DOMESTIC BURNING, HOUSEHOLD BILLS AND THE ENVIRONMENT

OCTOBER 2022 V_FINAL

WRITTEN BY GEMSERV

P U B L I C

Gemserv

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DISCLAIMER

This analysis has been undertaken by Gemserv Ltd. It was commissioned by CPL Industries (CPL). Analysis presented in this document has been undertaken by Gemserv using a range of published and industry sources.

This methodology explains the in-depth economic analysis regarding carbon and emission outputs. Data values are available in the appendix with sources quoted in the reference section.

In addition to commissioning, CPL assisted with the development of some of the economic modelling assumptions. This has been highlighted in the appendix - including providing emission factor data belonging to CPL's Homefire Ecoal (Ecoal50) product and assistance with some fuel cost assumptions.

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.

EXECUTIVE SUMMARY

2022 has been a turning point in energy costs for millions of homes and businesses. Despite the Energy Price Support announced by Prime Minister Truss in September 2022, the impact of increased energy prices combined with the wider cost of living will be felt by millions of households. Unfortunately, those most in need are likely already rationing energy consumption and according to experts, the most meaningful support that can be offered is direct financial intervention to help pay bills this winter[1].

Households further away from the fuel poverty line who are seeking to save money may consider options to improve energy efficiency or reduce how much energy they use. Provided that health and wellbeing is not compromised, such changes could bring positive long-term benefits for individuals, the economy and the environment by reducing unnecessary consumption.

Gemserv has been working with industry over several months to consider the connection between use of wood and multi-fuel burning stoves for individual room heating within homes and a low carbon heating future. We have looked at the impact on bills, greenhouse gasses, the energy system and air pollution when combining a stove with an air source heat pump. As part of this work, we decided to consider the potential for households to adopt a zonal heating strategy this winter.

Zonal heating is a term which captures a wide range of actions from turning off heating within an unused room permanently, to warming rooms to different temperatures reflecting occupancy and use type throughout the day or week. It can be achieved via manual adjustment to heating appliances, adjusting thermostatic radiator valves and through the use of smart thermostats

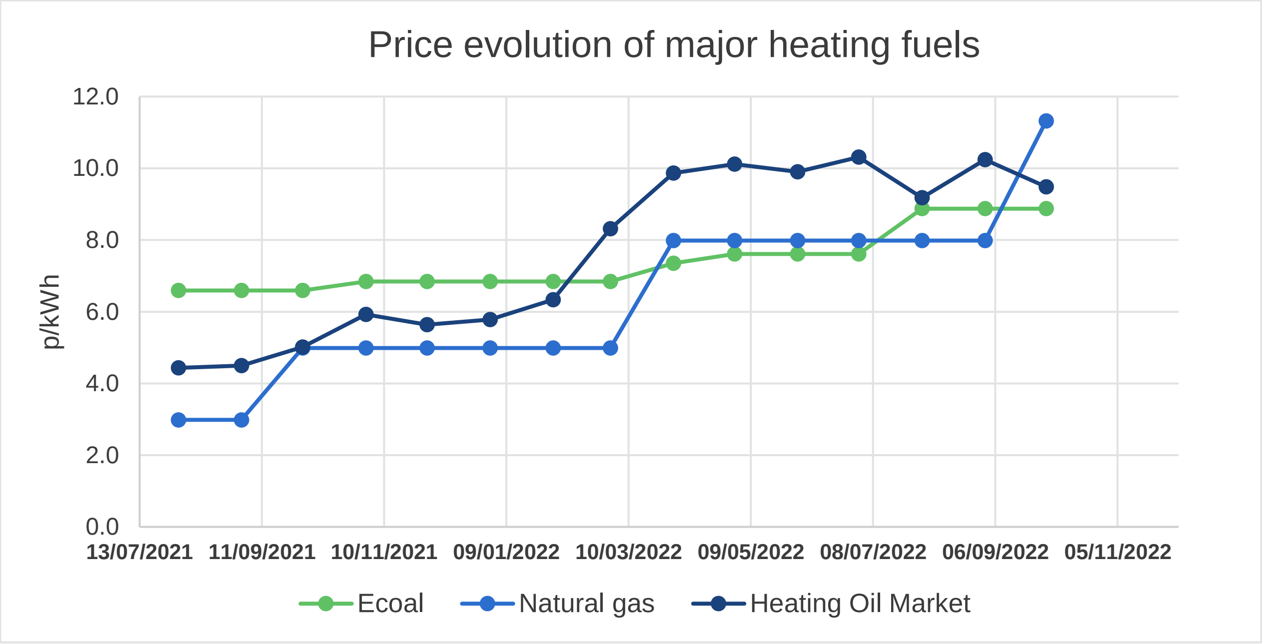
This paper sets out findings on the impact of moving to zonal heating using a wood or multi-fuel burning stove in a living room (whilst turning down the gas central heating to 18C) for a 3-hour period during winter evenings, on average five times per week. Modelled results suggest that:

1. **Households with gas central heating who adopt zonal heating using wood fuel could save on average, £132 / year, the equivalent of a 6.8% saving on heating bills (based on October 2022 Price Cap).**
2. **Using a smokeless solid fuel as secondary heating could increase savings to £213, the equivalent of an 11.0% saving. Savings increase even further for homes centrally heated using higher cost heating fuels such as heating oil or direct electric.**

[1] According to Adam Scorer, Chief Executive, National Energy Action (interviewed on C4 News, 31/03/22)

3. **Using renewable, sustainably sourced wood fuel instead of fossil fuel gas results in typical carbon savings of over half a tonne of CO_2e / year.**

As the graph below shows, prices have shifted dramatically over the past 12 months, increasing the affordability challenge for many whilst also making it hard for consumers to determine the relative economic merits of heating fuels. This analysis suggests that consumers who have a log or multi-fuel stove could be acting in an economically rationally and climate friendly way by switching to zonal heating this winter.



There is however a trade off to the benefits of solid fuel heating in the form of air pollution. The impact of this will vary by location and burning the wrong type of fuel can create substantial harm. However, modelled damage costs could be lower where households can burn clean fuels within the latest generation of eco-labelled stoves.

Through our work we have reviewed the available evidence and we calculate in respect of air pollution damage cost (the cost to society of air pollution) – there is over a 7-fold difference in damage cost between eco-labelled stove at £77 per annum and a conventional stove at £569. Meanwhile driving a diesel car has annual damage cost of £178 / year.

Finally for comparison, one hour of burning wood in an eco-labelled stove is the equivalent of driving 12.7 miles in a Euro 5 diesel car, whilst burning smokeless fuel is the equivalent of 11.7 miles. With the prospect that consumers may turn in increasing numbers to use of solid fuel this winter, re-enforcing recent policy changes to encourage clean burning should be a consideration for policymakers.

ZONAL HEATING METHODOLOGY

This analysis considers how the presence of a secondary heating source such as a stove, may allow for a reduced heat demand of a primary gas boiler system. It attempts to quantify the resulting financial and sustainability benefits and investigates the air pollution impacts of burning wood and smokeless fuel in a stove. A model was created to perform this analysis which averages across 28 property archetypes including a combination of detached single-family homes and terrace houses, covering a wide range of annual heat demands and heat transfer coefficients (displayed below).

A key consideration with domestic burning is that it can increase levels of air pollution. This analysis quantifies these air emissions with an associated (DEFRA derived) damage cost.

Figure 1: The 14 properties implemented in the model. Each property was modelled under two different renovation states, resulting in a total of 28 archetypes.

The core assumption behind the analysis is that when a household operates a stove (in the main living area), the occupier will primarily be in this room while the stove is in use. The occupier can therefore turn down their central heating thermostat and allow the mean internal temperature (MIT) in the rest of the home to drop below the conventionally acceptable comfortable daytime temperature of 21ºC, to as low as, but no lower than, 18ºC (see figure 2 below). Assuming this habitual pattern, a household would have a significantly reduced total heat demand over the course of a year, resulting in a net saving in heating costs as well as CO_2 emissions.

