Guernsey Electricity Limited

HEATING CARBON INTENSITY METHODOLOGY 2021

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HEATING LIFE-CYCLE CARBON INTENSITY

INTRODUCTION

Guernsey Electricity Ltd (GEL) is an integrated utility that generates, transmits and distributes electricity across the island of Guernsey. GEL also manages an interconnector with France, through which a large proportion of electricity is imported and for which the associated emissions are quantified using a market-based approach.

WSP UK has previously verified the intensity of the electricity that GEL distributes. The aim of this previous study was to calculate greenhouse emissions released for every kilowatt hour (kWh) of electricity consumed by GEL customers (gCO_2e/kWh), also taking into consideration emissions across the full lifecycle of the electricity production. The MS Excel file containing the verified calculations for the GEL intensities is: *WSP GHG Review Spreadsheet_RP of 2021_CLEAN 22-04-22.xlsx.*

WSP UK has also now been commissioned by GEL to conduct a study (this document) into the carbon intensity of different heating types, including Air Source Heat Pump (ASHP), Liquified Petroleum Gas (LPG),heating oil and Hydrotreated Vegetable Oil (HVO) (the latter a biofuel used by Rubis Channel Islands[1], a fuel company that supplies to the Islands of Jersey and Guernsey). Similar to the previous study, the aim of this work is to calculate the greenhouse emissions released for every kWh of heat provided to GEL customers (gCO_2e/kWh), by taking into consideration emissions across the full lifecycle of the associated electricity / fuel production.

[1] https://rubis-ci.co.uk/news/ecoheat100-100-renewable-heating-oil/

METHODOLOGY

This section of the report outlines how the study has been completed. Figure 1 provides a summary of the lifecycle stages taken into account in the emissions results of this study.

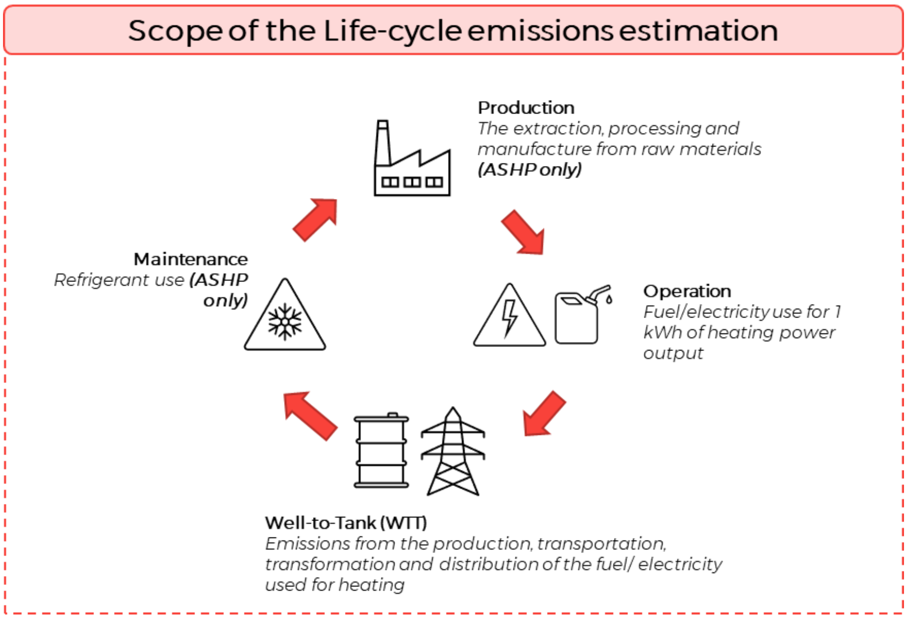

Figure 1 - Scope of the life-cycle emissions estimation

LPG and Heating Oil

For this study, WSP assessed the emissions resulting from the operational impacts (i.e the combustion) of heating using LPG and heating oil. The upstream well-to-tank (WTT) emissions associated with the extraction, refining and transportation of the raw fuel sources have also been taken into consideration for these two fuel types. Emissions factors have been sourced from DEFRA Greenhouse Gas Reporting: Conversion Factors 2021[2] and using net calorific value (CV) emissions factors.

Air Source Heat Pump (ASHP)

For ASHPs, the operational emissions have been calculated using GEL's 'Intensity of GEL Distributed Electricity' emissions figure (gCO_2e/kWh) for the year 2021 with a Coefficient of Performance (COP) of 3. Using a COP of 3 means that 3kW of heating power is generated while the compressor only needs 1kW of power to provide the associated heat (a ratio of 3:1). So, the GEL factor has been multiplied by 0.33333 to give the operational emissions (gCO_2e) per kWh.

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

Using academic literature[3], other lifecycle stages and factors such as the embodied carbon of equipment and refrigerant losses have been estimated to account for 5% of the ASHP lifecycle, with the remaining 95% accounting for the operation of the ASHP. Therefore 5% of the ASHP lifecycle emissions figure (from Table 6 of the stated literature) has been added onto the operational emissions of the ASHP to account for this.

