Zemo Partnership | **Zero Emission Bus Certification ID:** | **ZEB-VOLVO-7900E-2022** | Approved Test facility | UTAC

# Zero Emission Bus Certificate

| | | | | | | |
|---|---|---|---|---|---|---|
| *Customer:* | **Volvo Bus Corporation** | | | **DYNAMOMETER SETTINGS** | | |
| *Customer Address:* | **Dept 86100, ARAK3 S, SE-405 08, Gothenburg** | *Telematics Capability* | Yes | Test Weight | 15796 | kg |
| *Test Purpose:* | **Zero Emission Bus Testing** | *Maximum Speed (km/h)* | 80 km/h | F° | 789.20 | N |
| *Vehicle Manufacturer:* | **Volvo Bus Corporation** | *Seated Capacity* | 40 | F¹ | 6.4041 | N/kmh |
| *Vehicle Model Name:* | **7900E** | *Passenger Capacity* | *87* | F² | 0.1303 | N/kmh ² |
| *Powertrain Technology* | **Battery Electric** | *Declared Unladen Weight (kg)* | 12095 | *Equivalent test passengers* | 21.75 | passengers |
| *Powetrain Configuration* | **Direct Drive** | *Gross Weight (kg)* | 19500 | *Measured Unladen Weight (kg)* | 13167 | kg |
| *Zero Emission Heating* | **Heat Pump & PTC Heaters** | *GVW Check* | **OK** | Number of consecutive tests completed | 4 | tests |
| **Battery Specification** | | **Charging and Refuelling Capability** | | **Hydrogen Specification** | | |
| **Battery Manufacturer** | **-** | **Plug Type** | **CCS 2 & OppCharge** | **Fuel Cell Manufacturer** | | **N/A** |
| **Battery Chemistry** | **NMC** | **Max Charge Capability (kW)** | **Up to 150kW / 300kW** | **Fuel Cell Power Rating (kW)** | | **N/A** |
| **Battery Installed Capacity (kWh)** | **198** | **Charger Compatibility** | **DC / OppCharge** | **Hydrogen Storage Capacity (kg)** | | **N/A** |
| **Battery Usable Capacity (kWh)*** | **158** | **Charge time from 20-80% SOC** | **2 hours** | **Hydrogen Storage Pressure (bar)** | | **N/A** |

* Recommended manufacturer guideline, subject to warranty

## Declared fuel, properties and source plus carbon conversion factors

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Well-to-Tank Factor:* | ***Electricity*** | **80.92** | **g CO2e / MJ** | *Fuel Provider* | **UK market standard** | *WTT evidence* | **DBEIS Conversion 2021** |
| *Well-to-Tank Factor:* | ***Hydrogen*** | **N/A** | **g CO2e / MJ** | *Capacity of Tanker (kg)* | **N/A** | *Fuel Type / Pathway* | **UK Grid Electricity** |
| *Energy Density* | ***Hydrogen*** | **120** | **MJ / kg** | *Transport Distance of Hydrogen (km)* | **N/A** | *Hydrogen Production Energy Source* | **UK Grid** |

## Emissions and Energy consumption results from approved test facility - Average 4 tests

| Test Phase | HC (g/km) | CO (g/km) | NOx (g/km) | PM (g/km) | $CO_2$ (g/km) | $CH_4$ (g/km)* | $N_2O$ (g/km)* | Total Energy Consumption (kWh) | Vehicle Energy Consumption (kWh/km) | Grid Electrical Energy Consumption (kWh/ 100km) |
|---|---|---|---|---|---|---|---|---|---|---|
| Outer Urban | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 7.93 | 1.23 | 143.54 |
| Inner Urban | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 2.79 | 1.12 | 131.00 |
| Rural | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 6.88 | 0.93 | 109.19 |
| *LBC Average* | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 10.71 | 1.20 | 140.01 |
| **UK BUS Average** | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 17.59 | 1.08 | **126.10** |