The diagram below attempts to depict the scenario described above, with a reduced MIT required whilst the stove is in operation.

Figure 2: Property heat demand under two heating regimes. One with normal central heating usage and the second with reduced usage due to habitual change with the operation of a secondary heating.

With this assumed heating habit, the total reduction in annual heat demand is proportional to the use of secondary heating. An assumption of average usage was derived from the responses of a survey of secondary heating customers who were asked in one question how regularly they use their stove, and the weighted average was calculated to be five days per week. Assuming it is used on average for 3 hours per use, and that it is used exclusively during heating season (1st of November to 31st of March) the total number of hours of use per year is assumed to be 324 hours.

COST OF LIVING RESULTS

The reduced heating demand and lower gas consumption (as explained above) results in a cost saving to the heating bill. This saving has increased as the cost of increased, first in April 2022 when the energy price cap rose by 54% and additionally in October when the price cap increased again by 47%. These results use the cost of gas (October 1st onwards) via Ofgem to be 10.3p/kWh as well as including the standing charge of 28p per day.

The price per kWh of Homefire Ecoal 50 (Ecoal smokeless fuel made with up to 50% biomass) was derived from the market price as found on the 'Homefire' site on 28th September 2022 calculated to be 9.4p/kWh. The price per kWh of kiln dried wood logs was derived in an equivalent method and was calculated to be 16.2 p/kWh. These costs do not necessarily result in a direct cost saving, rather it is the nature of reducing heat demand through zonal heating, as described above, which is the main reason for the energy bill reduction. This cost saving of running a stove with Homefire Ecoal 50 is found to be on average £213 per year whilst the cost saving in using kiln dried wood is found to be on average £132 per year – illustrated in figure 3 below.

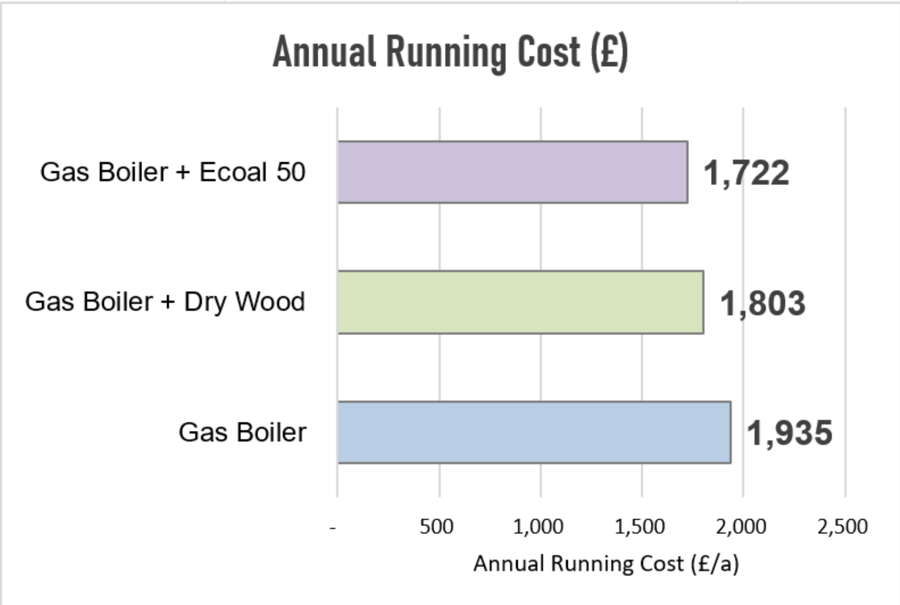


Figure 3: Displays the annual energy bill under three heating system scenarios showing a £132 per annum heating bill saving with the addition of a stove burning kiln dried wood and a £213 saving with the addition of a stove burning Homefire Ecoal 50.

