,995**	1,522	141
Biomass	10,695	1,309	163	9,245	1,309	155

Table 2: A comparison of the capital cost, operational cost and resulting levelized cost between multiple heating systems, transitioning from either a new, A-label oil condensing boiler (left), or from no system (right) thus avoiding the 'tank removal fee'. The first row represents the scenario in which the consumer keeps their current system without changing. For the propane boiler, biopropane boiler and propane/biopropane hybrid systems, the costs have been divided into an above ground (AG) tank rental cost and an underground (UG) tank rental cost. The rows highlighted in orange are made distinct from the rows in green on account of their carbon intensities. In this study, all heating systems highlighted in green are considered 'low-carbon' heating systems. Figures highlighted in bold and underlined, represent the lowest cost value of all low-carbon heating systems.

Archetype 1 - Sustainability:

The following table displays two values of carbon dioxide equivalent emissions and three pollutants associated with air pollution ($PM_{2.5}$, SO_2, and NO_X), for each heating system.

Heating System	**Carbon Emissions - 2020** (kgCO2e/yr)	**Carbon Emissions - 2030** (kgCO2e/yr)	**PM 2.5 Emissions – 2020** (gPM2.5/yr)	**SO_x Emissions – 2020** (gSO2/yr)	**NOx Emissions - 2020** (gNOx/yr)
Oil (condensing - new) (No Change)	4,556	4,556	72	2,528	2,370
Propane Boiler	3,556	3,556	9	0	2,082
Hybrid (Solar thermal + Propane)	2,938	2,938	7	0	1,720
Hybrid (Solar thermal + Biopropane)	1,158	1,158	7	0	1,720
Hybrid (ASHP + Propane)	1,292	1,055	2	0	416
Hybrid (ASHP + Biopropane)	745	555	2	0	416
Hybrid (ASHP + Solar PV)	621	311	<u>**0**</u>	<u>**0**</u>	<u>**0**</u>
Biopropane Boiler	1,402	1,402	9	0	2,082
Biomass	<u>**308**</u>	<u>**308**</u>	3,908	716	5,210

Table 3: Displays the greenhouse gas emissions and air pollutants. Values were calculated by multiplying the emission factors by the annual fuel demands of each heating system. A 2030 value is included for CO2e emissions to demonstrate how the ASHP options running on electricity will reduce in carbon intensity as the Belgium electricity supply is decarbonised. The first three heating systems are highlighted in orange to separate them from the heating systems in green, which have significantly lower annual CO2e emissions. Figures highlighted in bold and underlined, represent the lowest emission values of all heating systems.[6]

Archetype 1 – Summary of results:

Cost:

Factors contributing to capital expenditure:

- Upfront cost of system (all heating systems).
- Installation cost (all heating systems).
- Oil tank removal cost (applicable to all transitioning away from oil).
- Water cylinder cost (applicable to all ASHP hybrids).

Factors contributing to operational expenditure:

- Fuel cost (all heating systems).
- Maintenance cost (all heating systems).
- Tank rental fee (propane / biopropane boilers and all propane/biopropane hybrid systems).
- Negative costs (the ASHP + PV system operational cost is reduced by the solar PV systems lowering electricity bills as well as earning from a feed in premium).

Summary of archetype 1 pricing information:

- The lowest levelized cost of the *low-carbon* heating systems for archetype 1 is a biopropane boiler with above ground tank storage.
- This is followed by the biopropane boiler with an underground tank which has higher operational costs to the above ground system due to a higher tank rental fee, but despite this it remains cost competitive against the other low-carbon heating systems.
- The ASHP+PV hybrid system has the third lowest levelized cost, on account of its very low operational cost. However, its high capital costs may make it an inaccessible option for consumers with limited disposable income.
- The biopropane boiler systems have by far the lowest capital cost of any low-carbon heating system whilst remaining cost competitive over the system's lifetime, making them a financially appealing option to consumers.
- For consumers starting with no heating system, looking to purchase a new system, the oil tank removal cost no longer contributes to the total capital cost, therefore also lowering the levelized costs. However, the price ranking follows a similar pattern to the 'starting from oil boiler' scenario.

Sustainability:

- The heating system with the lowest carbon emissions is a biomass boiler. This result depends upon the estimate of biomass fuel's carbon intensity– this estimate, however, is contested in the literature, and alternative carbon intensities of biomass can be higher. This study uses emission values from a CE Delft study.[6]
- Biomass also has very high NOx emissions and PM2.5 emissions, meaning its use contributes greatly to air pollution, therefore making it a potentially damaging option for consumers living in highly populated areas.
- At present, the heating system with the second lowest CO2e emissions is the ASHP + PV hybrid system. The emissions of this hybrid system will also reduce further over time due to an expected decarbonisation of Belgium's electricity supply, and by 2030 the CO2e emissions will be almost as low as that of the biomass boiler.
- The emission factors of $PM_{2.5}$, NO_X and SO_x associated with electricity (ASHP hybrid systems) have been taken as zero, as it results in no direct emission of these pollutants at point of use (see Discussion of Results below for further details).

