Battery-Powered Electric Vehicle (BPEV)

Defining characteristics	*Narrative*
General	Worldwide, most light- and heavy-duty road vehicles powered by internal combustion engines (ICEs) running on energy-dense fuels such as petrol, but a small proportion of the vehicle population operates on an entirely different principle, that is, the conversion of electrical energy to mechanical power. There are two primary options for all-electric vehicles: batteries or fuel cells with potential to substantially reduce the carbon footprint of the transport sector (Thomas, 2009). By design, a battery powered electric vehicle (BPEV) has no fuel tank or internal combustion engine (ICE) but derives all its power for propulsion from chemical energy stored in rechargeable battery packs. With environmental concerns gaining traction on the global policy agenda, and environmental regulations driving technological innovations on several fronts, automotive manufacturers are looking to electric propulsion as viable alternative to the ICE. Advances in battery technology in particular are addressing qualitative issues such as limited travel ranges that until recently confined BPEVs to niche applications such as urban transport and haulage within smoke-free environments (Kobayashi et al., 2009; Thomas, 2009). In many ways, BPEVs are making a comeback after being totally eclipsed by ICEs during the course of the past eight decades (Chan, 2007). Unlike lead acid batteries which primarily serve to start the engine and run accessories like the radio or air conditioners on ICE vehicles, the battery in a BPEV runs everything. The main benefits to a BPEV is lower operating cost arising from comparatively lower cost of electricity vis-à-vis refined fuels, and zero tailpipe emissions.
Siting and land use	Not relevant

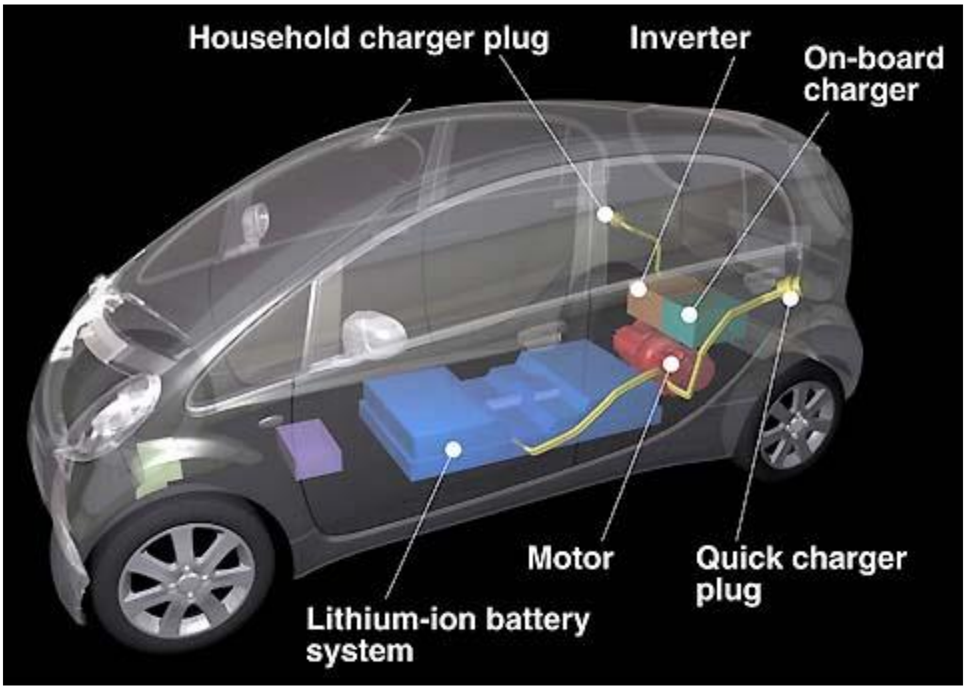
Design (components) and Operation	Except for external features such as a charging port, BPEVs sold on today's automotive market have the same generic form, steering controls and appliances as ICE vehicles. Similarly, a BPEV uses a regenerative braking system to recharge a standard 12-volt battery when its brakes are applied, which battery powers the vehicle's auxiliary systems when its electric motor is not in use. Essentially, a functional BPEV has three distinctive components: 1) an energy storage unit; 2) a control unit; and 3) a propulsion unit. The energy storage unit is a high capacity chemical battery pack made from high energy density materials that store electricity and deliver it to the vehicle's onboard motor on-demand (Kobayashi et al., 2009). A control unit or controller provides intelligent energy management; regulating power and supplying either variable pulse width direct current (DC) or variable frequency and variable amplitude alternating current (AC), depending on the type of onboard motor and driving conditions. The controller also provides a mechanism for charging the batteries during deceleration, and a DC-to-DC converter to recharge the BPEV's 12-volt accessory battery. The propulsion unit comprising an electric motor and integrated power electronics converts electrical energy into mechanical energy that turns a drive ***axle*** transmitting full torque to the BPEV wheels. In some BPEV designs, electric motors[97] are installed inside wheels instead of a central position on the drive axle. When a BPEV contactor is switched on, electricity from the battery pack is fed to the controller which keeps track of accelerator pedal settings and sends power to the electric motor proportionate to a signal from potentiometers connected by cable to the accelerator pedal. Current from the battery is routed to the onboard motor by the controller with or without conversion into AC with an in-built set of transistors, depending on the type of electric motor installed. Inside the electric motor, current flows to a set of brushes that transmit current to a commutator connected to an armature coil and output shaft. Concomitantly, current flow from the controller energises a rotor coil which produces a rotating magnetic field. In their energised states, current in the armature interacts with the magnetic field producing a rotational motion of output shaft. To this effect, the more electric power the motor receives, the faster it can turn the drive ***axle*** that transmits power to the wheels. A dashboard display provides to a BPEV conductor with feedback on stored power dynamics and travel range of BPEV before battery recharge/swap is required.
Cost	The cost of BPEVs is related to many variables including primarily performance-related specifications such as travel range, top speed, power consumption, recharging time, and brand name as well. In general, BPEVs are more expensive than conventional ICE vehicles, but price differences are likely to narrow down as the technology gains maturity and market share. According to a comparative cost analysis of various propulsion systems, Thiel et al. (2010) report the cost of a BPEV powered by 80kW electric motor at around 35,000 Euro of which 14,400 Euro goes to cover the cost of a 24 volt lithium-ion (Li-ion) battery pack, corresponding to a battery specific cost of 600 Euro/kWh. In the same study, an electric motor costs up to 2,160 Euro, otherwise expressed as electric motor specific costs 27 Euro/kW. Working from an inventory of BPEVs in Perujo and Ciuffo (2010), the Subaru Stella model which has the lowest capacity and travel range[98] has a price tag of JPY 4,725,000