Savings for alternative higher cost heating fuels such as heating oil and direct electric have not been presented, however savings will be higher for such homes with higher annual heating bills. This average cost saving has been calculated by averaging across multiple archetypes (shown in figure 1), but it is important to note that the cost saving is directly related to the heating demand of the property. Properties with a greater gas consumption benefiting financially to a greater extent than a low heat demand property. Figure four below presents Box and Whisker plots displaying the range of cost saving across all 28 archetypes for both stove scenarios.

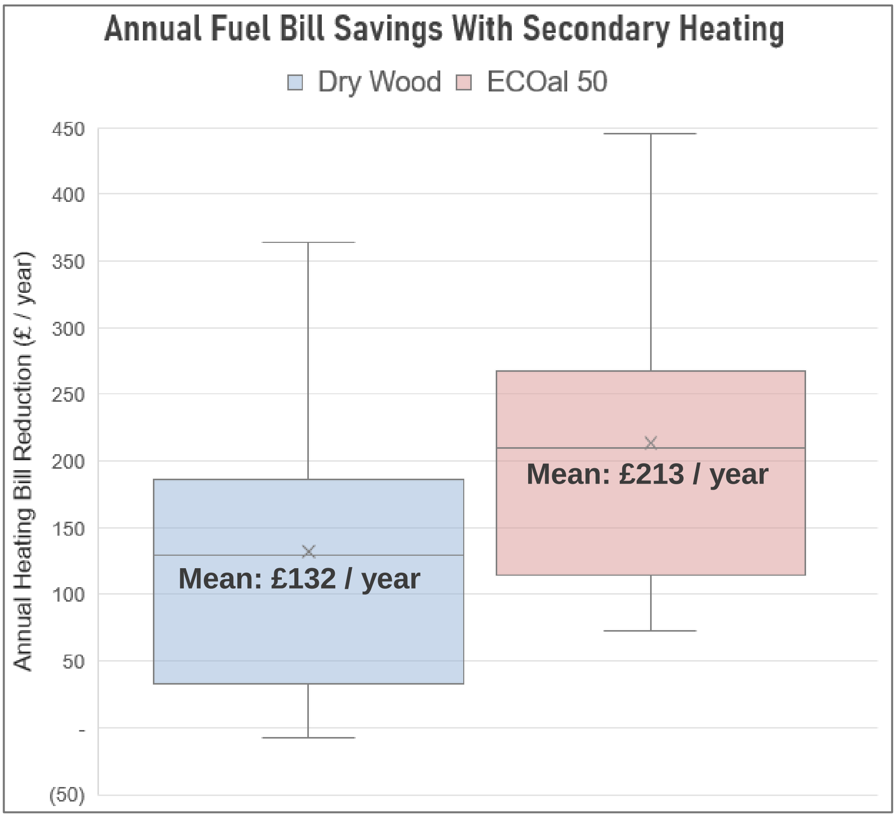


Figure 4: Box and Whisker plot displaying the cost savings resulting from the presence of a stove burning either dry wood or Homefire Ecoal 50 across all 28 archetypes used in this analysis.

For greater context – the lower quartile in both plots corresponds most closely to the pre-1918 terrace house archetype with loft insulation, solid wall insulation and double glazing with an annual heat demand of 10,662 kWh/a. The upper quartiles correspond most closely to the 1981-1990 single family home with no insulation measures and an annual heat demand of 17,417 kWh/a. The median cost saving corresponds most closely to the same 1981-1990 single family home archetype, but with the addition of loft insulation and cavity wall insulation, therefore resulting in a lower heat demand of 14,737 kWh/a.

The average energy saving bill across all archetypes, resulting from the utilisation of stove burning with dry wood, was calculated to be 6.8%. Meanwhile, stove burning with Ecoal 50 resulted in average heating bill reductions of 11.0%.

