Zemo Partnership

Zero Emission Bus Certification ID: ZEB-WRIGHTBUS-GB-KITE-HYDROLINER-FCEV-2023 | Approved Test facility | **N/A - Simulated**

Simulated Zero Emission Bus Certificate

				DYNAMOMETER SETTINGS		
Customer:	**Wrightbus**					
Customer Address:	**201 Galgorm Rd, Ballymena, County Antrim, BT42 1SA**	*Telematics Capability*	Yes	Test Weight	14210	kg
Test Purpose:	**Zero Emission Bus Testing**	*Maximum Speed (km/h)*	80 km/h	F°	N/A	N
Vehicle Manufacturer:	**Wrightbus**	*Seated Capacity*	40	F¹	N/A	N/kmh
Vehicle Model Name:	**GB Kite Hydroliner FCEV**	*Passenger Capacity*	90	F²	N/A	N/kmh ²
Powertrain Technology	**Hydrogen Fuel Cell**	*Declared Unladen Weight (kg)*	12605	*Equivalent test passengers*	N/A	passengers
Powetrain Configuration	**Direct Drive**	*Gross Weight (kg)*	18800	*Measured Unladen Weight*	N/A	kg
Zero Emission Heating	**HVAC utilising fuel-cell waste heat**	*GVW Check*	**OK**	Number of conseuitve tests completed	N/A	Tests

Battery Specification		Charging and Refuelling Capability		Hydrogen Specification	
Battery Manufacturer	**Microvast**	**Plug Type**	**N/A**	**Fuel Cell Manufacturer**	**Ballard**
Battery Chemistry	**NMC**	**Max Charge Capability (kW)**	**N/A**	**Fuel Cell Power Rating (kW)**	**70**
Battery Installed Capacity (kWh)	**54**	**Charger Compatibility**	**N/A**	**Installed Hydrogen Storage Capacity (kg)**	**39.6**
Battery Usable Capacity (kWh)*	**27**	**Charge time from 20-80% SOC****	**N/A**	**Usable Hydrogen Storage Pressure (kg)***	**37.5**

* Recommended manufacturer guideline, subject to warranty ** Based on manufacturer estimate

Declared fuel, properties and source plus 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***	**7.22**	**g CO2e / MJ**	*Capacity of Tanker (kg)*	**N/A**	*Fuel Type / Pathway*	**Off-site Electrolyser**
Energy Density	***Hydrogen***	**120**	**MJ / kg**	*Transport Distance of Hydrogen (km)*	**200 km**	*Energy Source*	**Renewable**

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 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	0.38	0.058	5.78
Inner Urban	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19	0.074	7.41
Rural	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.40	0.054	5.38
LBC Average	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.56	0.063	6.29
UK BUS Average	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.96	0.058	**5.84**

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

Test Charger Used	**N/A**	**Total measured energy consumed on vehicle (kWh)[1]**	**N/A**	**Max ZE Range at 100% Usable Tank Capacity (km)**	**642**
Hydrogen Energy Over Test (kWh)	**N/A**	**Measured grid energy during charging (kWh)**	**N/A**	**Max ZE Range at 80% Usable Tank Capacity (km)**	**514**
Hydrogen Delivered to Vehicle (kg)	**N/A**	**Grid-to-Wheel efficiency (%)[2]**	**N/A**	**Test Distance Travelled (km)**	**N/A**

[1] Total measured energy may include 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	6.94	50.08	N/A	N/A
Inner Urban	8.89	64.20	N/A	N/A
Rural	6.45	46.59	N/A	N/A
LBC Average	7.55	54.52	N/A	N/A
UK BUS Average	7.01	50.58	N/A	N/A

