Flexible Power Systems for Rail Vehicles

Development of discrete and interchangeable power packs to provide a range of alternative power source options.
The Class 230 – a new approach to passenger travel
vivarail

The beginning

London Underground D78

Built by Metro-Cammell, Birmingham, 1978-1981
Entered service District Line 1979-1983
Class 230 Driving Motor Car

Diesel Generator Sets each produce around 125 kWe and mount with special attachments to the vehicle underframe.

1. New Engines and Generators
2. New Auxiliary Equipment
3. New Traction control systems
4. New national rail safety systems
5. New cab structure
6. New gangways
7. New lighting
8. New or refurbished interior based on client requirements
9. Upcycled corrosion free aluminium bodyshell
10. Upcycled nearly-new bogies
Diesel engine unit (750v)
Ford 3.2l diesel unit
Latest alternator
Latest AC motors
New fire protection
Patented technology

www.vivarail.co.uk
Power unit being installed
Can be changed in 10 mins
No need for return to depot
Just needs a hard standing
Available low cost parts
Any available power source
Innovative connection
We decided to utilise the same mounting arrangement and similar power capacity for a range of interchangeable modules enabling the train to be readily convertible from one fuel source to another.

All other systems on the vehicles remain substantially or completely unchanged irrespective of the type of power-pack, enabling the drive system to be adaptable to accommodate newly developing technology.
Requirements for alternative power sources.

Diesel – commonly available on rail network - reasonable cost – make use of established automotive technology.

Stored Electrical Energy – a good economical solution but charging presents challenges

Hydrogen Fuel Cell – ecologically sound, fuel of the future?
• Battery optimisation
• Charging

Battery pack (750v)

Capacity around 100 kWh each raft, giving 200 kWh on the vehicle.

Planned to operate with 30% - 40% reserve capacity, so around 130 kWh useful energy.

Consumes around 2kWh per vehicle mile depending on route and duty profile, so useful range is in the region of 50 to 80 miles.
Power System

Traction Control Unit (TCU)

8 IGBT Phase Legs

of which

Three control the motors on one bogie

Three control the motors on the other bogie

The remaining two each connect to a battery raft via an inductor
Performance Characteristic on class 230 train
Initial acceleration rate controlled to 1.0 ms\(^{-2}\) higher values increase probability of wheelspin
Maximum power phase commences around 30 km/h.
Motor characteristic becomes significant above 75 km/h.
Future Development

Trailer Car used as power supply vehicle.

300 - 350 kW can keep the 3 car train operating continuously on the most arduous routes and duty cycles in conjunction with batteries.
Alternative Arrangements

2 Car carrying around 88 seated and 106 standing passengers

3 Car carrying around 136 seated and 161 standing passengers
As a “rule of thumb”, the Vivarail train consumes around 2.75 – 3.5 kWh per vehicle mile depending on loading, route and duty cycle.

Peak power demand is around 500 kW per motor car.
Power Source Options

DEMU Diesel Electric

BEMU Battery
Power Source Options

FCEMU Fuel Cell

Diesel Hybrid

FCEMU

Driving Motor Car (DM)

H₂ Containment
Fuel Cell
Battery

Diesel Generator Set
Fuel Tank

Diesel/Battery Hybrid

Driving Motor Car (DM)

Fuel Tank
Diesel Generator Set
Battery
The three car battery train can carry four additional battery rafts to extend the operating range on battery power and configured for “opportunity charging” at termini.

The time required for charging is around 7 minutes for each 1 hour of train operation, however, the power levels required to achieve this require the equipment to handle current levels well in excess of 1,000 A which presents a further challenge.

Wayside charging stations need their own storage systems to be able to transfer energy rapidly to the train, otherwise costly connections to grid supplies at 33 kV or 132 kV would be required.
G the same Power Source Options

Systems which can be carried on centre trailer car to provide 750 V dc supply to driving motor cars

Alternatively, the trailer car can be furnished with a transformer and rectifier for battery charging from 25 kV overhead supplies. Suitable for services where at least 25% of the route has overhead power.
Fuel cell and diesel hybrid configurations all utilising the same concept of interchangeable power pack modules.
Thank you for your interest and time;

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