Zemo Partnership

Zero Emission Bus Certification ID:

ZEB-WRIGHTBUS-STREETDECK-HYDROLINER-FCEV-2023 Approved Test facility

N/A - Simulated

Simulated Zero Emission Bus Certificate

| Overteen en | Main later a | | | | DYNAMOMET | | | | | | |
|---|---|----------------------------------|-----------------------------------|--------------------|--------------------------------------|---------------|--------------------|--|--|--|--|
| Customer: | Wrightbus | | | 1 | DINAMONE | ER SETTINGS | | | | | |
| Customer Address: | 201 Galgorm Rd, B | allymena, County Antrim, BT42 1S | Telematics Capability | Yes | Test Weight | 14039 | kg | | | | |
| Test Purpose: | Zero Emission B | us Testing | Maximum Speed (km/h) | 80 km/h | F° | N/A | N | | | | |
| Vehicle Manufacturer: | Wrightbus | | Seated Capacity | 63 | F ¹ | N/A | N/kmh | | | | |
| Vehicle Model Name: | StreetDeck Hydro | oliner FCEV | Passenger Capacity | 86 | F ² | N/A | N/kmh ² | | | | |
| Powertrain Technology | Hydrogen Fuel C | ell | Declared Unladen Weight (kg) | 12502 | Equivalent test passengers | N/A | passengers | | | | |
| Powetrain Configuration | Powetrain Configuration Hub Motors | | Gross Weight (kg) | 18425 | Measured Unladen Weight | N/A | kg | | | | |
| Zero Emission Heating HVAC utilising fuel-cell waste heat | | | GVW Check | ОК | Number of conseuitve tests completed | N/A | Tests | | | | |
| | Battery Spec | cification | Charging and Refuelling | Capability | Hydrogen S | Specification | | | | | |
| Battery Man | ufacturer | Forsee Power | Plug Type | N/A | Fuel Cell Manufactur | Ballard | | | | | |
| Battery Ch | emistry | LTO | Max Charge Capability (kW) | N/A | Fuel Cell Power Rating (kW) | | 85 | | | | |
| Battery Installed C | Capacity (kWh) | 27 | Charger Compatibility | N/A | Installed Hydrogen Storage Ca | 26.9 | | | | | |
| Battery Usable Ca | apacity (kWh)* | 13.5 | Charge time from 20-80% SOC** | N/A | Usable Hydrogen Storage Cap | 25.0 | | | | | |
| * Recommended manuf | acturer guideline, s | ubject to warranty | ** Based on manufacturer estimate | | | | | | | | |
| | | Declary offerel as | | | | | | | | | |
| | Declared fuel, properties and source plus carbon conversion factors | | | | | | | | | | |
| Well-to-Tank Factor: Electricity N/A g CO2e / MJ | | | MJ Fuel Provider | UK market standard | WTT evidence | Zemo (| Calculated | | | | |
| Weil-IU-Tarik Facior. | Well-to-Tank Factor: Hvdrogen 7.22 g CO2e / MJ | | | | | | | | | | |
| | Hydrogen | 7.22 g CO2e / | IJ Capacity of Tanker (kg) | N/A | Fuel Type / Pathway | Off-site I | Electrolyser | | | | |

| 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) | CH₄ (g/km)* | N₂O (g/km)* | Total Fuel Consumption (kg) | Vehicle Fuel Consumption (kg/km) | Fuel Consumption (kg/100km) | | |
| Outer Urban | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.43 | 0.067 | 6.69 | | |
| Inner Urban | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.21 | 0.084 | 8.42 | | |
| Rural | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.46 | 0.062 | 6.20 | | |
| LBC Average | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.65 | 0.072 | 7.24 | | |
| UK BUS Average | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 1.11 | 0.067 | 6.72 | | |