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*		
Greenhouse Gas Emissions: Well-to-Wheel	**50.6**	**g CO2e / km**	**Average Diesel GHG Emissions Equivalent**	**1327.8**	**g CO2e / km**
WTW CO2 per passenger km (@ Max Pass Capacity)	**0.6**	**g CO2e/pass km**	**WTW CO2 per passenger km (@ Max Pass Capacity)**	**14.8**	**g CO2e/pass km**

Overall Zero Emission Bus Performance

WTW GHG saving	**1277.2**	**g CO2e / km**	**Maximum Theoretical Zero Emission Range (km)**	**642.4**
% WTW GHG saving	**96%**	**g CO2e / km**	**Fuel Consumption (kg / 100 km)**	**5.84**
Approved as Zero Emission Bus? (50% GHG saving or more)			***YES***	

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

COMMENTS: LBC = London Bus Cycle - Inner & Outer Urban phases of UKBC only. Certificate generated using simulated data from fully-validated multi-physics simulation tool due to lack of available physical hydrogen testing and measurement facility. Certificate will be replaced with valid UKBC test as and when this method of certification becomes available. Simulated certificate is valid until 31/12/23, at which point it will be reviewed. Actual usable hydrogen storage with be slightly less than gross hydrogen storage capacity due to technical reasons relating to minimum allowable working pressures.

Heating Requirement	Cell	Lower Saloon	Upper Saloon
Target Temperatures ±2 (°C) :	10	17	17
Average Temperatures across testing (°C)	N/A	N/A	N/A

Test Numbers:

Certificate approved by: *On behalf of Bus manufacturer* — Brian Maybin — 06.07.2023

Certificate Approved by: *On behalf of DfT / Zemo Partnership* — Tim Griffen — 04.07.2023

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**

Zemo Partnership

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Simulated Zero Emission Bus Certificate

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Vehicle Model Name:	**GB Kite Hydroliner FCEV**	*Passenger Capacity*	90	F²	N/A	N/kmh ²
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Battery Installed Capacity (kWh)	**54**	**Charger Compatibility**	**N/A**	**Installed Hydrogen Storage Capacity (kg)**	**39.6**
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* Recommended manufacturer guideline, subject to warranty ** Based on manufacturer estimate

Declared fuel, properties and source plus 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**	*Transport Distance of Hydrogen (km)*	**200 km**	*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 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	0.38	0.058	5.78
Inner Urban	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.19	0.074	7.41
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Hydrogen Energy Over Test (kWh)	**N/A**	**Measured grid energy during charging (kWh)**	**N/A**	**Max ZE Range at 80% Usable Tank Capacity (km)**	**514**
Hydrogen Delivered to Vehicle (kg)	**N/A**	**Grid-to-Wheel efficiency (%)[2]**	**N/A**	**Test Distance Travelled (km)**	**N/A**

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

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

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Outer Urban	6.94	970.69	N/A	N/A
Inner Urban	8.89	1244.38	N/A	N/A
Rural	6.45	903.11	N/A	N/A
LBC Average	7.55	1056.71	N/A	N/A
UK BUS Average	7.01	980.42	N/A	N/A

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*		
Greenhouse Gas Emissions: Well-to-Wheel	**980.4**	**g CO2e / km**	**Average Diesel GHG Emissions Equivalent**	**1327.8**	**g CO2e / km**
WTW CO2 per passenger km (@ Max Pass Capacity)	**10.9**	**g CO2e/pass km**	**WTW CO2 per passenger km (@ Max Pass Capacity)**	**14.8**	**g CO2e/pass km**

Overall Zero Emission Bus Performance

WTW GHG saving	**347.4 g CO2e / km**	**Maximum Theoretical Zero Emission Range (km)**	**642.4**
% WTW GHG saving	**26% g CO2e / km**	**Fuel Consumption (kg / 100 km)**	**5.84**
Approved as Zero Emission Bus? (50% GHG saving or more)		***NO (*** *Based on UK Grid Electricity)*	

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

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Average Temperatures across testing (°C)	N/A	N/A	N/A

Test Numbers:

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