Archetype 2 - Medium-Consumption – costs for a consumer replacing an old oil boiler:

Heating System	**Replacing Oil Boiler (Tank Removal)**			**No Current Heating System**		
	Total Upfront Cost (CapEx) (€)	**Total Ongoing Annual Cost (OpEx) (€/yr)**	**Levelized Cost (€/MWh)**	**Total Upfront Cost (CapEx) (€)**	**Total Ongoing Annual Cost (OpEx) (€/yr)**	**Levelized Cost (€/MWh)**
Oil (condensing – 10 years old) (no change)	0	2,040	92	NA	NA	NA
Oil (condensing – new) (new system)	5,622	1,622	96	4,212	1,622	91
Propane Boiler (AG)	4,405	1,889	102	2,995	1,889	96
Propane Boiler (UG)	4,405	2,118	112	2,995	2,118	107
Hybrid - Solar thermal + Propane (AG)	12,057	1,694	123	10,647	1,694	117
Hybrid - Solar thermal + Propane (UG)	12,057	1,923	133	10,647	1,923	128
Hybrid - Solar thermal + Biopropane (AG)	12,057	1,917	133	10,647	1,917	127
Hybrid - Solar thermal + Biopropane (UG)	12,057	2,146	143	10,647	2,146	138
Hybrid - ASHP + Propane (AG)	10,465	1,998	130	9,055	1,998	125
Hybrid - ASHP + Propane (UG)	10,465	2,227	141	9,055	2,227	135
Hybrid - ASHP + Biopropane (AG)	10,465	2,050	133	9,055	2,050	127
Hybrid - ASHP + Biopropane (UG)	10,465	2,279	143	9,055	2,279	138
Hybrid – ASHP + Solar PV	14,050	**1894**	131	12,640	**1,844**	126
Biopropane Boiler (AG)	**4,405**	2,146	**113**	**2,995**	2,146	**108**
Biopropane Boiler (UG)	**4,405**	2,375	124	**2,995**	2,375	118
Biomass	14,553	2,105	140	13,143	2,105	136

Table 4: A comparison of the capital cost, operational cost and resulting levelized cost between multiple heating systems, transitioning from either a ten-year-old, A label oil condensing boiler (left), or beginning with no heating system (right). The first row represents the scenario in which the consumer keeps their current system without changing. For the propane boiler, biopropane boiler and propane/biopropane hybrid systems, the costs have been divided into an above ground (AG) tank rental cost and an underground (UG) tank rental cost. Figures highlighted in bold and underlined, represent the lowest cost value of all low-carbon heating systems.

Archetype 2 - Sustainability:

The following table displays two values of carbon dioxide equivalent emissions and three pollutants associated with air pollution ($PM_{2.5}$, SO_2, and NO_X), for each heating system.

Heating System	**Carbon Emissions - 2020** (kgCO2e/yr)	**Carbon Emissions - 2030** (kgCO2e/yr)	**PM 2.5 Emissions – 2020** (gPM2.5/yr)	**SO_x Emissions – 2020** (gSO2/yr)	**NOx Emissions - 2020** (gNOx/yr)
Oil (condensing - medium) (No Change)	9,248	9,248	158	5,133	4,812
Oil (Condensing – new)	7,458	7,458	127	4,139	3,881
Propane Boiler	6,259	6,259	16	0	3,665
Hybrid (Solar thermal + propane)	5,422	5,422	14	0	3,175
Hybrid (Solar thermal + Biopropane)	2,138	2,138	14	0	3,175
Hybrid (ASHP + Propane)	2,274	1,857	3	0	733
Hybrid (ASHP + Biopropane)	1312	977	3	0	733
Hybrid (ASHP + Solar PV)	**<u>1,305</u>**	**<u>652</u>**	**<u>0</u>**	**<u>0</u>**	**<u>0</u>**
Biopropane Boiler	2,468	2,468	16	0	3,665
Biomass	1,522	1,522	6,880	1,256	9,171

Table 5: Displays the greenhouse gas emissions and air pollutants. Values were calculated by multiplying the emission factors by the annual fuel demands of each heating system. A 2030 value is included for CO2e emissions to demonstrate how the ASHP options running on electricity will reduce in carbon intensity as the Belgium electricity supply is decarbonised. The first three heating systems are highlighted in orange to separate them from the heating systems in green, which have significantly lower annual CO2e emissions. Figures highlighted in bold and underlined, represent the lowest emission values of all heating systems.[6]

Archetype 2 – Summary of results:

Cost:

Factors contributing to capital expenditure:

- Upfront cost of system (all heating systems).
- Installation cost (all heating systems).
- Oil tank removal cost (applicable to all transitioning away from oil).
- Water cylinder cost (applicable to all ASHP hybrids).

Factors contributing to operational expenditure:

- Fuel cost (all heating systems).
- Maintenance cost (all heating systems).
- Tank rental fee (propane, biopropane and all propane/biopropane hybrid systems).
- Negative costs (the ASHP + PV system operational cost is reduced by the solar PV systems lowering electricity bills, as well as earnings from feed in premium).

