Entry points for cities – electric buses

Key policies to support the deployment of electric buses
Experience from London
Current technology outlook

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Group Product Manager
Alexander Dennis Limited
Alexander Dennis Limited

- World’s largest double deck bus manufacturer with over 120 years of experience in bus and coach design and manufacture
- 2,500 team members
- Extensive global experience in vehicle supply and support across Europe, Asia Pacific and North America
- Unwavering focus on designing lightweight, reliable vehicles which increase uptime and reduce whole life costs while responding to increasingly stringent environmental requirements and improving the passengers’ on-board experience
Worldwide presence

- **United Kingdom**
  - Larbert · Falkirk · Guildford · Scarborough
  - Skelmersdale · Anston · Harlow

- **Germany**
  - Berlin

- **Canada**
  - Toronto · Ottawa

- **USA**
  - Nappanee, IN
  - Canyon Lake, CA
  - Henderson, NV

- **Mexico**
  - Mexico City

- **Mexico**
  - Mexico City

- **China**
  - Zhuhai

- **Hong Kong**

- **Singapore**

- **Malaysia**
  - Puchong · Kuala Lumpur

- **New Zealand**
  - Tauranga
  - Auckland

- **Manufacturing locations**
- **Sales & aftermarket bases**
Key policies to support the deployment of electric buses
Electric buses: what are we talking about?

- Battery bus
- Fuel cell bus
- Plug-in hybrid bus
- Trolleybus

Electric bus: zero emission at point of operation
Electric buses: it is not all about the vehicle!

- Strategy
- Funding
- Infrastructure
- Vehicle
- Operations
- Synergies
Electric buses: system approach is necessary
Electric buses are not (yet) cost-neutral

- **Higher upfront costs** due to expensive batteries
  - Decrease expected, but will remain higher than conventional buses
- **Lower operational cost** due to reduced fuel cost
  - Scope for further reduction in maintenance cost
- **Total Cost of Ownership** parity expected in medium term
  - High upfront investment will remain challenging
- **Investment in wider benefits**
  - Improved quality of life through lower noise and emissions
    - Reduced strain on healthcare system
  - Fighting climate change
Germany: federal funding

- Administered by Federal Ministry for the Environment
- Available to public transport operators
- **Fixed proportion funding of additional investment** over conventional buses
  - Battery buses & charging infrastructure: 80%
  - Plug-in hybrid buses & charging infrastructure: 40%
  - Workshop equipment & staff training: 40%
- **Minimum 5 buses** per operator

- Alternatively state-level funding available in some federal states
France: Energy Transition Act

- Transition to cleaner fuels written into national law
- Applies to agglomerations over 250,000 inhabitants
  - Also smaller towns if they are subject to air quality management plans
- Defines different minimum environmental standards for centres and suburban areas
  - City centres: battery, fuel cell or biogas
  - Suburban areas: diesel-electric hybrid, natural gas or other biofuels
- Phased introduction
  - 50% of new buses from 2020
  - 100% of new buses from 2025
UK: Mayor of London’s Transport Strategy

- Published March 2018
- **Emissions timeline** for buses
  - NOW – new double deck buses are hybrid
  - 2020 – all existing buses retrofitted to Euro VI standard
  - 2020 – new single deck buses will be zero emission
  - 2025 – new double deck buses will be zero emission
  - 2037 – all existing buses in London to be zero emission
- Operators bid for **contracts** with **higher price** per mile
UK: Ultra Low Emission Bus funding

- Accreditation using LowCVP UK Bus test cycle to demonstrate well-to-wheel greenhouse gas emission reduction (CO$_2$ equivalent, CO$_2$e)
  - **ULEB** – Ultra Low Emission Bus
    30% less CO$_2$e than normal Euro VI diesel bus
- **£48m funding** available from UK Government in *Ultra-Low Emission Bus Scheme*
  - Minimum requirement is ULEB certification
  - Competitive bidding without fixed funding rate per vehicle
  - Electric vehicles favoured with higher funding available for zero emission range
USA: FTA Low-No Grants

- **Low or No Emission Vehicle Program** administered by **Federal Transit Administration**
- Annual funding rounds
  - $84.45m in 2018 funding 52 projects in 41 states
- **Competitive applications** to maximise value achieved with grants
- Funding for vehicles, charging infrastructure and wider related investment (e.g. facilities)
India: FAME

- Department for Heavy Industry provides funding through *Faster Adoption and Manufacturing of Electric Vehicles* (FAME) programme
- 60% of total vehicle purchase cost funded
- **11 cities** selected for total of 500 buses
  - 15, 40 or 150 buses per city
- High disparity in prices for comparable buses
  - Differences in purchase/leasing conditions and required guarantees
- **Delhi** separately procuring 700 electric buses
  - Funding through state instead of federal
Experience from London
London routes 507 and 521
Launch contract

