

**TRANSPORT
FOR LONDON**

EVERY JOURNEY MATTERS



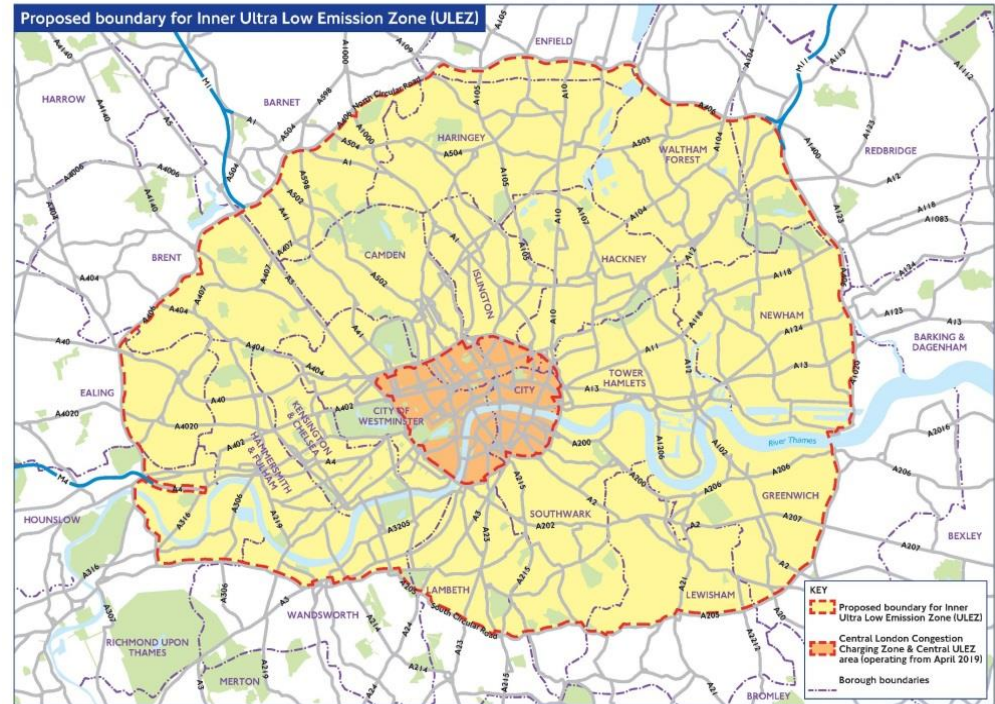
Integrating electric road vehicles with public transport electrical infrastructure in London

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London Context

- **Fast growing city**
- **Air quality**
- **Political will**
- **EV uptake**
- **Electricity demand and distribution**



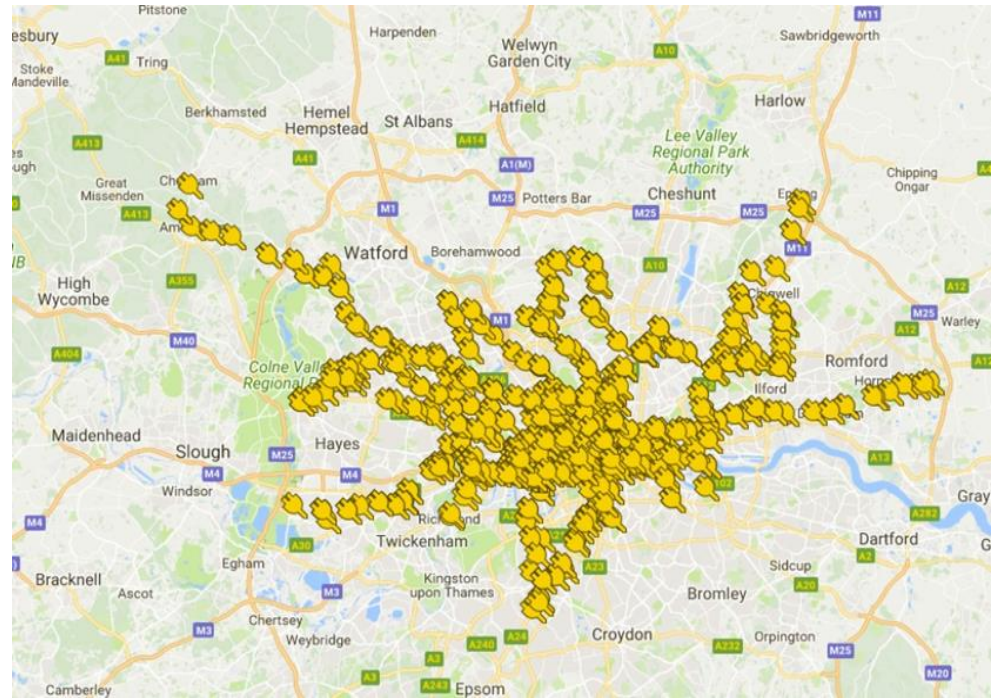
Electrifying London Bus Routes

- Overnight or opportunity charging
- Operational schedules
- 675 routes, >9000 buses, ~90 garages, annually almost 0.5Bn km travelled and 2Bn passenger journeys served



