Guernsey Electricity Limited

LIFECYCLE STUDY OF VEHICLE CARBON IMPACTS IN GUERNSEY

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GUERNSEY ELECTRICITY LIFE-CYCLE CARBON INTENSITY

WSP UK was commissioned by Guernsey Electricity Ltd (GEL), to conduct a study into the life-cycle greenhouse gas (GHG) emissions intensity of different types of passenger cars. This study was conducted to provide a comparison between the battery electric vehicles (BEV) and conventional internal combustion engine (ICE) vehicles using petrol, diesel or renewable diesel as fuel. The objective of this study was to calculate the average GHG emissions released per kilometre (km) driven, taking into account the GHG emissions across the complete lifecycle of production and usage of both ICEs and EVs.

GEL is an integrated utility that generates, transmits and distributes electricity across the island of Guernsey. GEL also undertakes operations that use electricity including works power, office activities and the charging of company electric vehicles.

WSP included in this study the life-cycle emissions from EVs using GEL's electricity. WSP calculated the carbon intensity of production and operation per kilometre of an average BEV and compared them with an average vehicle using petrol, diesel and renewable diesel. The study further compares the life-cycle carbon intensity with popular models of EV and conventional vehicles sold in the UK during 2021.

METHODOLOGY

For this study, WSP assessed the emissions resulting from the production, operation and end-of-life lifecycle stages of each in-scope vehicle type.

Production emissions are those arising from raw materials extraction and processing, whilst the operation emissions included the emissions generated by the combustion of fuel (petrol or the generation of electricity), vehicle maintenance activities, or well-to-tank emissions from the production of each fuel.

For EV charging, the life-cycle intensity of GEL's electricity supply was considered, by comparison with the standard UK electricity grid. A summary of the life-cycle stages assessed are included in Figure 1-1 .

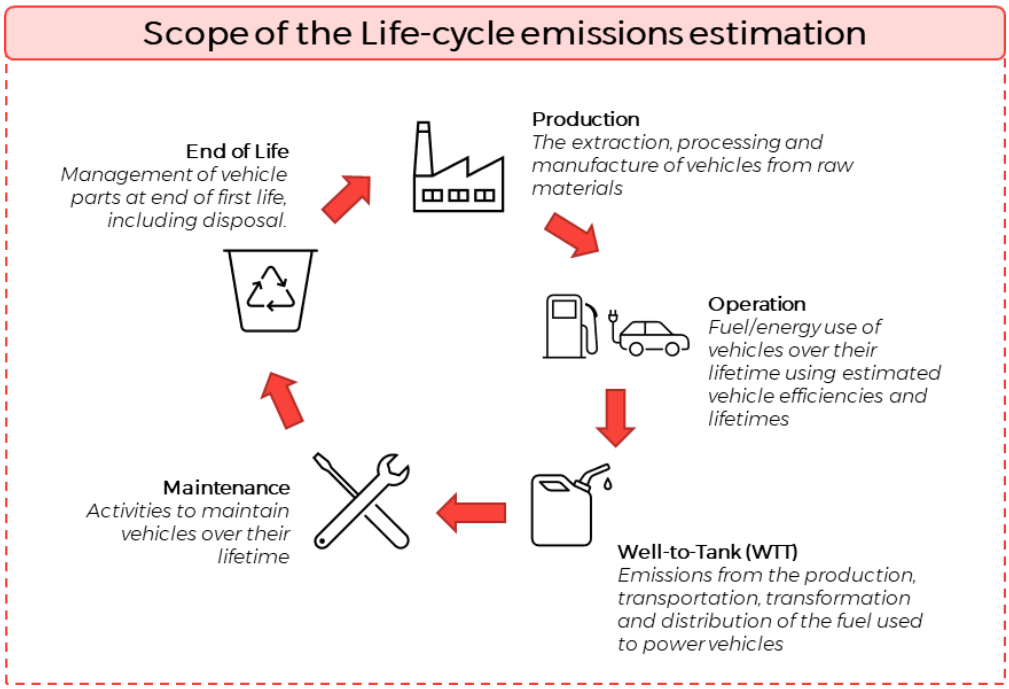

Figure 1-1 – Scope of the life-cycle emissions estimation

As part of this assessment, a literature review was conducted to obtain GHG emission values for each stage of vehicles' production and operation. To achieve this, an average factor for emissions during production[1], average lifetime kilometres driven, as well as fuel efficiency factors for an average diesel, petrol and battery electric vehicle, were estimated using available literature.

