

London's Hybrid and Hydrogen Bus Programmes

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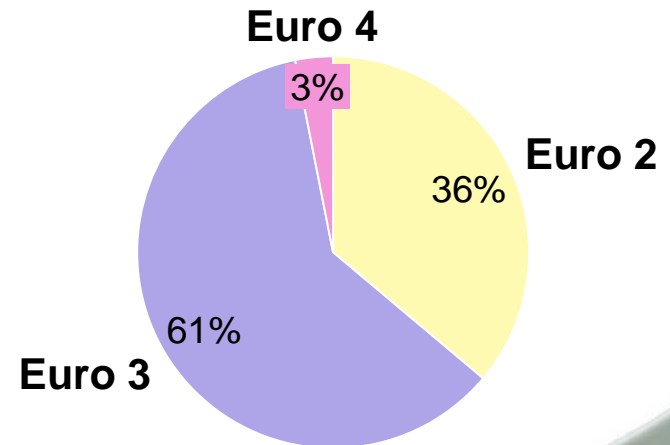
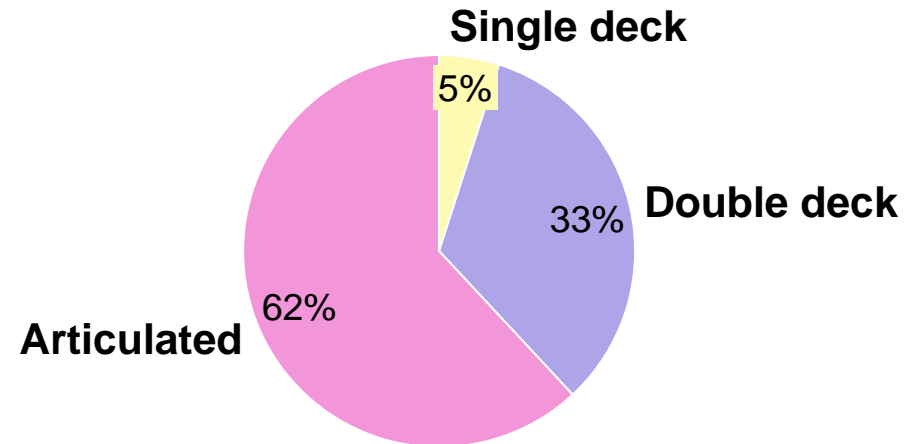
Presentation summary

- **Overview of the bus fleet and its environmental impact**
- **Hybrid buses – benefits and future developments**
- **Hybrid programme in London**
- **Hydrogen buses – benefits and challenges**
- **Hydrogen programme in London**
- **Hydrogen Bus Alliance**



London Bus Network - overview

- 8,000 vehicles in fleet (with peak vehicle requirement of 7,000)
- All Euro 2 and 3 vehicles are fitted with particulate filters
- Bus use has grown considerably since 1999/00, with 40% aggregate growth in number of trips
- 460 million operated km and 1.9 billion passenger trips in 2006/7
- Forecast growth of 4% operated bus km between 2006/07 and 2014/15



CO₂ impact of the bus fleet

- Buses are largest contributor to Transport for London's CO₂ footprint, accounting for 35% of emissions
- Bus network consumes 240 million litres of diesel per year
- 610,000 tonnes of CO₂ is emitted each year
- CO₂ emissions are forecast to grow in line with increased operated bus km
- New vehicle technology is needed to reduce trend
- Hybrid technology offers most cost-effective means of carbon reduction in short to medium term
- Long term objective is to move to zero emission drive train such as hydrogen-powered fuel cell technology



Hybrids – the benefits

- **At least 30% reduction in fuel consumption and CO2 obtained through chassis dyno testing – field trials show similar fuel savings**
- **Reduction in local air pollutants e.g. NOx (further testing work to be undertaken before benefits can be quantified)**
- **Lower exterior and interior noise – at least 4 dBA lower on EC drive by noise test**
- **Smoother acceleration creates better passenger environment**
- **Lower operating costs due to reduced maintenance requirements**



Hybrids – challenges

- **Capital cost is approximately 75% higher than diesel**
- **No tax incentives or government support for hybrid bus technology in UK**
- **Need to accelerate volume production in UK and rest of Europe**
- **Durability of key components still unknown, especially battery technology**



Hybrids – future developments

- **Most European bus manufacturers have hybrid development programmes underway**
- **Early operational experience has led to refinement of technology**
- **Battery technology likely to improve significantly in terms of performance and durability**
- **Use of alternative energy sources becoming more widespread e.g., ultra/super capacitors**



London's hybrid programme – Phase 1

- **Trial and evaluation:**
 - 13 hybrids in operation to date (12 single deck, 1 double deck)
 - Total of 60 vehicles to be introduced by December 2008
 - Objective is to trial different technologies from many manufacturers and gain operator experience
- **Eight manufacturers supplying single, double and articulated buses using a range of hybrid systems - series/parallel, engine size, battery and ultra/super capacitor technology**
- **Two U.S. systems being adapted for the UK market (BAE used in New York and Allison in Seattle)**
- **Some suppliers (e.g., Volvo) are using systems also designed for the urban truck delivery market – potential for economies of scale**