GREENHOUSE GAS RESULTS

The reduction in gas demand corresponds to a reduction in annual carbon emissions and results in a substantial carbon emission saving over a year. Using dry wood in a stove, (whilst reducing gas demand - as described above), has been estimated to result in an average emission saving of 561 kgCO_2e over the year, or alternatively emissions 17% lower than a standalone gas boiler. The use of Homefire Ecoal 50, with a higher carbon emission factor than wood, results in a lower but still significant annual carbon saving of 334 kgCO_2e – the equivalent of a 10% emissions reduction.

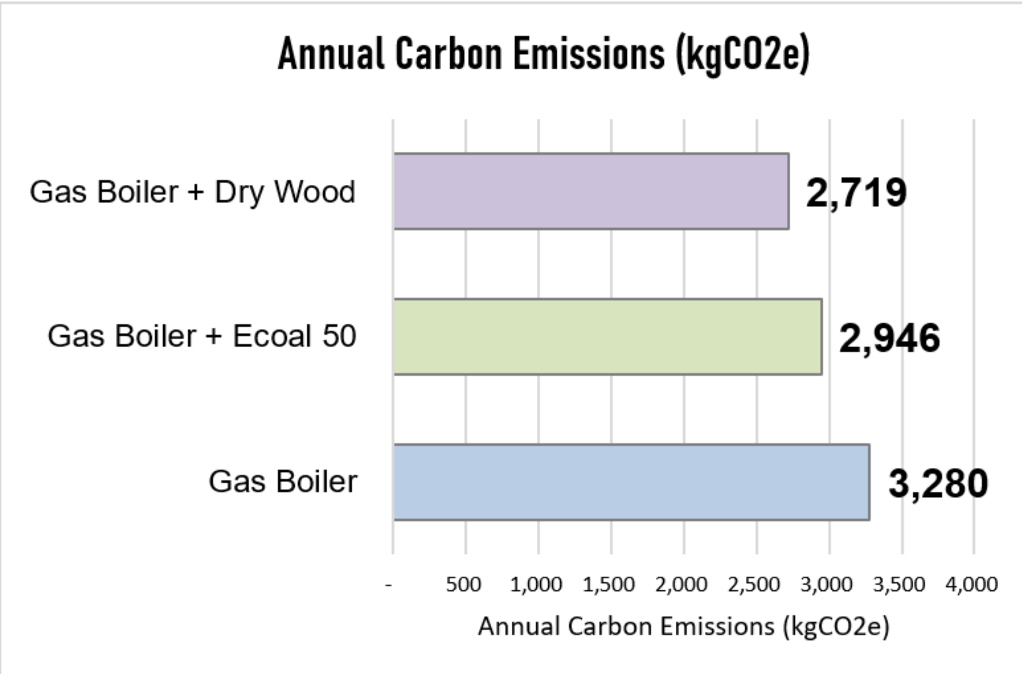


Figure 5: Displays the annual carbon emissions under three heating system scenarios, showing a 561 kg CO_2e saving with the addition of a stove burning kiln dried wood and a 334 kg CO_2e with the addition of a stove burning Homefire Ecoal 50.

AIR QUALITY RESULTS

One concern associated with domestic burning is air pollution. In particular, the burning of wood and other solid fuels can result in high PM2.5 and PM10 emissions. Analysis was conducted to calculate the air pollution impacts of burning dry wood and Homefire Ecoal50, averaging across the same archetypes listed in figure 1. This was achieved by multiplying the total mass of the air emissions (PM10, PM2.5, NO_x and SO_x), by the societal damage cost, as stated by DEFRA[2]. It is important to note that damage costs are dependent on a range of factors such as the population density surrounding the point of emission. Rural areas have a far lower damage costs to urban areas. In order not to discriminate between regions, this analysis chose the *central* damage costs quoted by DEFRA.