Summary of archetype 2 pricing information:

- For the higher heat demand archetype 2, fuel consumption and therefore operational expenditure increases, compared with archetype 1.
- Capital costs increase for some systems but remain the same for other systems due to their power ranges covering both archetypes' maximum heating demands.
- The levelized costs decrease due to the consumer paying less per unit of energy generated.
- Biopropane boilers with above ground storage and biopropane boilers with underground storage, again have the lowest and second lowest levelized costs, respectively. ASHP + PV systems, also still have the third lowest levelized cost, despite a large increase in their capital cost.
- The upfront costs of the biopropane boiler options are also less than half the cost of the next cheapest low-carbon heating system – making them overall the most affordable option.
- The assumed current oil boiler belonging to archetype 2 is a similar A-label condensing oil boiler to that in archetype 1, but at an older age (10 years) and therefore a lower efficiency. The 'no change' scenario, as a result, experiences a greater increase in operational expenditure and levelized cost.

Sustainability:

- For archetype 2, with a higher heating demand and greater fuel consumption, the emission factors for all the heating systems increase.
- The heating system with the lowest carbon emissions is now the ASHP + PV hybrid system, ahead of the biomass boiler which now has the third lowest carbon emissions. By 2030 the carbon emissions of all ASHP hybrids are even lower as the carbon intensity of electricity is expected to decrease.
- The ASHP + biopropane hybrid now has the second lowest carbon emissions, closely behind the ASHP + PV system.
- The air pollution emissions are also significantly lower for both ASHP + PV and ASHP + biopropane systems when compared with biomass boilers.
- With archetype 2 currently using an oil boiler assumed to be 10 years old, the reduced efficiency with age results in greater emissions, and therefore the 'no change' scenario represents an increasingly damaging position when compared with archetype 1 not replacing its systems.

Archetype 3 - High-Consumption:

Heating System	Replacing Oil Boiler (Tank Removal)			No Current Heating System		
	Total Upfront Cost (CapEx) (€)	Total Ongoing Annual Cost (OpEx) (€/yr)	Levelized Cost (€/MWh)	Total Upfront Cost (CapEx) (€)	Total Ongoing Annual Cost (OpEx) (€/yr)	Levelized Cost (€/MWh)
Oil (condensing - new) (no change)	0	2,613	105	NA	NA	NA
Oil (condensing – new) (new system)	7,801	1,852	101	6,391	1,852	96
Propane Boiler (AG)	5,486	2,096	103	4,076	2,096	98
Propane Boiler (UG)	5,486	2,325	112	4,076	2,325	107
Hybrid - Solar thermal + Propane (AG)	13,138	1,941	123	11,728	1,941	118
Hybrid - Solar thermal + Propane (UG)	13,138	2,170	132	11,728	2,170	128
Hybrid - Solar thermal + Biopropane (AG)	13,138	**2,201**	134	11,728	**2,201**	129
Hybrid - Solar thermal + Biopropane (UG)	13,138	2,430	143	11,728	2,430	138
Hybrid - ASHP + Propane (AG)	9,145	2,340	125	10,635	2,340	121
Hybrid - ASHP + Propane (UG)	9,145	2,569	135	10,635	2,569	130
Hybrid - ASHP + Biopropane (AG)	9,145	2,398	128	10,635	2,398	123
Hybrid - ASHP + Biopropane (UG)	9,145	2,627	137	10,635	2,627	132
Hybrid – ASHP + Solar PV	12,730	2,278	130	14,220	2,278	126
Biopropane Boiler (AG)	**5,486**	2,385	**115**	**4,076**	2,385	**110**
Biopropane Boiler (UG)	**5,486**	2,614	124	**4,076**	2,614	119
Biomass	14,553	2,328	134	13,143	2,328	130

Table 6: A comparison of the capital cost, operational cost and resulting levelized cost between multiple heating systems, transitioning from either a fifteen-year-old system oil boiler (left) or beginning from no heating system (right). The first row represents the scenario in which the consumer keeps their current system without changing. For the propane boiler, biopropane boiler and propane/biopropane hybrid systems, the costs have been divided into an above ground (AG) tank rental cost and an underground (UG) tank rental cost. Figures highlighted in bold and underlined, represent the lowest cost value of all low-carbon heating systems.

Archetype 3 - Sustainability:

The following table displays two values of carbon dioxide equivalent emissions and three pollutants associated with air pollution ($PM_{2.5}$, SO_2, and NO_X), for each heating system.

Heating System	**Carbon Emissions - 2020** (kgCO2e/yr)	**Carbon Emissions - 2030** (kgCO2e/yr)	**PM 2.5 Emissions – 2020** (gPM2.5/yr)	**SO_x Emissions – 2020** (gSO2/yr)	**NOx Emissions - 2020** (gNOx/yr)
Oil (system - old) (No Change)	11,962	11,962	204	6,639	6,224
Oil (Condensing – new)	8,360	8,360	143	4,640	4,350
Propane Boiler	7,017	7,017	18	0	4,108
Hybrid (Solar thermal + Propane)	6,322	6,322	16	0	3,701
Hybrid (Solar thermal + Biopropane)	2,492	2,492	16	0	3,701
Hybrid (ASHP + Propane)	2,660	2,147	4	0	822
Hybrid (ASHP + Biopropane)	1,810	1,297	4	0	822
Hybrid (ASHP + Solar PV)	**<u>1,643</u>**	**<u>821</u>**	**<u>0</u>**	**<u>0</u>**	**<u>0</u>**
Biopropane Boiler	2,766	2,766	18	0	4,108
Biomass	1,707	1,707	7,712	1,408	10,281