| | Zer | o Emission | s (Z.E.) F | Range: | Energy cons | umption ar | nd chargi | ng efficiend | cy | | |
|---|------------------|------------------------|-----------------|--|--|--|-------------------------------------|-----------------------------------|-------------------|-------|----------|
| Test Charge | er Used | N/A | Total measured | measured energy consumed on vehicle (kWh) ¹ N/A Max ZE Rang | | Max ZE Range | e at 100% Usable Tank Capacity (km) | | | 372 | |
| Hydrogen Energy Over Test (kWh) N/A Measured g | | | grid energy du | ring charging (kWh) | N/A | Max ZE Rang | e at 80% Usable Tanl | Capacity (km) | : | 298 | |
| Hydrogen Delivered to Vehicle (kg) N/A G | | | d-to-Wheel effi | iciency (%) ² | N/A | Te | st Distance Travelled | (km) | l | N/A | |
| Fotal measured energy Grid to Wheel efficience | | | - | | r charge efficiency calcula ie bus. | tion. | | | | | |
| Calcu | lated tota | l Well-to-W | heel GHG | CO 2 eq | uvialent emis | sions over to | est | Data Generated by (facility): | On behalf of Test | Date: | |
| Test Phase | Fuel Energy | Fuel WTT*GHG | Emissions | Elec | ctrical Energy | Electricity WTT* 0 | HG Emissions | | | | |
| | (MJ / km) | (g CO ₂ e / | km) | | (MJ / km) | (g CO₂e | / km) | | | | |
| Outer Urban | 8.03 | 57.96 | 5 | | N/A | N/A | 1 | Data Approved by: | | Date: | |
| Inner Urban | 10.10 | 72.95 | i | | N/A | N/A | 1 | | | | |
| Rural | 7.44 | 53.72 | | | N/A | N/A | ١ | 1 | | | |
| LBC Average | 8.69 | 62.73 | 3 | | N/A | N/A | \ | | | | |
| UK BUS Average | 8.06 | 58.22 | | | N/A | N/A | ١ | | | | |
| | | | Zero | Emissio | on Bus Certif | icate Sumr | nary | | | | |
| | Tes | st Vehicle | | | | | Average E | uro VI Diesel E | quivalent | | |
| Greenhouse Gas Emissions: Well-to-Wheel | | | | 58.2 | g CO2e / km | Average Diesel GHG Emissions Equivalent | | s Equivalent | 1290.1 | g CC | 02e / km |
| WTW CO2 | per passenger km | (@ Max Pass Capac | | 0.7 | g CO2e/pass km | WTW CO2 per pas | | ax Pass Capacity) | 15.0 | g CO2 | e/pass k |
| | | | | Overall Z | ero Emission | Bus Perform | ance | | | | |
| WTW GHG saving | | | | 1231.9 | g CO2e / km | Maximum Theoretical Zero Emission Range (km) | | | 37 | 72.0 | |

| WTW 0110 3a | | 1231.3 | | 072.0 | | | |
|---|-----------------------|----------|--------------------------|--|-------|--------------|--------------|
| % WTW GHG s | aving | 95% | Fuel Consumpti | | 6.72 | | |
| Approved as Zero Em | ission Bus? (50% GHG | G saving | | | | | |
| * WTT : Well-to-Tank | ** TTW : Tank-to-Whee | el | *** WTW : V | Vell-to Wheel | | | |
| COMMENTS: LBC = London Bus Cycle - Inner & (| | | | Heating Requirement | Cell | Lower Saloon | Upper Saloon |
| rom fully-validated multi-physics simulation tool du Certificate will be replaced with valid UKBC test as | | | | Target Temperatures ±2 (°C) : | 10 | 17 | 17 |
| valid until 31/12/23, at which point it will be reviewe storage capacity due to technical reasons relating | | | than gross hydrogen | Average Temperatures across testing (°C) N/A | | N/A | N/A |
| Test Numbers: | | | | - | | | |
| Certificate approved by: | | | Certificate Approved by: | 7 (| 1.1.0 | Tim Griffen | |
| On behalf of Bus manufacturer | | | 06.07.2023 | On behalf of DfT / Zemo Partnership | m | tim Mar | |

Note: Hydrogen Fuel Pathway - Off-Site, On-Shore Electrolysis, using Renewable Electricity. Compressed gas delivery (200km), 350bar dispense. For more information on hydrogen production pathways, please contact **hello@zemo.org.uk**