- **Turn-key contract** including:
  - 51 BYD ADL Enviro200EV **buses**
  - **Maintenance** over 5 years
  - **Infrastructure** for overnight charging in depot
  - Installation including **civil works**

- Signed July 2015 between **Go-Ahead London** and three suppliers:
  - **BYD** (primary contractor to Go-Ahead London)
  - **ADL**
  - **SSE** (utilities provider)
    - In liaison with UK Power Networks (grid operator)

- £19m contract value
BYD ADL Enviro200EV

- Chassis, driveline and battery technology from BYD
  - Produced in China
  - Same proven technology as all-BYD vehicles

- Body from ADL
  - Built in Scotland
  - Lightweight aluminium construction
  - Commonality with Enviro200 range
Waterloo Garage

- **Central location very close to routes**
  - Highly space constrained with **no room for expansion**
  - Closed at weekends due to sensitive location
- **46 buses allocated**
  - Using all available space
  - 4 buses fewer than previous diesel fleet
- **5 buses operated from Camberwell Garage**
  - Used to cover weekend vehicle requirement
Full depot conversion

- First bus depot in Europe to have been completely converted from diesel to electric
- Overnight charging only
- **2.2MW** maximum power requirement
- **Smart charging** lowers actual requirement
- No regular top-ups between peaks
  - Not required for range
  - Large consumers nearby in grid
  - Cheaper tariff at night
Charging infrastructure design

- 2 substations
- 2 transformers from 11,000V to 400V
- 2 distribution boards
- 43 charging units
  - AC dual plug design with Combo2 plugs
  - 39 rated at 40kW
  - 4 rated at 80kW
  - central charging island
  - 3 parking bays without charging units
- 99.8% mileage maintained during installation
Installed charging infrastructure
Entry into service

- **Production rate of 5 buses per week**
  - Dedicated production line at ADL’s Falkirk plant

- **Delivery from Scotland to London under own power**
  - 415 miles distance
  - One recharging stop at ADL site in Skelmersdale, Lancashire

- **Official launch on 9 September 2016**

- **All buses in service by end of 2016**
  - **Availability** consistently above 98%
Enviro200EV in London and other UK cities
Enviro400EV double decker

- Coming in 2019 to continue the successful partnership between BYD and ADL
- **37 ordered for London** by operator **Metroline**
- **Stagecoach** plans fleet of **105 in Manchester**, subject to allocation of funding
Current technology outlook
Energy density in batteries

- **Underlying challenge of physics**
  - Batteries have far lower energy density than liquid fuels or compressed gaseous fuels
  - Not enough spare weight allowance or unused space on buses
Energy consumption defines range

- Strongly depends on specification, local conditions, style of driving
- ‘Household’ figures
  - Without heating/cooling/air-conditioning
    - 12m bus: ~1.1 kWh/km in urban conditions (SORT 2)
    - 18m bus: ~1.8 kWh/km in urban conditions (SORT 2)
  - With electric heating/cooling/air-conditioning
    - 12m bus: up to ~2.5 kWh/km in same conditions
    - 18m bus: up to ~3.5 kWh/km in same conditions
    - In moderate climates, heating more energy intensive than air-con
- Worst case to ensure all-year performance
Overnight / depot charging
Opportunity charging – at terminus
Opportunity charging – charging hubs
In-motion charging
Charging infrastructure – cost examples

**Overnight charging**
- AC on-board charger, low power: €2,000 +
- AC station, low power: €6,000 [1]
- DC plug charger, 80kW: €13,000 (Kraków, Poland)

**Opportunity charging**
- Gantry mast: €50,000 (Hannover, Germany)
- Pantrograph mast, including charger, grid connection and installation: €450,000 (Ostrava, Czech Republic)
- 3x pantrograph masts, 3x 300kW chargers at terminus + 4x 22kW chargers in depot: £1.08 million (Harrogate, UK)

**Hydrogen**
- Hydrogen filling station: €2 million (Germany), €16 million (Riga, Latvia)

**In-motion charging**
- Trolleybus catenary, new system: €1.7 million per km (Osnabrück, Germany)

**Grid connection**
- Low voltage: €700/metre [1]
- High voltage: €1,000/metre [1]

**Substation**
- €10,000 start-up cost + €17,000 per 1MW [1]

Maintenance

- Staff needs to be trained in **handling high voltage components**
- Increase in components located on roof
  - Installation of platforms at maintenance bays
- Different **wear and tear** from conventional buses
  - In time should make upkeep cheaper
- Downtime may be caused by technology not specific to electric buses
China: 98% of world market for electric buses

Electric bus sales per year

- Europe
- North America
- China

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China: economies of scale
Thank you

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