Table 7: Displays the greenhouse gas emissions and air pollutants. Values were calculated by multiplying the emission factors by the annual fuel demands of each heating system. A 2030 value is included for CO2e emissions to demonstrate how the ASHP options running on electricity will reduce in carbon intensity as the Belgium electricity supply is decarbonised. The first three heating systems are highlighted in orange to separate them from the heating systems in green, which have significantly lower annual CO2e emissions. Figures highlighted in bold and underlined, represent the lowest emission values of all heating systems.[6]

Archetype 3 – Summary of results:

Cost:

Factors contributing to capital expenditure:

- Upfront cost of system (all heating systems).
- Installation cost (all heating systems).
- Oil tank removal cost (applicable to all transitioning away from oil).
- Water cylinder cost (no longer applicable to ASHP hybrids replacing system oil boilers as this will already be in place).

Factors contributing to operational expenditure:

- Fuel cost (all heating systems).
- Maintenance cost (all heating systems).
- Tank rental fee (propane, biopropane and all propane/biopropane hybrid systems).
- Negative costs (the ASHP + PV system operational cost is reduced by the solar PV systems lowering electricity bill as well as earnings from feed in premium).

Summary of archetype 3 pricing information:

- For the highest heat demand archetype 3, fuel consumption and therefore operational expenditure have increased again. Additionally, the capital cost now increases for both the Oil and Propane boilers, due to the higher peak heat demand requiring a higher boiler power rating.
- ASHP hybrid systems replacing the old system oil boilers now avoid the cost of a new water cylinder which is already present and therefore see a countering reduction in upfront costs, despite the higher power rating of the heat pump.
- All of the levelized costs decrease again with consumers paying less per unit energy.
- Biopropane boilers with above ground storage maintain the lowest levelized cost, followed closely by biopropane boilers with underground storage. The ASHP + PV heating system no longer has the third lowest levelized cost, now behind both the ASHP + propane and ASHP + biopropane with above ground storage systems.
- Generally, all levelized costs converge when moving to higher heat demand archetypes; this is a feature of the operational costs increasing more rapidly than the capital costs.
- Biopropane boiler systems consistently having the lowest capital cost of any heating system, makes them the most affordable heating system, particularly to the consumers who cannot afford the high upfront costs of the biomass boilers / hybrid systems.
- The assumed current oil boiler belonging to archetype 3 is now a 15-year-old system oil boiler with a much lower efficiency and therefore greater operational expenditure. When defined by levelized cost, it has now become cheaper to replace this old boiler with a newer condensing oil boiler (soon to be restricted by policy) or a new condensing propane boiler.

Sustainability:

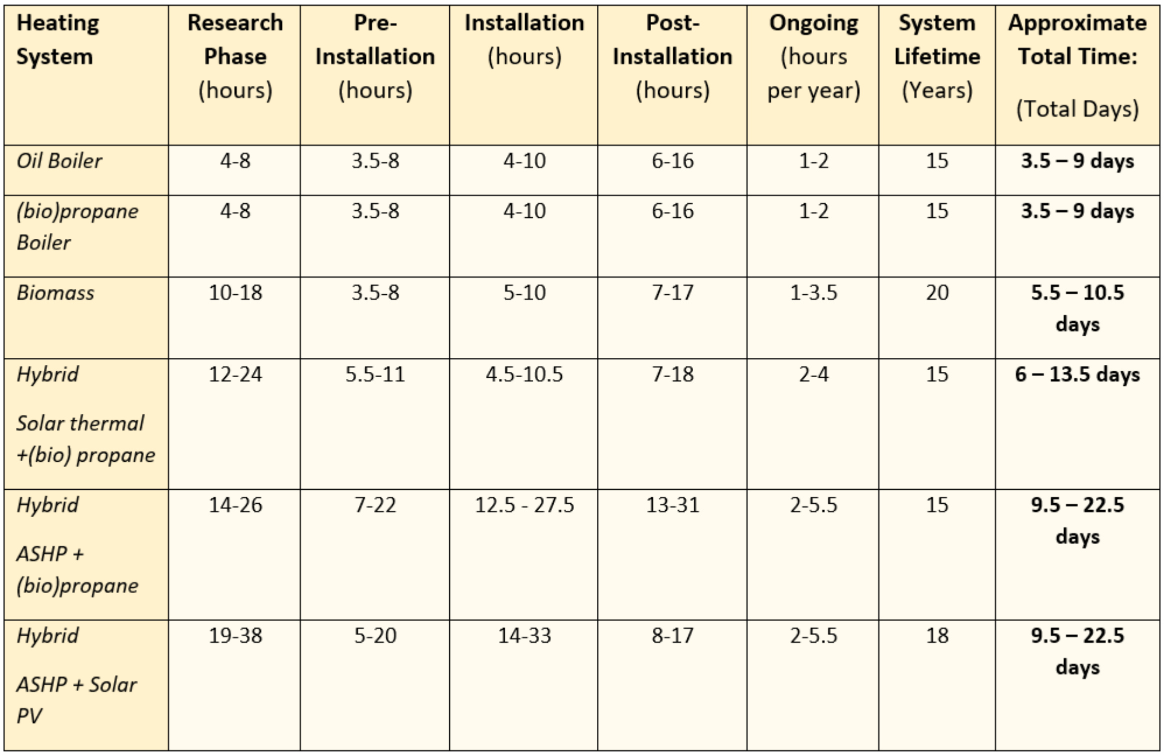
- With archetype 3 having the highest heating demand and fuel consumption, the emission factors for all of the heating systems have increased again.
- The heating system with the lowest carbon emissions again belongs to the ASHP + PV hybrid.
- The heating system with the second lowest CO2e emissions is the biomass boiler, however by 2030 this fall to third lowest, behind the ASHP + biopropane hybrid system.
- The 15-year-old system oil boiler with low efficiency now results in very high emissions, and the ‘no change’ scenario represents the most damaging consumer option when compared with archetypes 1 and 2 not replacing their systems.