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N/A - Simulated

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| Customer: | Wrightbus | | | | DYNAMOMETER SETTINGS | | | |
|-------------------------------------|---|--------------------------|-------------------------------------|-----------------------------------|--------------------------------------|---|--------------|--------------------|
| Customer Address: | 201 Galgorm Rd, B | allymena, County Antrim, | BT42 1SA | Telematics Capability | Yes | Test Weight | 14039 | kg |
| Test Purpose: | Zero Emission B | us Testing | | Maximum Speed (km/h) | 80 km/h | F° | N/A | N |
| Vehicle Manufacturer: | Wrightbus | | | Seated Capacity | 63 | F ¹ | N/A | N/kmh |
| /ehicle Model Name: | StreetDeck Hydro | oliner FCEV | | Passenger Capacity | 86 | F ² | N/A | N/kmh ² |
| Powertrain Technology | Hydrogen Fuel C | ell | | Declared Unladen Weight (kg) | 12502 | Equivalent test passengers | N/A | passengers |
| Powetrain Configuration | ation Hub Motors | | Gross Weight (kg) | 18425 | Measured Unladen Weight | N/A | kg | |
| Zero Emission Heating | ro Emission Heating HVAC utilising fuel-cell waste heat | | GVW Check | OK | Number of conseuitve tests completed | N/A | Tests | |
| | Battery Spec | cification | | Charging and Refuelling | Capability | Hydrogen S | | |
| Battery Manufacturer Forsee Power | | /er | Plug Type | N/A | Fuel Cell Manufacture | er | Ballard | |
| Battery Che | emistry | LTO | | Max Charge Capability (kW) | N/A | Fuel Cell Power Rating | (kW) | 85 |
| Battery Installed C | apacity (kWh) | 27 | | Charger Compatibility | N/A | Installed Hydrogen Storage Capacity (kg) | | 26.9 |
| Battery Usable Ca | pacity (kWh)* | 13.5 | | Charge time from 20-80% SOC** | N/A | Usable Hydrogen Storage Capacity (kg)* 29 | | |
| Recommended manufa | acturer guideline, si | ubject to warranty | | ** Based on manufacturer estimate | | | | |
| | | Declared fu | el, prop | erties and source p | olus carbon | conversion factors | | |
| Well-to-Tank Factor: | Electricity | N/A | g CO2e / MJ | Fuel Provider | UK market standard | WTT evidence | Zemo | Calculated |
| Well-to-Tank Factor: | Hydrogen | 139.95 | g CO2e / MJ | Capacity of Tanker (kg) | N/A | Fuel Type / Pathway | Off-site | Electrolyser |
| Energy Density Hydrogen 120 MJ / kg | | MJ / kg | Transport Distance of Hydrogen (km) | 200 km | Energy Source | UK Grid | | |
| | | | | | | | | |
| Ε | missions | and Energy | consu | mption results from | n approved t | est facility - Averag | e 4 tests | |
| | 1 | | | <u> </u> | | Total Fuel | Vehicle Fuel | Fuel Consum |

| Test Phase | HC (g/km) | CO (g/km) | NOx (g/km) | PM (g/km) | CO ₂ (g/km) | CH₄ (g/km)* | N₂O (g/km)* | Total Fuel Consumption (kg) | Consumption (kg/km) | Fuel Consumption (kg/100km) |
|----------------|-----------|-----------|------------|-----------|------------------------|-------------|-------------|--------------------------------|------------------------|--------------------------------|
| Outer Urban | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.43 | 0.067 | 6.69 |
| Inner Urban | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.21 | 0.084 | 8.42 |
| Rural | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.46 | 0.062 | 6.20 |
| LBC Average | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 0.65 | 0.072 | 7.24 |
| UK BUS Average | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 1.11 | 0.067 | 6.72 |

