

London Hybrid Bus Trials



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London Buses

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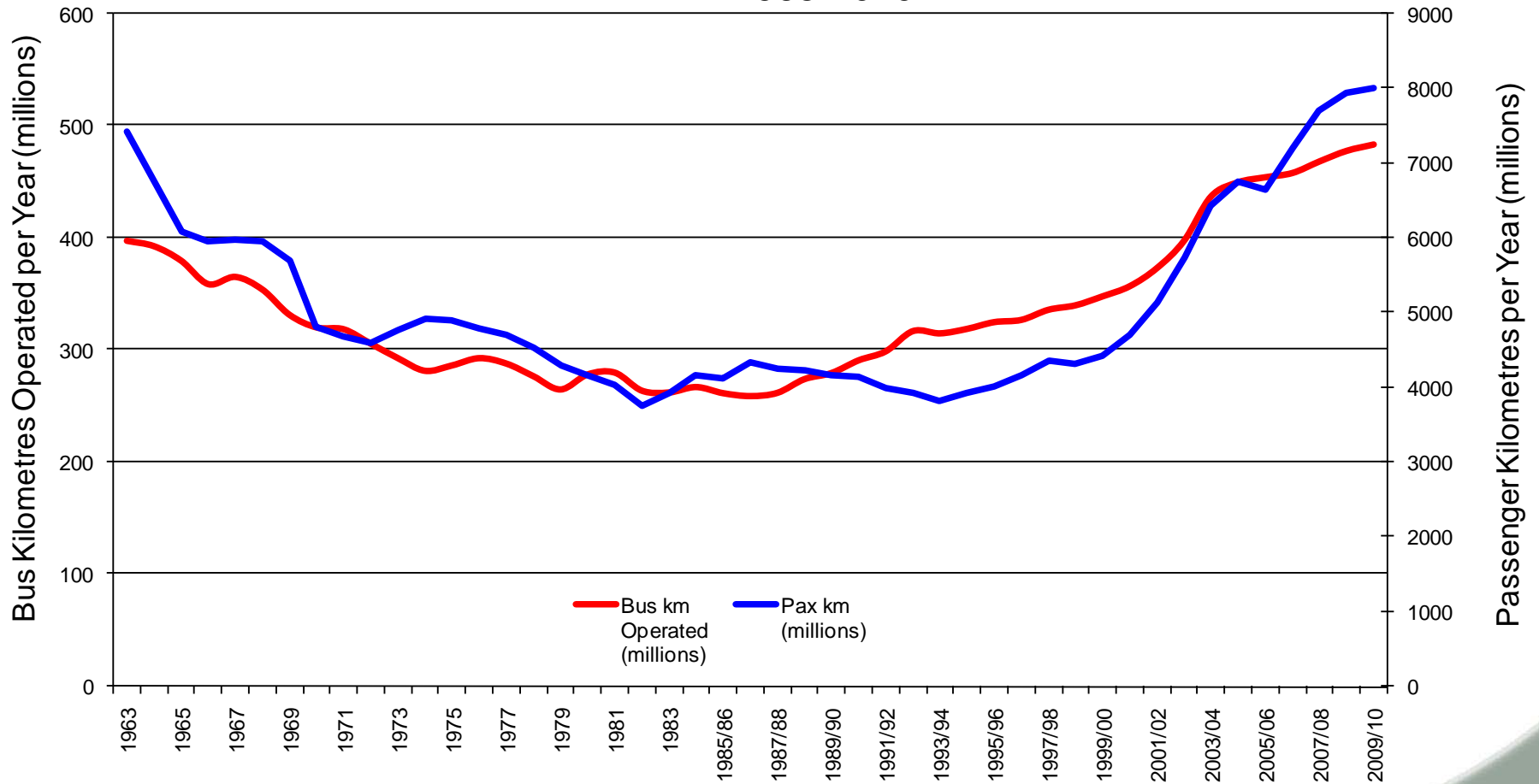
Network scale

- **Buses operate 24 hours per day, 7 days per week**
- **6.4 million journeys per weekday; 2257m journeys in 2009/10**
- **Approximately 700 routes**
- **8,500 + buses**
- **19,500 bus stops**



Bus usage in London 1963-2010

London bus network: service volume and usage
1963-2010



Environmental priorities

- **Climate Change**
 - Carbon dioxide (CO₂) and other greenhouse gases such as nitrous oxide
- **Air Quality**
 - Fine particles (PM10)
 - Oxides of nitrogen (NO_x) and nitrogen dioxide (NO₂)
- **Noise and vibration**
 - Idling buses
 - Engine/fan noise