A key finding of the analysis is the high level of dependency on the stove type being used to burn the fuel in. Emission factors were taken from the European Environmental Agency's EMEP air pollution inventory guidebook 2019[3] which are differentiated by stove type. For this analysis, the emissions associated with a 'conventional stove' has been compared against those resulting from an 'eco-labelled stove'. The resulting annual damage costs are shown below in figure 6.

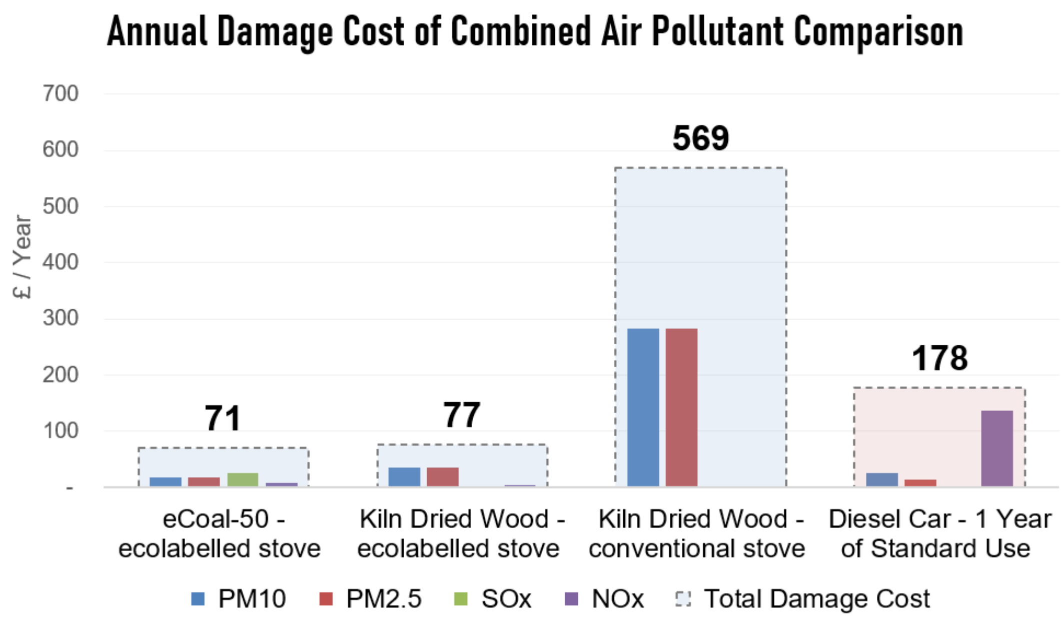


Figure 6: The damage costs from the burning of kiln dried wood and Homefire Ecoal 50 for secondary heating, also compared between two stove types. The damage cost resulting from the normal usage of a Euro 5 diesel car is also included to provide context.

[2] https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
[3] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

The analysis demonstrated a 7-fold difference between the two stove scenarios. The annual damage cost for kiln dried wood in an eco-labelled stove was calculated to be £77, in comparison to £569 for a conventional stove. This demonstrates clear potential for future reduction in air pollution impacts through improved stove regulations, allowing the burning of dry wood and smokeless fuel to remain a sustainable method of heating. Since 1st January 2022, all new stoves on sale across the UK have been eco-labelled.

To provide greater context we considered the annual emissions resulting from the average use of a Euro 5 – diesel car with emission factors also taken from the European Environmental Agency's EMEP. The average mileage was found to be 15,238 km/year – as specified by the Department for Transport[4]. The damage cost, dominated by NO_x emissions, was found to be £178 / year.

To express this equivalency in another way – one hour of burning wood in an eco-labelled stove is the equivalent of driving 12.7 miles in a Euro 5 diesel car. Meanwhile, one hour of burning Ecoal 50 in an eco-labelled stove is the equivalent of driving 11.7 miles in a Euro 5 diesel car.