CONSUMER JOURNEY

Consumer journey measures the amount of time required throughout all stages of the installation process of a new system, indicating the associated time to install each option. Low-heat demand archetype 1 will be closer to the lower time range whilst high heat demand archetype 3, will be closer to the upper limit, and archetype 2 will be somewhere in between.

The below table has been developed based on research carried out in the UK and gives a guide to the time taken to install a new heating system. Whilst this will vary by property and could differ slightly in Belgium, the data provides a useful overview of the process for installing and operating the heating systems featured in this report. This is broken down into five steps:

1. **Research Phase:** Includes time spent identifying options, evaluating the pros and cons of each and checking for grant availability.
2. **Pre-installation:** Includes the time of the survey, appointment of contractor, preparation of internal/external space, e.g., scaffolding.
3. **Installation:** Time taken for installation of heating system along with any other necessary additional components, as well as any internal/external connections.
4. **Post- installation:** Removal of old system and any other waste materials, any potential alterations to the system after its installation, and learning to use the new system controls.
5. **Ongoing:** Annual maintenance and any necessary ongoing sourcing of fuel.



Heading System	Research Phase (hours)	Pre-Installation (hours)	Installation (hours)	Post-Installation (hours)	Ongoing (hours per year)	System Lifetime (Years)	Approximate Total Time: (Total Days)
Oil Boiler	4-8	3.5-8	4-10	6-16	1-2	15	**3.5 – 9 days**
(bio)propane Boiler	4-8	3.5-8	4-10	6-16	1-2	15	**3.5 – 9 days**
Biomass	10-18	3.5-8	5-10	7-17	1-3.5	20	**5.5 – 10.5 days**
Hybrid *Solar thermal +(bio) propane*	12-24	5.5-11	4.5-10.5	7-18	2-4	15	**6 – 13.5 days**
Hybrid *ASHP + (bio)propane*	14-26	7-22	12.5 - 27.5	13-31	2-5.5	15	**9.5 – 22.5 days**
Hybrid *ASHP + Solar PV*	19-38	5-20	14-33	8-17	2-5.5	18	**9.5 – 22.5 days**

Table 8: A breakdown of the five key time components of the total heat system transition process. Assumption from data source that one day is equivalent to five hours.

Comments - Oil Boilers:

- Requires time to research, contact and manage a contractor.
- Removal of an old system is assumed as part of the post-installation phase.
- Ongoing time input involves managing fuel refills and annual maintenance, but this requires little supervision.
- The overall consumer journey is relatively hassle free.

Comments – Propane / Biopropane Boiler:

- Overall consumer journey is similar to that of an oil boiler consumer journey.
- Also assumed propane and biopropane are equivalent processes with identical technologies and expertise requirements.
- The overall consumer journey is relatively hassle free.

Comments - Biomass Boiler:

- Less conventional heating system choice to oil boiler demands a longer research phase - deciding upon wood pellet fuel source and an auto-feed system over other fuels sources and systems.
- The overall consumer journey is slightly longer than oil and (bio)propane boiler systems but requires less involvement compared with the Hybrid options.

Comments - Solar Thermal + (bio)propane Hybrid System:

- The consumer journeys of the hybrid systems were determined by adding together the time demands of the two components of the system with there being limited overlap in the installation of the technologies.
- The solar thermal adds time to the research and installation phases but requires little additional involvement in the other operational phases.

Comments - ASHP + (bio)propane Hybrid System:

- ASHPs significantly increase the time taken for the installation and post installation phases.
- Additional ongoing time requirement is mainly a result of annual maintenance of the pump.
- Landscaping exterior to the property may also be a requirement for heat pump options, however ASHP require less involvement than other heat pump options.

Comments - ASHP + Solar PV Hybrid System:

- The addition of a Solar PV array follows a similar consumer journey to that of a Solar Thermal system, requiring roof area surveys, potential planning permission constraints, scaffolding for roof access as well as greater research, likely involving involvement of electricity supplier with a new electricity contract.
- Ensuring that automated intelligence exists, synchronising the ASHP with the Solar PV, is assumed to fall within the installation phase and will not add significant ‘learning time’ from the consumer.