The assessment of life-cycle emissions for vehicles in Guernsey entailed the following key steps:

Vehicle types: Based on the available literature[2] and vehicle sales statistics in the UK[3], the Tesla M3 was considered for as the most popular electric car model in 2021. Additionally, an average car running on diesel, petrol and electricity was also compared. The types of vehicles incorporated in this study are therefore:

- BEV-GEL charged
- BEV-GEL charged (imports only)
- Petrol vehicle
- Diesel vehicle
- Tesla M3
- Tesla M3 (imports only)
- Electric Fiat 500
- Electric Fiat 500 (imports only)
- VW Golf Tdi
- BEV-UK (grid charged)
- VW Golf Renewable Diesel (RD)100
- Diesel vehicle Renewable Diesel (RD)100

1 https://d1v9sz08rbysvx.cloudfront.net/ricardo/media/media/news%20assets/lowcvp%20study%20demonstrates%20importance%20of%20whole%20life%20co2%20emissions.pdf

2 https://www.eea.europa.eu/publications/electric-vehicles-from-life-cycle/at_download/file

3 Vehicle licensing statistics: 2021 - GOV.UK (www.gov.uk)

Efficiency and lifetime usage: Based on the available scientific literature[4], vehicle fuel efficiency and average lifetime usage was assumed for an average car. Also based on the literature, fuel (for the Volkswagen) and energy efficiency (for the Tesla[5] and electric Fiat 500[6]) were also assumed.

Life-cycle emissions estimation: The life-cycle emissions from the chosen vehicle types in Guernsey were calculated by first multiplying the efficiency of the vehicle, the average lifetime usage in km and fuel emissions factor. This gave the overall operational emissions for each vehicle, which was then combined with GHG emission estimates from the production, maintenance and end-of-life stages of each asset, to arrive at the total life-cycle emissions as represented in the equations (bulleted) in the following section. Production, maintenance and end-of-life emissions values were taken directly from life-cycle assessment results detailed in scientific research papers[4].

Following updates have been made in this revision of study:

- Emission factors (operational and WTT) have been updated with the latest UK Greenhouse Gas Reporting Conversion Factors for 2021[7].

- For BEV - UK Grid Charged vehicle category, UK electricity generation factors have been used. Additionally, 'petrol' and 'diesel' have been revised to 'Average Biofuel Blends' in this document, as these are the typical fuel blends used in forecourts.

- For BEV-GEL Charged (including 'imports only'), Tesla M3 GEL Charged (including 'imports only') and Fiat 500 GEL Charged (including 'imports only'), the emission factors specific to Guernsey Electricity were used; these factors were sourced from the Annual Greenhouse Gas Emissions Database for 2021 (Refer Tab: CY Intensities Summary, Cells N51 and N53).

- Well-to-Tank (WTT) emission factors have been updated with the latest UK Greenhouse Gas Reporting Conversion Factors for 2021[7].

- For BEV-UK Grid Charged vehicle type, Transmission & Distribution UK electricity factors have been used, sourced from the latest UK Greenhouse Gas Reporting Conversion Factors for 2021[7].

- The RD 100 emissions factor for fuel combustion and WTT emissions has been updated to the UK Greenhouse Gas Reporting Conversion Factors for Biofuel - Biodiesel HVO from the latest 2022 emissions factor database[8]. This is because RD100 is the Rubis[9] product brand name for "Biodiesel HVO".

[4] https://www.mdpi.com/2071-1050/12/22/9390/htm (refer table 7). This paper is a review of several other LCAs and provides an overall figure for each lifecycle stage based on all the LCAs.
[5] https://www.e3s-conferences.org/articles/e3sconf/pdf/2019/62/e3sconf_icbte2019_01009.pdf
[6] https://www.parkers.co.uk/fiat/500-electric/specs/
[7] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021
[8] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022
[9] https://rubis-ci.co.uk/motor-and-aviation/rd100/

Following calculations have been used to arrive at the life cycle emissions:

- **Emissions from energy usage (diesel/petrol) (Equation 1)**
  Vehicle fuel efficiency x average lifetime usage x fuel emissions factor

- **Emissions from energy usage (electric) (Equation 2)**
  Vehicle electricity efficiency x average lifetime usage x GEL electricity intensity or UK average grid emissions intensity

- **WTT emissions (Equation 3)**
  Lifetime fuel used x WTT fuel emission factor

- **Operation emissions (Equation 4)**
  Emissions from usage of fuel + WTT emissions of fuel + maintenance activity emissions