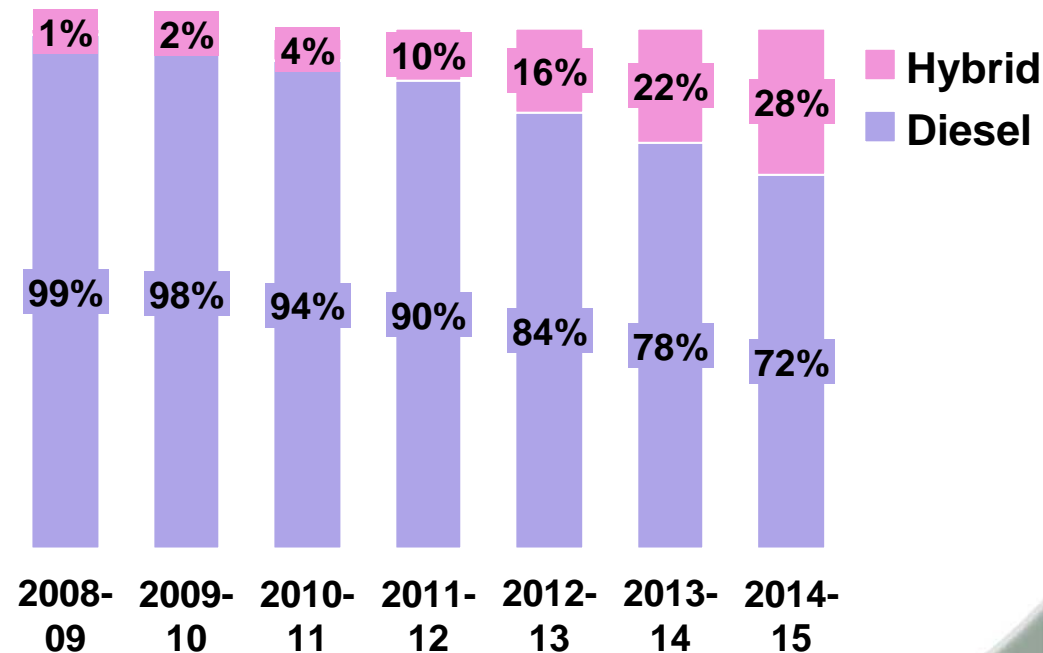
Launch of world's first double deck hybrid bus October 2006



London's Hybrid programme – Phase 2

- Once the technology is proven in Phase 1, the technology will be rolled out into the fleet as follows:
 - 100 vehicles by March 2010
 - 200 vehicles by March 2011
 - 500+ vehicles by March 2012 and each year thereafter

Projected hybrid roll out into London fleet



Hydrogen fuel cell buses - benefits

- **Zero emissions at point of use**
- **Potential for significant Well To Wheel CO₂ reduction**
- **Reduced reliance on diesel – security of supply benefits**
- **Lower interior and exterior noise levels**
- **Smooth and comfortable ride for passengers**



Hydrogen fuel cell buses – challenges (1)

Vehicle technology:

- **Premium cost of vehicles and hydrogen – when will the technology reach commercialisation?**
- **Vehicle efficiency and range – most manufacturers are now looking at hybridisation to achieve this**
- **Lifetime/warranty of fuel cell stacks**
- **Vehicle certification?**



Hydrogen fuel cell buses – challenges (2)

Hydrogen Infrastructure:

- **Regulations and Standards – need for set of consistent standards across Europe**
- **Public perceptions of hydrogen – perceived safety concerns particularly around refueling facilities**
- **Scaling up depot refueling facilities – pipeline v onsite production?**
- **Sustainable hydrogen production – can we achieve the holy grail of ‘green’ hydrogen for large scale production plants?**



London's hydrogen transport programme

CUTE/HyFLEET:CUTE project

- Completed three year trial of three DaimlerChrysler fuel cell buses in January 2007 as part of European project part funded by the EC
- Very good operational availability achieved for the buses – 90% on average
- Main limitation was the high fuel consumption and limited range of the vehicles
- Next generation vehicle will address this through hybridisation



CUTE fuel cell bus in service on route RV1

Results from CUTE and HyFLEET:CUTE can be obtained from the following websites:

www.fuel-cell-bus-club.com and www.global-hydrogen-bus-platform.com



London's hydrogen transport programme (1)

First stage deployment

- Following on from the success of CUTE, TfL announced signing of contract for 10 new hydrogen buses on 13 November
- The buses will be manufactured by ISE, Wrights and Ballard
- All 10 hydrogen buses will be operate on one London route, starting in 2009/10
- Five buses will be fuel cell and five will be hydrogen internal combustion engine allowing for full comparison of the two technologies
- A dedicated hydrogen refuelling facility will be built at the bus depot



Design of new hydrogen bus for London



London's hydrogen transport programme (2)

- **Principle objective of this project is to assess whether hydrogen/fuel cell buses can match the operational performance of diesel**
- **Operational requirements include:**
 - 20 hour operation per day for 364 days per year
 - 300km range
 - Vehicle availability target of 95%
 - Fast refuelling of buses in quick succession (refuel 8 buses in 4 hours)
 - Target fuel consumption of 11 km per kg for fuel cell and 7 km per kg for ICE buses



Hydrogen Bus Alliance (1)

- **London established a Hydrogen Bus Alliance in October 2006 with five other cities and regions around the world engaged in hydrogen bus programmes**
- **Aim of Alliance is to:**
 - **Give clear signal to the market that there is demand for hydrogen buses**
 - **Work with hydrogen bus industry to develop a pathway towards commercialisation**
 - **Achieve economies of scale where possible through co-ordinating procurement programmes**



**Hydrogen Bus Alliance launch
in Brussels**



Hydrogen Bus Alliance (2)

- To date there are eight cities and regions represented in the Alliance but others have expressed interest in joining
- Current members include:
 - Amsterdam
 - Berlin
 - British Columbia, Canada
 - Cologne
 - Hamburg
 - London
 - Western Australia
 - South Tyrol
- New members welcome who are actively seeking to procure hydrogen buses in near future and have political support
- For more information visit the website www.hydrogenbusalliance.org

