

Dearman engine economic case study: Heat Hybrid versus Electric Buses

With the UK government offering large capital subsidies to technologies used in electric hybrid buses, heat hybrid vehicles may not attract too much attention despite offering lower upfront cost and quick payback without requiring government support.

Producing heat hybrid buses would cost significantly less compared to other low carbon technologies such as electric hybrid buses since the Dearman engine is built almost entirely with the components of a conventional piston engine.

Investment Comparison between electric hybrid & heat hybrid double decker buses				
Double deck bus in London	Subsidised electric hybrid	Electric hybrid: no subsidy	LIN/LAIR heat hybrid	Subsidised LIN/LAIR heat hybrid
Base price £000s	£200	£200	£200	£200
Additional cost £000s	£100	£100	£6	£6
Subsidy (Green bus fund)	70%	0%	0%	
Subsidy £000s	£70	£0	£0	£70
Net additional cost £000s	£30	£100	£6	-£64
Total price £000s	£230	£300	£206	£136
Approximate fuel savings	28%	28%	25%	25%
Average fuel saving (litres/year)	£9,729	£9,729	£9,137	£9,137
LIN/LAIR use (tonnes/year)			121	121
Diesel savings (£/year)	£11,351	£11,351	£10,660	£10,660
LIN/LAIR cost (£/year)			£6,037	£6,037
Opex savings (£/year)	£11,351	£11,351	£4,623	£4,623
Additional investment case				
Simple payback (years)	2.6	8.8	1.3	-
5 year TCO	-£26,753	£43,247	-£17,014	-£87,014
Battery replacement cost	-£25,000	-£25,000		
10 year TCO	-£58,506	£11,494	-£40,128	-£110,128
Annual ROI over 10 years	20%		66%	
BSOG and Green Bus Payments				
BSOG Foregone p.a.	£3,363	£3,363	£3,159	
Estimated green bus payments	£1,452	£1,452		
Net subsidy	-£1,911	-£1,911	-£3,159	
Assumptions:				
Assumed all VAT costs are reclaimed - fuel and LIN				
LIN/LAIR	5p/kg ex VAT			
Diesel	£1.40/litre inc VAT = £1.17 Ex VAT @ 20%			
BSOG	34.57p/litre on average			
Additional subsidy for E-hybrid	6p/km			
	3.75p/mile			

Double deck average fleet fuel consumption figures

Average fuel use d/deck	34,589 litres per annum
Average distance d/deck	38,718 litres per annum
Average distance e-hybrid d/deck	33,311 litres per annum
Estimated fuel savings [^]	9,729 litres per annum for electric hybrid
[^] Note that actual electric hybrid mileage is smaller than for conventional d/deck fleet	
Hence, fuel savings may over-estimated	
Battery pack cost	£25,000
Replaced after	7 years
Annualised replacement cost	£3,571 per annum

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Economic without subsidy

A liquid air heat hybrid bus would cost around £ 206,000 (\$349,442) assuming volume production. But its requirement for liquid air would increase the operating costs by around £9,000 (\$15,266) per year compared to the electric hybrid. Whereas electric hybrid buses, which are designed to reduce diesel consumption by around a quarter, come at a premium with 50% higher upfront costs in the range of £200,000-300,000 (\$339,264-508896).

Despite its high cost, the electric hybrid bus is likely to be preferred since it is entitled to receive a Green Bus Fund in the United Kingdom which subsidises additional cost of electric hybrid buses by up to 70%. A fleet company's total cost of ownership after five years would be almost £27,000 (\$45,800) lower if it owned a electric hybrid bus compared with a standard diesel model and £17,000 (\$28,837) lower if the company opted for the liquid air heat hybrid.

Total cost of ownership

However, if one removes the subsidy factor from the equation, the total cost of ownership (TCO) would reverse. The electric hybrid's TCO would be £43,000 (\$72,941) more than the diesel and £60,000 (\$101,779) than the heat hybrid.

If heat hybrid vehicles received a similar level of subsidy as the electric hybrids, the TCO saving to the bus operator would be more than three times larger -- £87,000 (\$147,580) rather than £27,000 (\$45,800).

Return on investment

As far as the payback is concerned, heat hybrid buses would be able to pay for themselves in half the time compared with the electric hybrid – 1.3 years compared to 2.6 years. Besides, electric hybrid buses would require battery replacements, which, conservatively, would cost £25,000 (\$42,408). So, after a decade, the annual return on investment would be three times higher for a heat hybrid (66%) than an electric (20%).

Encouraging low-carbon technologies

There is no doubt that government support has encouraged the uptake of low carbon vehicle technologies. However, it is time to review the eligibility criteria. Focusing only on capital cost, the policy may be "picking winners" instead of meeting a wider purpose of being technology neutral.

A possible solution could be to review parameters based on which subsidies can be provided. Governments can consider factors such as flat subsidy to those technologies that achieve emission reduction targets. Such steps could pave the path for other low carbon technologies and eliminate the distortion.