TfL electricity infrastructure

- **London Underground (LU) Electricity Grid**
 - Major AC and DC electricity grid across the city
 - Sometimes deeply buried
 - Demand constrains from underground operations
 - Operating rules



Using the LU AC Grid for EV Charging

- **Complex interplay of supply and demand**
- **High reliability and redundancy but dirty power**
- **Very tightly constrained operating rules**
- **Cost of groundworks**
- **Proof of concept**



Validating the connection

- Ensure no detrimental effects on grid reliability
- Ensure charge points will operate from LU grid
- 6 7kW charge points
- Stepped approach to acceptance testing
- Vehicles integrated into regular fleet operations



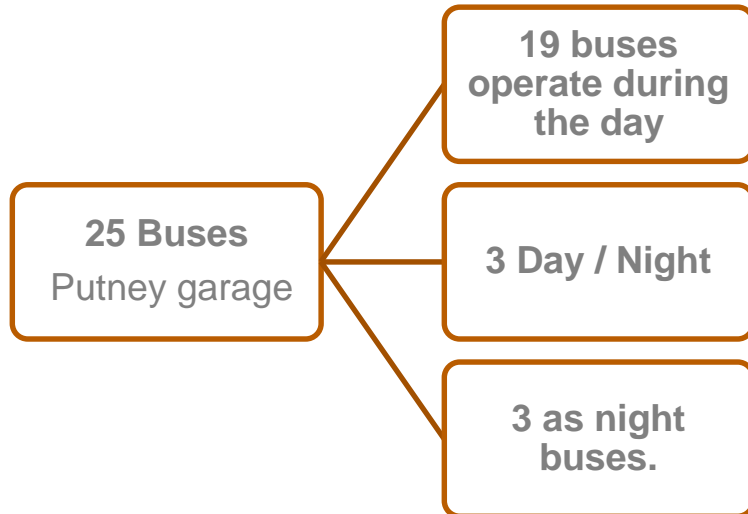
Case Study: Route 74 Baker St to Putney Exchange

Route	Day PVR			Night PVR		Route Length		No. passengers (Usage year 2015/16)	Bus Km Operated year 2015/16	Garage	
				Sun-Thursday	Fri-Saturday						
	Mon-Fri	Sat	Sun	Mon-Fri	Sat-Sun	miles	km				
74 / N74	21	21	16	4	5	7	11.27	5193768	1113122	Putney	

Frequencies (buses per hour)											
Monday-Friday				Saturday				Sunday			
Am Peak	Am normal	Pm Peak	Pm normal	Early Am	Late Am	Afternoon	Evening	Early Am	Late Am	Afternoon	Evening
7.5	7.5	7.5	6	6.0	7.5	7.5	6	4	6	6	5



Case study: Bus parameter



- Individual buses run between 45km and 202km /day (2 to 9 round trips.)
- Based on current technology electric buses would consume between 68 and 304 KWh/day
- As batteries age not able to cover the duty cycle from overnight



Case Study: Degraded battery

BUS No	% Battery Consumed (Only overnight charging)	% Battery Consumed if charged one at Baker Street	% Battery Consumed if charged twice at Baker Street
159	75	60.6	45.7
160	75	60.6	45.7
151	82	66.8	52.0
153	88	73.1	58.2
158	88	73.1	58.2
163	88	73.1	58.2
164	88	73.1	58.2
166	88	73.1	58.2
168	88	73.1	58.2
171	94	79.4	64.5
157	94	79.4	64.5
165	94	79.4	64.5
169	94	79.4	64.5
155	107	92.0	77.1
162	113	98.3	83.4

- 16% Degradation in capacity assumed
- 10 Buses can run several days on 1 depot based full charge.
- 13 min dwell time at far end of route
- 8 min charge via 300KW pantograph system.
- Adding in power requirements for heating increases the number of end of route charges.



Case Study: Environmental Impacts

CO₂ reductions

- 2.35 Tons/day
- 844 Tons/year

Nox reductions

- 50.3 kg/day
- 18 Tons/year

PM reductions

- 91.2 g/day
- 32.8 kg/year

FC reductions

- 1761.3 L/day
- 634079 L/year



Conclusions

- The LU AC grid can in some cases supply power for both TfL fleet vehicles and buses cost effectively.
- Geographic and electricity grid factors are site specific
- Larger trial needed to fully validate this alternate use of the LU grid.
- Heating has a major impact on electrical power requirements.
- Combination of overnight charging and on route top ups needed in some circumstances.



Future rollout

- **The London bus fleet**
- **TfL Estate**
- **London Boroughs of Hounslow and Haringey and the Cross River Partnership including the boroughs of Camden, Islington, Lambeth, Lewisham and Southwark**





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