- **Life-cycle emissions (Equation 5)**
  Operation emissions + Production emissions + End-of-life emissions (Equation 5)

ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations apply to this study:

- In the absence of Guernsey-specific data on the average lifetime usage of a car, 150,000 km[10] was assumed, based on estimates available from literature.
- The production, maintenance and end of life lifecycle stage emissions for all vehicles types are based on averages of these vehicles types from a range of LCA studies from the following review paper: *Review and Meta-Analysis of EVs: Embodied Emissions and Environmental Breakeven (Dillman et al 2020)[4].*
- End of life (EOL) emissions have been discerned from following review paper: *Review and Meta-Analysis of EVs: Embodied Emissions and Environmental Breakeven (Dillman et al 2020)[4].* This review did, however, highlight that there was inconsistency in data regarding emissions from the end of life stage and battery replacement; the review asserted that this was because of a lack of available data on recycling technologies and their success (as EVs have only relatively recently entered the mass market and many are yet to reach end of life. The EV EOL emissions factor is the mean average of the meta-analysis of a range of EV LCA's, of which a few of these studies included recycling aspects.

[10] https://www.nbcnews.com/id/wbna12040753#.XHdpzC2ZMWo

RESULTS

Figure 1-2 presents a comparison of life-cycle emissions (gCO_2e/km) of different types of conventional vehicles and battery electric vehicles operating with various fuels in Guernsey.

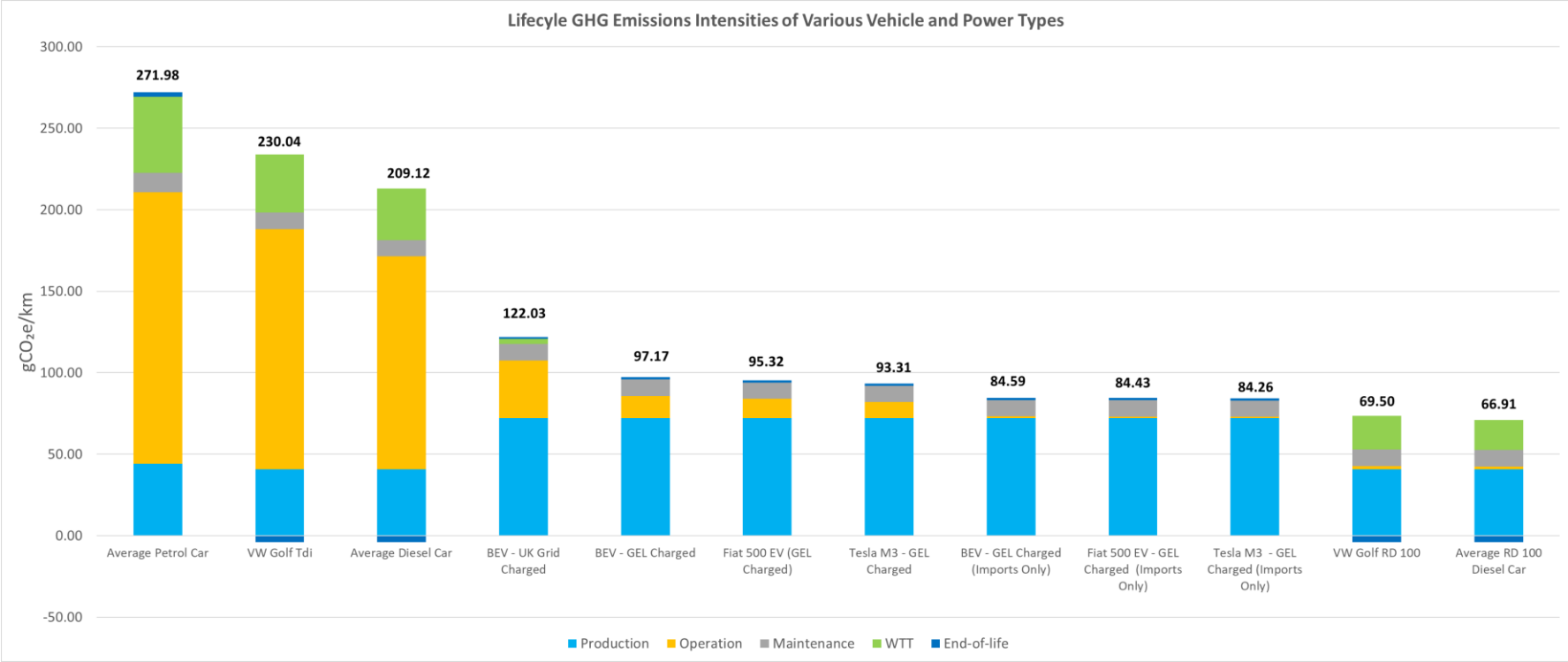

Figure 1-2 Lifecycle Emissions Intensities

The results show that the use of RD100 (diesel bio-fuel) in a VW Golf or an average diesel car equates to the lowest emissions in gCO_2e per km compared to other vehicles types and fuel consumption. This is primarily the result of the lower emissions for the production of diesel cars compared to EV's at present.