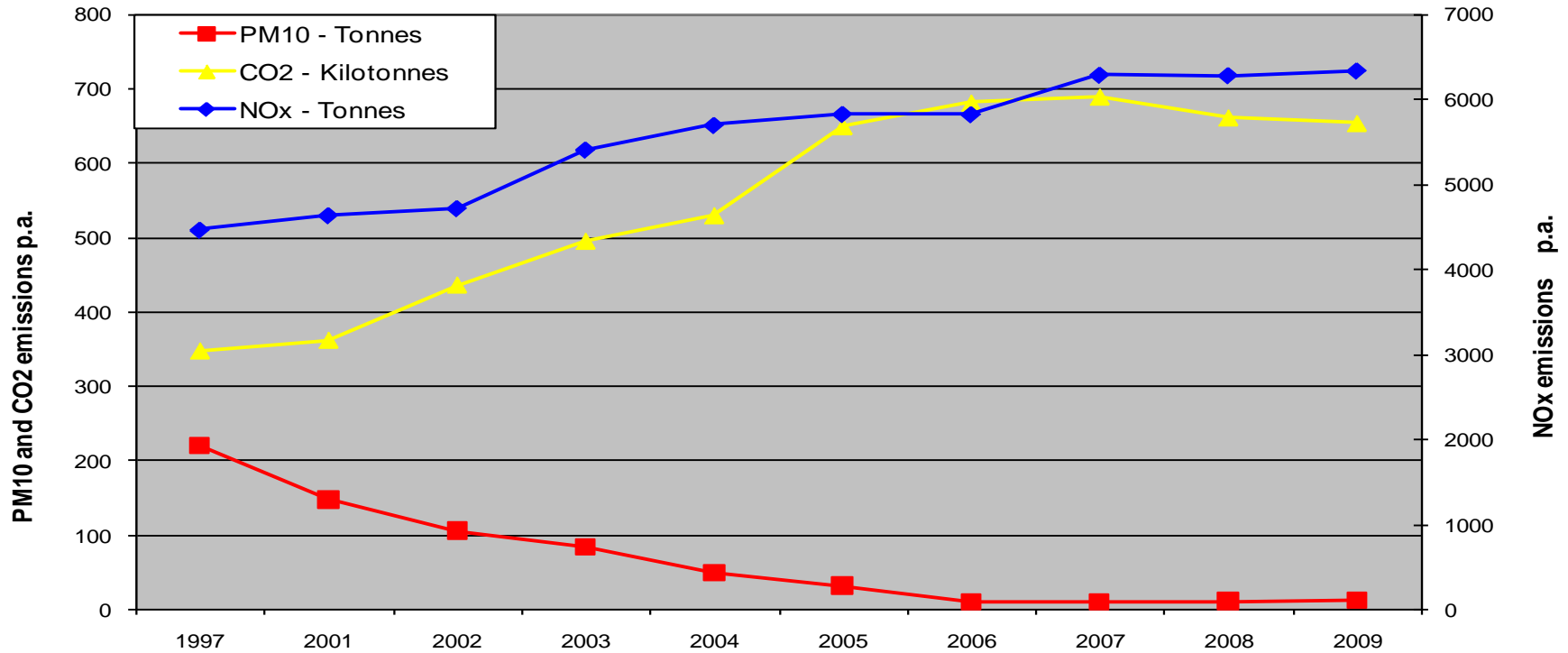


CO₂ impact of the bus fleet

- **5% of London's transport CO₂ emissions come from buses**
- **Buses are largest contributor to TfL's CO₂ footprint accounting for 38% of emissions**
- **Network consumes 240 million litres of diesel per year**
- **610,000 tonnes of CO₂ emissions produced per annum**



Fleet emission trends 1997-2009



Hybrid Trials

- **Initial emissions tests at Millbrook showed significant reduction in DD hybrid emissions compared to Euro IV:**
 - **31% reduction in fuel consumption/CO2**
 - **33% reduction in particulates**
 - **12% reduction in NOx**
 - **98% reduction in carbon monoxide**
 - **76% reduction in hydrocarbons**
 - **5 dBA noise reduction on EC drive by test**
- **TfL committed a programme of up to 60 hybrid buses from any manufacturer that could provide a hybrid bus meeting London's specifications**
- **Currently the London trial has 56 hybrid buses from all previous diesel bus suppliers**