HVO

The DEFRA Greenhouse Gas Reporting: Conversion Factors 2021[2] has emissions factors for Biodiesel HVO per Gigajoule (GJ), litre or kilogram (kg). Table 1 describes the Defra emissions factors for HVO (2021).

Table 1 - Defra UK 2021 emissions factors for HVO

	Unit	Combustion (kgCO2e per unit)	WTT (kgCO2e per unit)	Total (kgCO2e per unit)
Biodiesel HVO	Litres	0.03558	0.2132	0.24878
	GJ	1.03677	6.21212	7.24889
	Kg	0.04562	0.27333	0.31895

To convert the units outlined in Table 1 into kgCO_2e per kWh, the GJ has been converted into kWh using the formula in Figure 2.

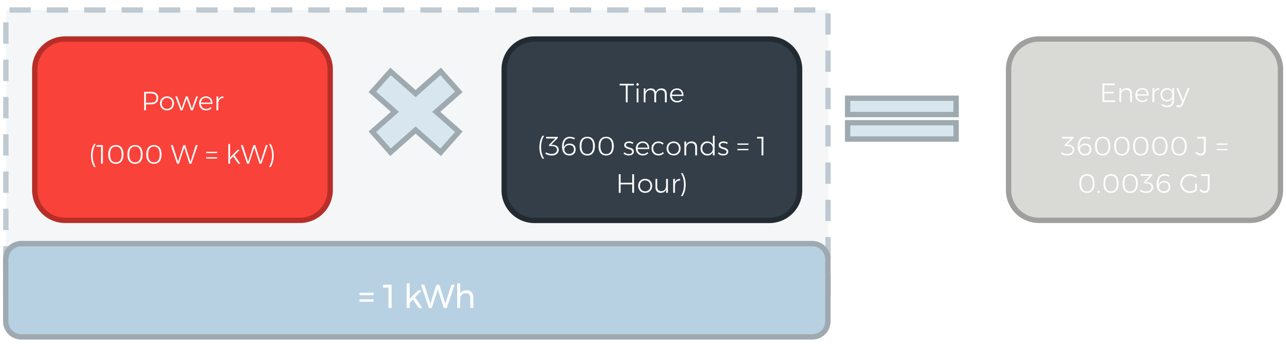

Figure 2 - Equation to convert 1 kWh to GJ

With 1 kWh equating to 0.0036 GJ, the Defra emissions factors (combustion and WTT) per GJ were multiplied by 0.0036 to provide a result equivalent to 1 kWh.

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[3] https://www.escholar.manchester.ac.uk/api/datastream?publicationPid=uk-ac-man-scw:178995&datastreamId=POST-PEER-REVIEW-PUBLISHERS.PDF (Table 6)

A review of other data sources for HVO emissions factors was conducted and it was determined that the above-described approach was robust. However, should new data sources or information on HVO become available or more applicable to GEL's circumstance then this study should be updated.

Efficiency

To be able to make comparisons with the ASHP using a COP of 3, boiler efficiencies for the other fuel types have also been taken into account. GEL have outlined the boiler types and their efficiencies, for use in this study, below.

Table 2 – Boiler efficiencies used in this study

Boiler Type	Efficiency
LPG boiler (condensing)	90%(1)
Oil boiler (condensing)	90%(1)
HVO boiler	90%(2)
Electric Boiler	100%(3)

(1) *'A condensing boiler will always be at least 90% efficient' -* https://www.britishgas.co.uk/home-services/boilers-and-heating/guides/boiler-efficiency.html
(2) *Assumed efficiency based on LPG and Oil fuel boilers*
(3) *'Electric boilers are often labelled as being 99-100% efficient' -* https://www.boilerguide.co.uk/articles/electric-boiler-efficiency-explained

Figure 3 demonstrates the relationship between the energy input and the heating energy output, taking into account the efficiencies of boilers and ASHP.

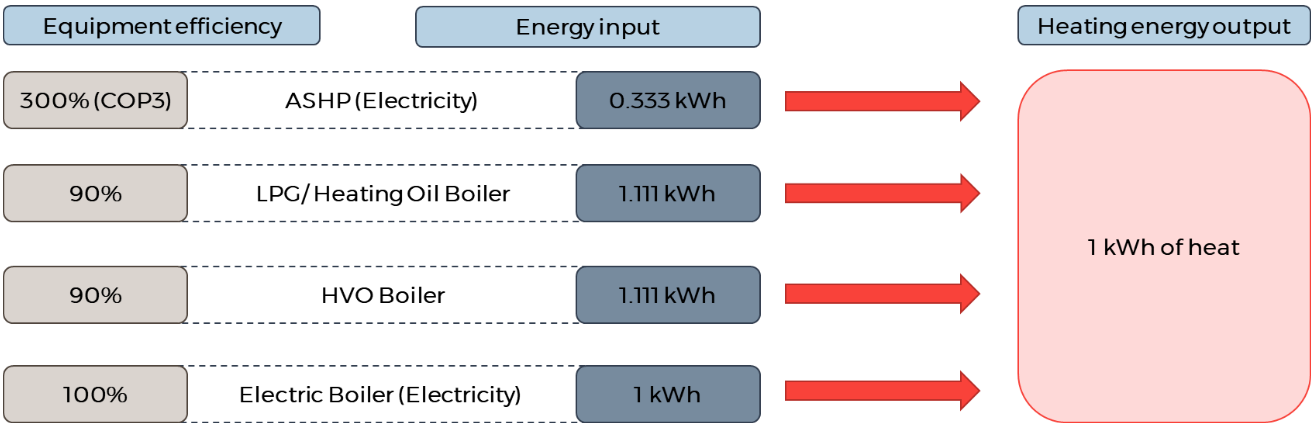

Figure 3 – Relationship between energy input and heating energy output

ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations apply to this study:

- This study references 'carbon' but this is used as short-hand for 'carbon dioxide equivalents (CO_2e)', which accounts for all of the greenhouse gas (GHG) impacts as identified in the Kyoto Protocol[4].
- Heating oil, LPG and HVO do not have other embodied impacts accounted for (other than those stated), though such contributions would be expected to be negligible relative to operational emissions. This is evidenced by the lifecycle study used to estimate emissions from ASHP, which quotes: '*For all the systems (Air/ Ground/ Water Source Heat Pumps and Gas Boilers), CO_2 emissions from electricity generation and natural gas combustion are the main contributor to GWP, causing over 95% of the impact.'*
- For HVO, conversions had to be made to provide the unit of emissions in gCO_2e per kWh.
- HVO boiler efficiency has been assumed to be 90%.
- The study uses the GEL lifecycle emissions intensity (gCO_2e per kWh for 2021), for ASHP and an electric boiler.
- Taking into account the efficiency of the boilers (and ASHP) means that the results reflect the emissions associated with 1 kWh of heating energy provided to GEL's customers. This is different to the emissions associated with the energy input (kWh) required for heating.

[4] https://unfccc.int/kyoto_protocol

RESULTS

The carbon intensity of different heat sources is described in Table 3. The results are described by the lifecycle carbon intensity of the fuels used for heating (i.e. energy input in gCO_2e per kWh) and accounting for the boiler efficiencies. The results also show the gCO_2e for every kWh of heat provided to GEL's customers (i.e. heating energy output).

Table 3 – Carbon intensity of heating sources

Source	Lifetime carbon intensity of fuel source/ energy input (gCO_2e per kWh)	Efficiency of equipment	Lifetime carbon intensity to generate 1 kWh of heat energy (gCO_2e per kWh)
Air Source Heat Pump (ASHP) (using GEL electricity)*	82.27	300% (COP 3)	27
LPG Fuel used for heating**	258	90%	286
Heating oil used for heating**	348	90%	387
HVO***	26	90%	29
Electric boiler (using GEL electricity)	82.27	100%	82

*The lifetime carbon intensity assumes the use of GEL electricity in an ASHP with a coefficient of performance (COP) of 3. GEL confirmed that the COP of 3 is appropriate to use due to the higher ambient temperature of Guernsey compared to the UK. The intensity figure includes an estimation of refrigerant losses and the embodied carbon of the equipment; associated assumptions have been sourced from academic literature.

**This includes carbon emissions from the combustion of fuel for heating and upstream emissions for the supply of LPG and heating oil (well-to-tank emissions). This information has been sourced from 'DEFRA Greenhouse gas reporting: conversion factors 2021'. The intensity does not include embodied carbon of the equipment used or emissions from the downstream distribution of fuel, which are both deemed to be negligible in the context of the results.

*** This includes carbon emissions from the combustion of the fuel for heating and the upstream emissions for the supply of HVO (well-to-tank emissions). This has been modelled on converting the GJ unit in the 'DEFRA Greenhouse gas reporting: conversion factors 2021' for HVO to kWh using the methodology outlined in the Methodology (HVO) of this document. At 90% equipment efficiency has also been assumed.

The results show that on a per kWh of heating output basis, use of GEL electricity in ASHP has the lowest carbon intensity when compared to the other fuels. This is because of the higher efficiency of the ASHP, relative to other boiler equipment. HVO is the second lowest in carbon intensity in per kWh of heating power when compared with LPG and Heating oil.

However, when considering the fuel source/energy input on a per kWh basis, HVO fuel has the lowest carbon intensity. This is because these latter results don't take into account the efficiencies of the equipment used to provide heating energy.

Interpretation

This study provides two results on a gCO_2e per kWh basis:

1. Lifetime carbon intensity of fuel source/ energy input **(input)**
2. Lifetime carbon intensity to generate 1 kWh of heat energy **(output)**

Result number 1 (input) provides the context for combusting 1 kWh of energy from the various fuel types over the fuels lifetime. Result number 2 (output) accounts for the efficiency of equipment and allows for comparison between different fuels by normalising the result to 1 kWh of heating energy provided by the equipment.

To avoid any misinterpretation of the results, WSP recommends that care is taken when disseminating this data, on the difference between the carbon intensity of the energy inputs per kWh and the carbon intensity of heating energy outputs per kWh. As this will affect which heating source is considered lower in carbon emissions.

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