| | Zer | o Emission | s (Z.E.) F | Range: | Energy cons | umption ar | nd chargii | ng efficiend | cy | |
|--|---------------------------|--|-----------------------|---------------------|------------------------------------|---|--|-----------------------|-------------------|--------------|
| Test Charge | er Used | N/A | Total measured | d energy cons | umed on vehicle (kWh) ¹ | N/A | Max ZE Range | at 100% Usable Tan | k Capacity (km) | 372 |
| Hydrogen Energy Over Test (kWh) N/A Measured (| | | grid energy du | ring charging (kWh) | N/A | Max ZE Range | e at 80% Usable Tanl | Capacity (km) | 298 | |
| Hydrogen Delivered to Vehicle (kg) N/A G | | | | d-to-Wheel eff | ficiency (%) ² | N/A | Tes | at Distance Travelled | (km) | N/A |
| Grid to Wheel efficienc | y represents the tot | al energy losses betw | een the grid and | the wheels of th | | | | Data Generated by (| | Date: |
| Calcu | lated tota | l Well-to-W | heel GHG | со ₂ ес | uvialent emis | sions over te | est | facility): | Un benair of Test | Date: |
| Test Phase | Fuel Energy | Fuel WTT*GHG | Emissions | Ele | ctrical Energy | Electricity WTT* G | HG Emissions | | | |
| | (MJ / km) | (g CO₂e / | ˈkm) | | (MJ / km) | (g CO ₂ e | / km) | | | |
| Outer Urban | 8.03 | 1123.52 | | | N/A | N/A | - | Data Approved by: | | Date: |
| Inner Urban | 10.10 | 1414.0 | | | N/A | N/A | | | | |
| Rural | 7.44 | 1041.2 | | | N/A | N/A | \ <u></u> | | | |
| LBC Average | 8.69 | 1215.8 | | | N/A | N/A | | | | |
| UK BUS Average | 8.06 | 1128.5 | 56 | | N/A | N/A | A Contraction of the second se | | | |
| | Tes | st Vehicle | Zero | Emissi | on Bus Certif | icate Sumr | - | uro VI Diesel E | auivalent | |
| Groon | | ions: Well-to-Wheel | | 1128.6 | g CO2e / km | | 0 | | 1290.1 | g CO2e / kn |
| | | (@ Max Pass Capad | ity) | 1120.0 | g CO2e / km | Average Diesel GHG Emissions Equivalent 1290.1 WTW CO2 per passenger km (@ Max Pass Capacity) 15.0 | | | g CO2e / ki | |
| 1111 002 | per pussenger kin | | | | Zero Emission | | | (ass oupdoiry) | 13.0 | g 0026/pass |
| | WTW GHG | saving | | 161.6 | q CO2e / km | Maximum | Theoretical Ze | ro Emission Ra | nge (km) | 372.0 |
| | % WTW GHO | | | 13% | g CO2e / km | F | uel Consumpti | on (kg / 100 km) | | 6.72 |
| Approve | ed as Zero E | mission Bus | ? (50% GH | G saving | or more) | | NO (Base | d on UK Grid I | Electricity) | |
| * WTT : Well- | -to-Tank | ** TTW | : Tank-to-Whe | el | *** WTW : W | ell-to Wheel | | | | |
| | | & Outer Urban phases | | | | Heating Req | uirement | Cell | Lower Saloon | Upper Saloor |
| rtificate will be replaced | with valid UKBC test | I due to lack of available t as and when this methe | od of certification b | ecomes availab | le. Simulated certificate is | Target Temperat | tures ±2 (°C) : | 10 | 17 | 17 |
| id until 31/12/23, at whi | ch point it will be revie | ewed. Actual usable hyd | rogen storage with | be slightly less | than gross hydrogen | Average Temperatures | across testing (°C) | NI/A | NI/A | NI/A |

| | from fully volidated multi-physics simulation tool due to look of available physical bydrogr | nouting kequiternetic | Cell | Lower Saloon | Upper Saloon | | |
|---|---|---|--|--------------|-----------------------------|------------|--|
| | Certificate will be replaced with valid UKBC test as and when this method of certification | becomes available. Simulated certificate is | Target Temperatures ±2 (°C) : | 10 | 17 | 17 | |
| | valid until 31/12/23, at which point it will be reviewed. Actual usable hydrogen storage with storage capacity due to technical reasons relating to minimum allowable working pressure | h be slightly less than gross hydrogen es. | Average Temperatures across testing (°C) | N/A | N/A | N/A | |
| | Test Numbers: | | - | | | | |
| | Certificate approved by: | Brian Maybin | Certificate Approved by: | 7 (16 | | im Griffen | |
| | On behalf of Bus | · · · · · · · · · · · · | On behalf of DfT / Zemo Partnership | Tim M | $\mathcal{O}^{\mathcal{O}}$ | - | |
| L | manufacturer 06.07.2023 | | on bonal of bit / Zano ranneranip | U y | 0 | 4.07.2023 | |

Note: Hydrogen Fuel Pathway - Off-Site, On-Shore Electrolysis, using UK Grid Electricity. Compressed gas delivery (200km), 350bar dispense. For more information on hydrogen production pathways, please contact **hello@zemo.org.uk**