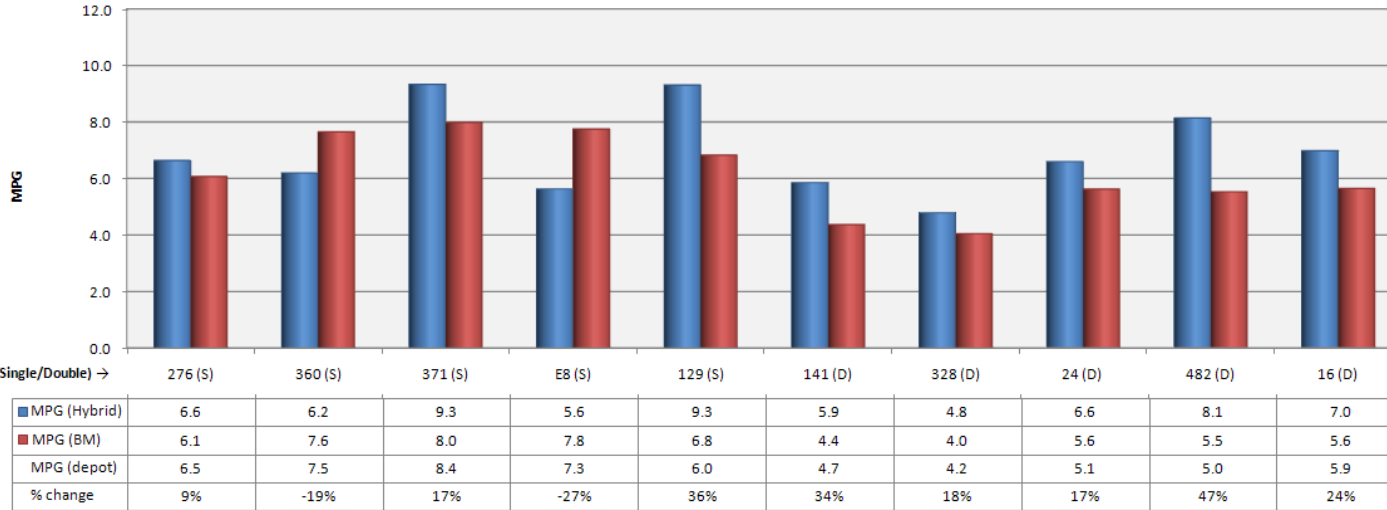
Hybrid Trials

- The first single-deck diesel electric hybrid buses were introduced in March 2006
- Each supplier has developed a variation in the hybrid technology that provides an extensive review of most known systems
- Variations include
 - Single and double-deck buses
 - Series, parallel and blended systems
 - Gel lead acid, Nickel metal hydride and Lithium Iron batteries
 - Engines options from 2.4ltr to 6ltr
 - Control systems from BAE, Siemens, Allison, Enova and Volvo
- The evaluation process will cover
 - 3 Single deck products
 - 3 Double deck products
 - 7 Operators
 - 10 Routes in London