## Zero Emissions (Z.E.) Range: Energy consumption and charging efficiency

| | | | | | |
|---|---|---|---|---|---|
| **Test Charger Used** | **22 kW** | **Total measured energy consumed on vehicle (kWh)[1]** | **105.55** | **Max ZE Range at 100% SOC (km)** | **147** |
| **Hydrogen Energy Over Test (kWh)** | **N/A** | **Measured grid energy during charging (kWh)** | **123.48** | **Max ZE Range at 80% SOC (km)** | **118** |
| **Hydrogen Delivered to Vehicle (kg)** | **N/A** | **Grid-to-Wheel efficiency (%)[2]** | **85%** | **Test Distance Travelled (km)** | **65** |

[1] Total measured energy includes energy used during the 23 minute warmup, this is needed for charge efficiency calculation.

[2] Grid to Wheel efficiency represents the total energy losses between the grid and the wheels of the bus.

## Calculated total Well-to-Wheel GHG $CO_2$ equvialent emissions over test

| Test Phase | Fuel Energy (MJ /km) | Fuel WTT*GHG Emissions ($g\ CO_2e$ / km) | Electrical Energy (MJ / km) | Electricity WTT* GHG Emissions ($g\ CO_2e$ / km) |
|---|---|---|---|---|
| Outer Urban | N/A | N/A | 5.17 | 418.15 |
| Inner Urban | N/A | N/A | 4.72 | 381.61 |
| Rural | N/A | N/A | 3.93 | 318.09 |
| *LBC Average* | N/A | N/A | 5.04 | 407.87 |
| **UK BUS Average** | N/A | N/A | 4.54 | 367.34 |

*Data Generated by (On behalf of Test facility):* *Date:*

*Data Approved by:* *Date:*

## Zero Emission Bus Certificate Summary

| *Test Vehicle* | | | *Average Euro VI Diesel Equivalent* | | |
|---|---|---|---|---|---|
| **GHG Well-to-Wheel** | **367.3** | **g CO2e / km** | **Average Diesel GHG Equivalent** | **1300** | **g CO2e / km** |
| **WTW CO2 per passenger km (@ Max Pass Capacity)** | **4.2** | **g CO2e / pass km** | **WTW CO2 per passenger km (@ Max Pass Capacity)** | **14.9** | **g CO2e/pass km** |
| **Overall Zero Emission Bus Performance** | | | | | |
| **WTW GHG saving** | **932.2** | **g CO2e / km** | **Maximum Theoretical Zero Emission Range (km)** | **147.0** | |
| **% WTW GHG saving** | **72%** | **g CO2e / km** | **Vehicle Energy Consumption (kWh/ km)** | **1.08** | |
| ***Approved as Zero Emission Bus? (50% GHG saving or more)*** | | | ***YES*** | | |

**** WTT : Well-to-Tank*** ***** TTW : Tank-to-Wheel*** ****** WTW : Well-to Wheel***

**COMMENTS:** Emission results marked in red are below detection levels.

LBC = London Bus Cycle - Inner & Outer Urban phases of UKBC only.

| Heating Requirment | Cell | Lower Saloon | Upper Saloon |
|---|---|---|---|
| **Target Temperatures ±2 (°C) :** | **10** | **17** | **N/A** |
| **Average Temperatures across testing (°C)** | 9.41 | 16.05 | N/A |

***Test Numbers:*** ML02018887 (10-Oct-19), ML02018888 (10-Oct-19), ML02018889 (10-Oct-19), ML02018890 (10-Oct-19), ML02018891 (10-Oct-19), ML02018892 (10-Oct-19).

*Certificate approved by:* *On behalf of Bus manufacturer* — Phil Fletcher 07.04.22

*Certificate Approved by:* *On behalf of DfT / Zemo Partnership* — Dan Hayes — Daniel Hayes 7.04.22