DISCUSSION OF RESULTS

1. Cost:

Cost is the primary consumer consideration when deciding on switching heating system. The information in the cost tables above includes capital cost, operational cost and the levelized cost of multiple heating system transition scenarios. Of these three costs, the levelized cost, calculated using both the upfront (capital) and ongoing (operational) costs, provides the best indicator of the total amount of money the consumer will pay over the system's lifetime and as such is of prime consumer consideration. However, the capital cost is also an important metric as some of the more expensive heating systems are limited to high income consumers.

The general trend of capital cost across all three archetypes is that the low-carbon heating systems are more expensive. Whilst low-carbon heating systems such as the ASHP+PV hybrid present competitive levelized costs for all three archetypes, the high upfront cost may make them prohibitive without a generous grant scheme in place.

Biopropane boiler's levelized cost is highly dependent on whether it has an above or underground tank, with much higher annual tank rental costs for underground tanks. However, both options still present the two lowest levelized costs of all low-carbon systems, across the three archetypes. Additionally, biopropane boilers present a far lower upfront cost compared with any other heating system, making them a much more accessible option to a wider range of consumers.

2. Sustainability

The sustainability of a heating system, whilst also being of consumer consideration, is usually of secondary concern after the consideration of cost. However, policy can limit the sale of environmentally unfriendly heating systems and incentivize more sustainable options through grant schemes and tax exemptions, therefore making this also a critical feature of the system's overall attractiveness. In the context of this report, oil boilers are being phased out by all three regions in Belgium; they have been included in the analysis mainly for the sake of comparison. With the ban only affecting the sale of new systems, a 'no replacement' scenario was also included – in which, the consumer keeps their current oil boiler for a further fifteen years. This is the least environmentally friendly scenario with oil boilers dropping in efficiency over time resulting in greater fuel consumption and greater emissions.

The emissions of each system were found by multiplying emission factors of four different pollutants by the annual fuel consumption for each heating system pertaining to each of the three archetypes. The CO_2e emissions is the most important pollutant in the context of decarbonisation policy as it represents all greenhouse gas emissions associated with the heating system. The other three pollutants, $PM_{2.5}$, NO_X and SO_x, relate to air pollution and are primarily of concern to the health of the population. These are therefore also important for policy restrictions, particularly in built up areas with high population exposure.

Biomass boilers provided the lowest level of CO_2e emissions for archetypes 1 and 2, whilst ASHP + PV hybrid systems had the lowest emissions for archetype 3. However, whilst biomass boilers may provide a low-carbon heating option, their $PM_{2.5}$ and NO_X are extremely high, resulting in high levels of air pollution. Air pollution related policies and the possible formation of low-emission zones could therefore limit the sale of biomass boilers in the future. Furthermore, as Belgium's electricity supply begins to decarbonise, the CO2e emission factors belonging to the ASHP hybrid systems begin to fall below the biomass boiler emissions and therefore become increasingly attractive from a sustainability perspective.

In this analysis, the air pollution emission factors ($PM_{2.5}$, NO_X and SO_x) associated with electricity (ASHP hybrid systems) have been taken as zero, as it results in no direct emission of these pollutants at the point of use. There will be some emissions of these pollutants at point of generation, but this will be away from densely populated regions and therefore is less of a health hazard.

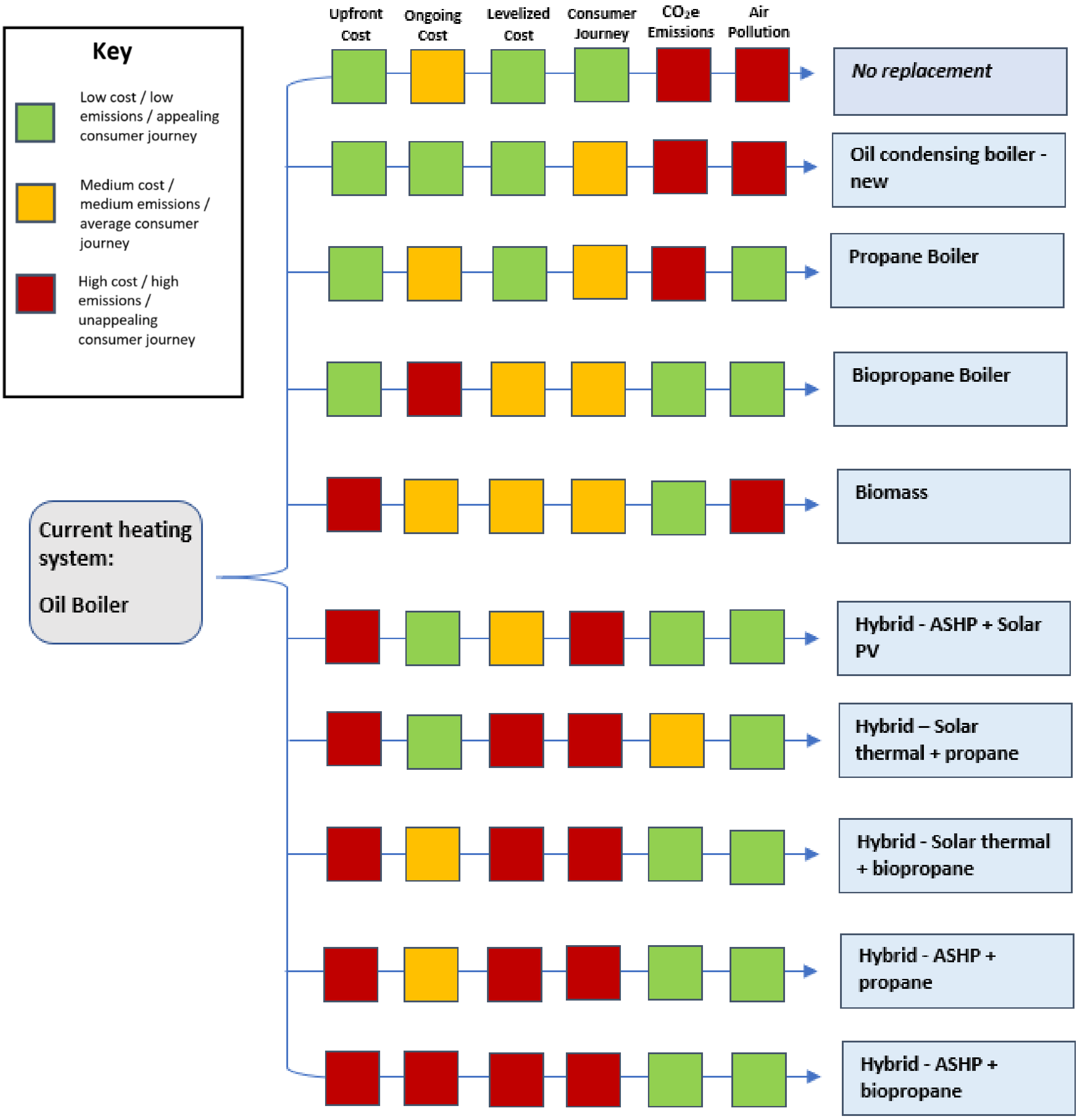
3. Consumer Journey:

The consumer journey defines the amount of time and hassle associated with the overall heating system transition process. This aspect is often not defined when considering the overall consumer decision but remains an important component. Naturally, this consideration will be of greater importance to certain consumers more than others.

The table in the results section above, displays the time taken throughout the five main stages of the heat system transition process, the total of which displays an estimated range of time taken for each heating system. These estimates were not made specific to each archetype as this would have required an arbitrary assumption, however it can be assumed that lower consumption archetypes, requiring smaller systems, will be towards the lower end of the range, and vice versa for the high heating demand archetypes.

Consumer Heating System Scenarios – Summary of Results:

The infographic below shows the consumer pathway scenarios in transitioning away from an oil boiler. The key areas of consideration include cost, time, and sustainability, characterised here by five measurements. These five measurements have been colour coded using a traffic light system, with green indicating an appealing feature, amber indicating neutral and red indicating an unappealing feature. These specific measurements vary between archetypes, but the general themes can be characterized simplistically with a colour coding system. The graphic demonstrates how there tends to be a trade-off between cost and sustainability.



Key

🟩 Low cost / low emissions / appealing consumer journey

🟨 Medium cost / medium emissions / average consumer journey

🟥 High cost / high emissions / unappealing consumer journey

Current heating system:

Oil Boiler

Upfront Cost	Ongoing Cost	Levelized Cost	Consumer Journey	CO_2e Emissions	Air Pollution	
🟩	🟨	🟩	🟩	🟥	🟥	*No replacement*
🟩	🟩	🟩	🟨	🟥	🟥	Oil condensing boiler - new
🟩	🟨	🟩	🟨	🟥	🟩	Propane Boiler
🟩	🟥	🟨	🟨	🟩	🟩	Biopropane Boiler
🟥	🟨	🟨	🟨	🟩	🟥	Biomass
🟥	🟩	🟨	🟥	🟩	🟩	Hybrid - ASHP + Solar PV
🟥	🟩	🟥	🟥	🟨	🟩	Hybrid – Solar thermal + propane
🟥	🟨	🟥	🟥	🟩	🟩	Hybrid - Solar thermal + biopropane
🟥	🟨	🟥	🟥	🟩	🟩	Hybrid - ASHP + propane
🟥	🟥	🟥	🟥	🟩	🟩	Hybrid - ASHP + biopropane

Figure 1: Infographic displaying consumer pathways towards alternative heating systems, away from an oil boiler.

CONCLUSION

Oil Boilers:

It is assumed that all three archetypes begin with oil boilers of various ages. The consumers have the option of keeping their current system or transitioning to a new system. As the oil boilers age, they reduce in efficiency, the operational costs increase, and the decision to transition becomes a more financially appealing option. With archetype 1 assumed to have a new oil boiler, it is unlikely that they will be financially motivated to transition to a new system over at least the next decade. Archetypes 2 and 3, with older systems, are more likely to transition in the imminent future.

Belgium policy (region dependent) is intending to ban the sale of new oil boilers, however this option is kept in the analysis to allow the costs of the low-carbon systems to be compared against them

Propane / Biopropane Boiler:

The (bio)propane boiler options have been divided into systems with above ground storage and systems with underground storage. This significantly influences the tank rental fee and therefore the operational and levelized costs of the systems.