The Tesla M3 operating on imported electricity (84.26 gCO_2e/km) and GEL charged (imports only) BEV (84.59 gCO_2e/km) shows a slight improvement over the previous assessment (based on 2020 data) for these vehicle types (-1% and -2% respectively).

The Fiat 500 EV has a higher kWh per km consumption i.e. lower efficiency than a Tesla which results in increased emissions from operation relative to the Tesla for both GEL charged and GEL charged (imports only) scenarios. However, as an average EV emissions factor is used for the remaining lifecycle stages and because operation contributes to a smaller proportion of EV emissions, this emissions saving for the Tesla shows a minimal improvement on the Fiat 500 EV's lifecycle emissions performance. For GEL charged it means the emissions from a Fiat 500 EV is 2.2% greater than a Tesla and for the GEL charged (imports only) only 0.2% greater in emissions (gCO_2e/km).

Vehicles operating on petrol and diesel represent the highest contributors to GHG emissions, primarily as a result of the operation lifecycle stage i.e. in-use fuel consumption.

APPENDIX – FULL RESULTS

Table 1 - Emissions (gCO_2e/km) from a typical vehicle over its lifecycle

Vehicle type	Emissions (gCO_2e/km)					
	Production	Operation	Maintenance	End-of-life	WTT	Total
Average Petrol Car	44.00	166.71	12.00	2.67	46.61	**271.98**
VW Golf Tdi	40.67	147.47	10.10	-4.00	35.80	**230.04**
Average Diesel Car	40.67	130.64	10.10	-4.00	31.71	**209.12**
BEV - UK Grid Charged	72.00	35.46	10.10	1.33	3.14	**122.03**
BEV - GEL Charged	72.00	13.74	10.10	1.33	0.00	**97.17**
Fiat 500 EV - GEL Charged	72.00	11.89	10.10	1.33	0.00	**95.32**
Tesla M3 - GEL Charged	72.00	9.87	10.10	1.33	0.00	**93.31**
BEV - GEL Charged (Imports Only)	72.00	1.16	10.10	1.33	0.00	**84.59**
Fiat 500 EV - GEL Charged (Imports Only)	72.00	1.00	10.10	1.33	0.00	**84.43**
Tesla M3 - GEL Charged (Imports Only)	72.00	0.83	10.10	1.33	0.00	**84.26**
VW Golf RD 100	40.67	2.09	10.10	-4.00	20.65	**69.50**
Average RD 100 Diesel Car	40.67	1.85	10.10	-4.00	18.29	**66.91**

Table 2 - Total lifetime emissions (tCO_2e) from a typical vehicle over its lifecycle

Vehicle type	Lifetime emissions (tCO_2e)					
	Production	Operation	Maintenance	End of Life	WTT	Total
Average Petrol Car	6.60	25.01	1.80	0.40	6.99	**40.80**
VW Golf Tdi	6.10	22.12	1.52	-0.60	5.37	**34.51**
Average Diesel Car	6.10	19.60	1.52	-0.60	4.76	**31.37**
BEV - UK Grid Charged	10.80	5.32	1.52	0.20	0.47	**18.30**
BEV - GEL Charged	10.80	2.06	1.52	0.20	0.00	**14.58**
Fiat 500 EV - GEL Charged	10.80	1.78	1.52	0.20	0.00	**14.30**
Tesla M3 - GEL Charged	10.80	1.48	1.52	0.20	0.00	**14.00**
BEV - GEL Charged (Imports Only)	10.80	0.17	1.52	0.20	0.00	**12.69**
Fiat 500 EV (Imports Only)	10.80	0.15	1.52	0.20	0.00	**12.67**
Tesla M3 - GEL Charged (Imports Only)	10.80	0.12	1.52	0.20	0.00	**12.64**
VW RD 100	6.10	0.31	1.52	-0.60	3.10	**10.43**
Average RD 100 Diesel Car	6.10	0.28	1.52	-0.60	2.74	**10.04**

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