[97] There are four types of motors: synchronous, repulsion, universal, induction motors. Induction motors are more widely used because of their simplicity, low cost,, ruggedness, wide speed range and absence of back electromotive force (Chan, 2007)

[98] Subaru Stella battery capacity = 9kW, travel range = 80 km

	(USD49,000), whilst the BYDe6 which features the highest capacity and travel range[99] costs USD50,000. Delucchi and Lipman (2001) report a retail price difference of USD3,000 to USD15,800 between a gasoline-powered Ford Taurus, and BPEVs using different battery packs. The authors found that lifecycle costs of approximately USD45,000 are considerably higher than comparable BPEV costs, except for some extensive range vehicles using nickel metal hydride (NiMH) batteries. Thomas (2010) citing an MIT study on the costs of various alternative vehicles, report that mass-produced BPEVs with ranges up to 320 km are likely to cost approximately USD10,200 more than conventional cars, one possible reason the Japanese government is offering a JPY1,380,000 (USD14,308) subsidy on the price of the Subaru Stella through its Next Generation Vehicle Promotion Center Program.[100]
Supporting infrastructure	Fuelling infrastructure High quality roads
Advantages	Higher energy efficiency compared to an ICE (Kobayashi et al., 2009) Few components (less maintenance requirements) Zero emissions Electricity generally cheaper than fuel oil Silent propulsion system (reducing noise pollution from traffic) Value for money with respect to FCEVs (Eaves and Eaves, 2004)
Disadvantages /Challenges	High initial cost Short battery life and high cost of batteries (Kobayashi et al., 2009) Short driving range (high recharging frequency) Exceedingly long battery recharge (power/fuel replenishment) times compared to other automotive technologies (Thomas, 2009) Requires recharging infrastructure analogous to refueling stations (Thomas, 2009)
Abatement potential	Greenhouse emissions reduction attributable to BPEVs is strongly correlated with the carbon intensity of the electricity generation infrastructure as wells as electric energy consumption of vehicles. The latter, specifically used in determinations of tank-to-wheel (TtW) GHG abatement, is dependent on a semi-finite set of BPEV motor efficiency and driving conditions. To fix some ideas, the TtW CO_2 abatement derived for the Subaru Stella electric vehicle with energy consumption of 11.25 kWh/100km is roughly 105gCO_2/km. Comparing well-to-wheel (WtW) CO_2 emissions 145gCO_2/km and 160gCO_2/km or higher for advanced diesel and gasoline vehicles respectively, with 60gCO_2/km for BPEVs, Thiel et al. (2010) concludes that the BPEV is the best automotive concept from a CO_2 WtW perspective, and is expected to maintain its advantage through 2030.
Level of penetration	Single digits

[99] BYDe6 battery capacity =72kW, travel range = 400km
[100] http://www.motorauthority.com/news/1033370_subaru-stella-electric-vehicle-goes-on-sale-in-japan



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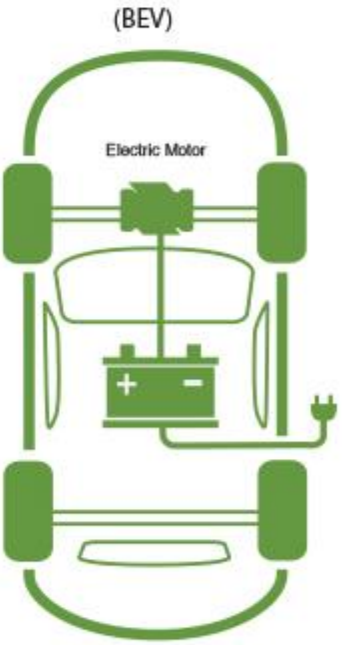

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