The fuel cost of biopropane is also assumed to be 15% higher than that of conventional propane, further increasing the operational and levelized cost of these boiler systems. However, the carbon intensity of biopropane is significantly lower making it a far more sustainable heating option.

Biopropane boilers with above ground storage consistently demonstrate, for all archetypes, to have the lowest levelized cost of all low-carbon systems. Meanwhile, biopropane boilers with *underground* storage, consistently have the second lowest levelized costs. The low capital cost of the biopropane boilers also provides a significant financial advantage to consumers, particularly those with limited income.

Overall, when considering the cost, alongside the sustainability and consumer journey, biopropane boilers, with either above or underground tank storage, present one of the most appealing options to consumers.

Biomass Boiler:

Biomass boilers have recurringly reasonably low levelized costs however, without a generous grant scheme, its very high capital costs result in it being prohibitive to households with less disposable income.

Biomass boilers also have some of the lowest CO2e emissions of any heating system. However, its air pollution related emissions are extremely high, particularly PM2.5 and NOx.

Solar Thermal + (bio)propane Hybrid System:

Solar thermal + propane hybrid systems provide a cost competitive option. However, with propane providing the majority of the heat demand, it has high emissions and low sustainability. Therefore, in this analysis the system has *not* been classified as low carbon. This could change if a larger solar thermal system was assumed – however, this would further increase the capital and levelized costs.

The solar thermal + biopropane system does classify as low-carbon, however due to the higher fuel cost of biopropane, this system is one of the least financially attractive when defined by levelized cost, for any of the archetypes.

ASHP + (bio)propane Hybrid System:

The ASHP+(bio)propane hybrid systems are assumed to be providing heat from the ASHP 80% of the time and therefore electricity is the dominant fuel source. Due to the very high efficiency ratings of ASHPs, they have low fuel consumption and therefore relatively low emissions.

With lower capital costs and similar operational costs to solar thermal + biopropane hybrid systems, they are slightly more affordable with lower levelized costs. For Archetype 3, they have the third lowest levelized cost, behind only the biopropane boilers, making them a relatively affordable and low-carbon option for consumers living in high heat demand properties.

ASHP + Solar PV Hybrid System:

For the ASHP + Solar PV system, the additional upfront cost of the solar PV array results in the system having the lowest operational costs. This is a product of reducing ASHP grid electricity usage and reducing additional household grid electricity demand as well as a feed-in-premium income. The low operational costs result in the heating system having the third lowest levelized cost behind the biopropane boilers (above ground / underground) for archetype 1 and 2. However, the heating system becomes less financially attractive to the higher heat demand archetype 3. Overall, this heating system may be financially attractive to consumers living in low heat demand properties who can afford the high upfront costs of the system.

Due to the low fuel usage, this system is one of the most sustainable and it will become increasingly sustainable as Belgium's electricity supply begins to decarbonise.

All hybrid systems have significantly more time-demanding consumer journeys compared to the biomass and biopropane boiler systems, which could make them off-putting to some consumers.

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[16]: Cost of biomass* SR19_Pellet_final-web-1.pdf (bioenergyeurope.org)

** All cost information that is not sourced from the year 2020 has been inflation adjusted accordingly.*
*** See Appendix for energy density conversion factors used.*

APPENDIX

Capital Costs:

Heating System:	**Cost:**
A1 + A2: Oil Condensing Boiler - A-label – small:	€4,212[8] (includes installation)
A3: Oil Condensing Boiler - A-label – large:	€6,391[8] (includes installation)
Non-condensing Oil Boiler 18-30kW	€7,396[8] (includes installation)
Oil Tank Removal	€1,410[8]
A1 + A2: (Bio)propane Condensing Boiler A-label – small:	€2,995[8] (includes installation)
A3: (Bio)propane Condensing Boiler A-label – large:	€4,076[8] (includes installation)
LPG Tank Rental Underground	*€307 / year[9]*
LPG Tank Rental Above Ground	*€78 / year[9]*
A1: Biomass Boiler 10kW and below	€8,039[10]
A2: Biomass Boiler 16-20kW	€11,429[10]
A3: Biomass Boiler 16-20kW	€11,429[10]
Air Source Heat Pump	€790 / kW[11] (includes installation)
Solar Thermal System - six meters-squared	€1,159 / meters-square [12]
Solar PV System 3 kW	€3,300[13]

Fuel Price:

Heating Fuel:	**Fuel Price:**
Electricity	0.2746 €/kWh [14]
Electricity – off-peak tariff	0.2242 €/kWh [14]
Conventional Propane	0.0709 €/kWh [15]
Biopropane	0.0815 €/kWh [15]
Oil	0.0448 €/kWh [15]
Biomass (wood pellets)	0.0579 €/kWh [16]

Propane / Heating Oil Energy Conversion Factors:

Conversion Factors for Oil and Propane	
Heating Oil	10.35 kWh / litre
Propane	7.1 kWh / litre

Carbon Intensity Factors:

Heating Fuel:	**Carbon Intensity**
Electricity	0.2070 kgCO2e/kWh [6]
LPG	0.2145 kgCO2e/kWh [6]
Biopropane	0.0487 kgCO2e/kWh [6]
Heating Oil	0.3060 kgCO2e/kWh [6]
Biomass	0.0170 kgCO2e/kWh [6]

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