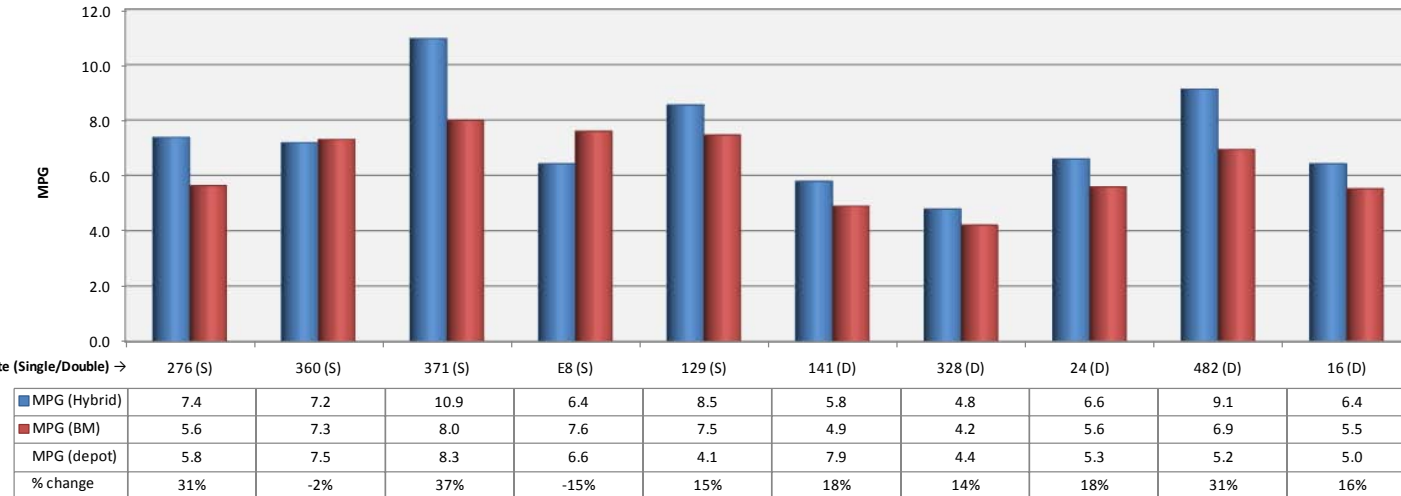


Hybrid performance

PERIOD 13 MPG



PERIOD 13 YTD MPG



Emissions Standards and Testing

DOUBLE-DECK

Vehicle	System	Euro	HC (g/km)	CO (g/km)	NOx (g/km)	Pm (g/km)	CO2 (g/km)	Fuel litres / 100km	mpg
Hybrid Objective Standards	Any	E4	0.015	0.040	7.500	0.030	850.0	33.000	8.6
Green Bus Fund standard		E5					878.80		
Wright Gemini 1H	Siemens Series	E4	0.012	0.039	7.616	0.060	866.0	32.800	8.6
Wright Gemini 2H	Siemens Series	E4	0.044	0.115	5.248	0.097	734.4	27.746	10.1
ADL Enviro 400H	BAE Series	E4	0.053	0.815	8.792	0.029	856.1	32.380	8.8
Volvo	ISAM	E5 +EE	0.020	0.152	6.738	0.043	937.3	35.400	8.1
Comparative Standard	Any	E4	0.051	1.620	8.583	0.045	1253.1	47.600	6.4
Scania	Diesel EGR	E4	0.049	0.090	11.546	0.130	1572.1	59.380	4.8
Wright Gemini 2	Diesel SCR	E5	0.028	1.985	7.734	0.053	1250.6	47.350	6.0
ADL Enviro 400	Diesel SCR	E4	0.051	1.620	8.646	0.045	1253.1	47.600	5.9
Volvo B9TL / ADL	Diesel SCR	E4	0.000	0.013	8.583	0.030	1670.3	63.080	4.5



Emissions Standards and Testing

SINGLE-DECK

Vehicle	System	Euro	HC (g/km)	CO (g/km)	NOx (g/km)	Pm (g/km)	CO2 (g/km)	Fuel litres / 100km	mpg
Hybrid Objective Standards	Any	E4	0.012	0.050	1.500	0.010	700.0	25.000	11.300
Green Bus Fund standard							878.80		
Wright H	Enova Series	E4	0.012	0.051	1.435	0.079	701.0	26.600	10.620
Wright H	Enova Series	E4	0.019	0.030	3.180	0.138	1081.0	40.800	7.000
Optare Tempo H	Allison EP40	E5	0.114	1.202	11.896	0.023	991.9	37.540	7.400
ADL Enviro 200H	BAE Series	E5	0.028	0.899	15.852	0.023	726.6	27.500	10.080
Comparative Standard	Any	E4	0.031	0.946	8.604	0.029	966.1	36.680	7.700
ADL Enviro 200	Diesel SCR	E4	0.031	0.946	8.604	0.029	966.1	36.680	7.700



Future Hybrid Programme

- **6 hybrid buses have been awarded on a commercial basis to operate on route 360**
- **Green Bus Fund – TfL secured £5m to fund an additional 50 hybrid buses**
- **Proposed roll out into fleet of successful trial buses**
 - **Up to 300 by 2012**
- **After 2012 all new buses entering the fleet will be of hybrid technology**
 - **Normally between 500 to 700 buses per year as annual intake**



Lesson learnt

- **Ensure operators are issued with data collection forms in advance of hybrid bus operation for monitoring of hybrid bus performance**
- **Provide robust benchmark data for performance comparison with diesel buses operating on the same route as hybrid buses**
- **Perform regular external livery and internal project promotional notice audits**
- **Hold regular meetings with key operational stakeholders, such as bus operators and manufacturers to discuss key issues**
- **Set aside financial provisions for driver training and hybrid bus maintenance above a standard diesel bus**