[4] https://www.nimblefins.co.uk/cheap-car-insurance/average-car-mileage-uk

APPENDIX:

Data Inputs		
Input:	**Value:**	**Source:**
Cost		
Gas (as of 01/10/22)	0.103 £/kWh [i]	Energy bills support factsheet gov.uk
Kiln Dry Wood	0.162 £/kWh [ii]	Kiln Dried Birch Firewood Logs - Large Bag | Homefire UK
Homefire Ecoal 50	0.094 £/kWh [iii]	Ecoal Smokeless Coal 25kg & 10kg | Homefire
Working Assumptions *i – In addition to a 28p per day standing charge* *ii – Derived directly from market price using some industry assumptions on bulk density and the calorific value of wood* *iii – Derived directly from market price using specific energy of coal*		
Carbon Emission Factors		
Gas	0.1840 kgCO2e/kWh	DEFRA – Conversion Factors 2021
Kiln Dry Wood	0.0151 kgCO2e/kWh	DEFRA – Conversion Factors 2021
Homefire Ecoal 50	0.2068 kgCO2e/kWh [i]	DEFRA – Conversion Factors 2021 + Ecoal Smokeless Coal 25kg & 10kg | Homefire
Working Assumptions *i - Manufactured solid fuels containing a proportion of renewable bioenergy content typically deliver an emission saving compared to house coal. Amounts will vary by product and bioenergy source. We have used a figure of 40% based on inputs provided to us by CPL for Homefire Ecoal 50*		
Air Pollutants Emission Factors		
Dry Wood - conventional stove: PM10	2.7360 gPM10/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Dry Wood - conventional stove: PM2.5	2.6640 gPM2.5/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Dry Wood - conventional stove: SO_x	0.0396 gSO_x/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Dry Wood - conventional stove: NO_x	0.1800 gNO_x/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Dry Wood – eco-labelled stove: PM10	0.3420 gPM10/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Dry Wood – eco-labelled stove: PM2.5	0.3348 gPM2.5/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Dry Wood – eco-labelled stove: SO_x	0.0396 gSO_x/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Dry Wood – eco-labelled stove: NO_x	0.3420 gNO_x/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)

Smokeless Fuel – eco-labelled stove: PM10	0.1728 gPM10/kWh [i]	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Smokeless Fuel – eco-labelled stove: PM2.5	0.1584 gPM2.5/kWh [i]	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Smokeless Fuel – eco-labelled stove: SO_x	1.6200 gSO_x/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Smokeless Fuel – eco-labelled stove: NO_x	0.5400 gNO_x/kWh	1.A.4 Small combustion 2019.pdf (envihaifa.org.il)
Diesel Car - tailpipe	*Sum of PM10, PM2.5, SO_x and NO_x*	EEA EMEP – 1.A.3.b.i – Passenger Cars - 2021
Diesel Car - non-tailpipe	*Sum of PM10, PM2.5, SO_x and NO_x*	EEA EMEP – 1.A.3.b.vi and 1.A.3.b.vii (tyre and brake ware and road abrasion)
Diesel Car – annual mileage	15,128 km	Department for Transport – via: https://www.nimblefins.co.uk/cheap-car-insurance/average-car-mileage-uk
Working Assumptions		
i – Smokeless fuel typically produces less smoke than normal house coal. Estimates vary however we have used a figure of 80% based on industry input		
Air Pollution Damage Costs		
PM10 - domestic	87.49 £/kg	https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
PM2.5 - domestic	89.46 £/kg	https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
SO_x - domestic	13.03 £/kg	https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
NO_x - domestic	12.45 £/kg	https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
PM10 - transport	79.73 £/kg	https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
PM2.5 - transport	81.52 £/kg	https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
SO_x - transport	13.03 £/kg	https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
NO_x - transport	9.07 £/kg	https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
System Efficiencies		
Stove	82.0% [i]	Snug 7 Eco Design And Defra Approved Multi-Fuel Stove (stoveworlduk.co.uk)
Gas boiler	82.5%	GASTEC at CRE Ltd AECOM EA Technology - EST
Working Assumptions		
i – Averages across five DEFRA Approved Eco-labelled stoves found on the Stove World UK website		

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