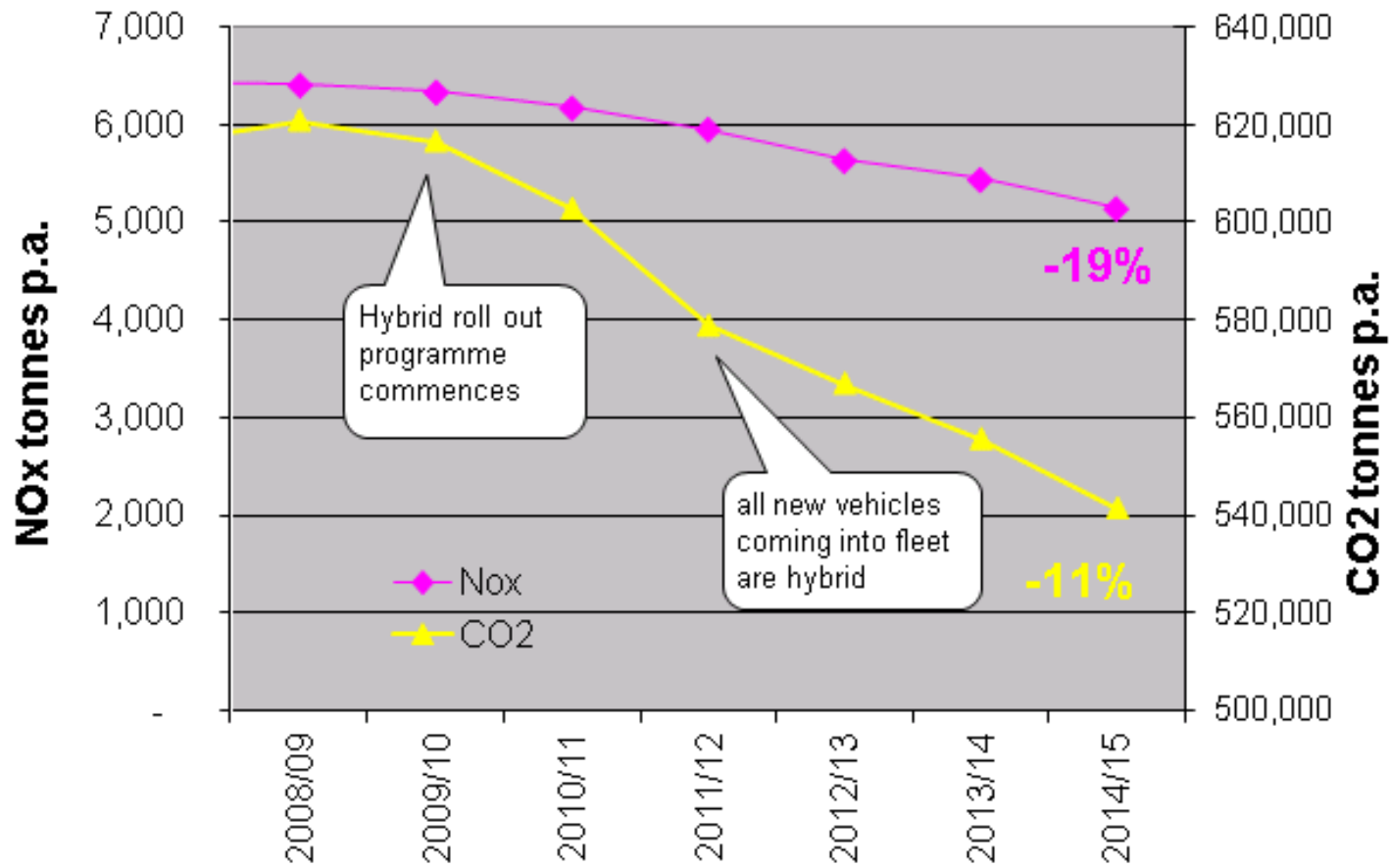


Hydrogen Hybrid Fuel Cell bus for 2010

- London Buses is now taking steps towards a hydrogen bus programme to build on the success of the CUTE project
- A fleet of 5 hydrogen buses will be operated on route RV1 starting in 2010. The technology will be hybrid hydrogen fuel cell provided from ISE in the USA.
- A dedicated hydrogen refuelling facility will be built at the bus depot – main objective will be reliability, but consideration will be given to reducing CO2 emissions where possible
- Aim to achieve operation as close as possible to diesel buses
 - **Full route peak vehicle requirement operated by Hybrid Hydrogen Fuel Cell buses**
 - **18 hours per day with 370km range without refuelling**
 - **364 days per year**
 - **Five year contract**
 - **Fast refuelling of buses in quick succession**



Impact of environmental initiatives



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