Electric and Plug-in Hybrid Vehicles

HIGHLIGHTS

■ **PROCESS AND TECHNOLOGY STATUS –** Battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) share characteristics that provide a range of benefits such as lower CO_2 emissions (potentially zero for pure EVs); no local pollution; competitive operating costs, quiet operation; high acceleration; regenerative braking and other systems that help improve energy efficiency. Both BEVs and PHEVs have batteries that can be charged from grid electricity to provide all the motive power of the vehicle. While BEVs rely only on the battery technology for both powering the vehicle and storing energy, PHEVs have smaller batteries (and therefore reduced range powered by grid electricity) that rely on the use of a conventional Internal Combustion Engine (ICE) for topping up the battery during use and/or as back up power when the battery charge has depleted, thus delivering drive range and refuelling time equivalent to those of conventional vehicles. Volume manufactured BEVs and PHEVs will be available in a few years.

■ **PERFORMANCE AND COSTS –** For both BEVs and PHEVs, performance and cost are inextricably linked to those of the battery technology, although this affects BEVs to a greater extent. Lithium-ion (Li-ion) is the battery technology with the most promise, however these still need further development in terms of cost, performance, abuse-tolerance and reliability over a longer lifetime. PHEVs offer performance and drive range similar to their conventional equivalents, but could provide a 40-55% improvement in fuel economy. BEVs currently offer significantly reduced range (typically up to 100km) compared to their conventional equivalents, but could provide improvement in fuel economy /energy consumption equivalent to 60-70% or more. The current cost differential for small-medium sized PHEVs and BEVs is in the order of +150-200% and +200-300% respectively more than conventional gasoline vehicles (depending on the battery size and range). This differential is expected to decrease significantly on mainstream adoption of these technologies through technology learning and reduction in costs through mass-production.

■ **POTENTIAL AND BARRIERS –** Key barriers to both BEVs and PHEVs are the cost of the vehicles, the battery lifetime and the public perception regarding the drive range, vehicle availability and reliability, especially for BEVs. Also a particular barrier for BEVs is the lack of infrastructure and charging stations. The limited drive range of the vehicles means that, although home recharging is available and use for short distance journeys in urban areas is possible, a widespread charging network is required for more widespread use. Consumers are unlikely to purchase BEVs in significant numbers until this infrastructure is available. PHEVs are not so restricted, although in the absence of ~~pubic~~ public recharging infrastructure home charging is necessary, which may not be possible in many cases (i.e. where parking on a driveway or in a garage is not available). However, the investment for recharging facilities is costly and is unlikely to happen on a large scale until consumers start to buy the vehicles. Also the time for recharging batteries using existing technology is relatively much slower than refuelling conventional vehicles, even with fast-charging stations available. Alternative battery lease and 'hot-swapping' schemes are therefore also under investigation as a means of countering this issue, together with reducing the high initial capital costs of the vehicles. Other alternatives include in-road wireless recharging infrastructure, but this would be considerably more expensive to install than standard recharging infrastructure and is currently a lot less energy-efficient.

PROCESS AND TECHNOLOGIES - Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs) and Hybrid Electric Vehicles (HEVs) are electrical vehicles (EV) powered by electrical motors with different reliance on electrical power. While BEVs are powered solely by electricity, PHEVs and HEVs are also equipped with an additional power source (i.e. an internal combustion engine, ICE, or – in the future - a fuel cell system), either as back-up/range-extender or main power systems.

■ **Battery Electric Vehicles (BEVs)** are powered solely by electricity stored in onboard batteries. BEVs do not feature on-board ICEs, but relies only on electrical motors powered by batteries that are charged by plugging into the electrical grid or - on a limited number of models - by swapping the battery. Apart from the emissions associated to electricity generation, BEVs produce no emissions during operation. In addition, electrical motors are more efficient than ICEs and the electricity grid is more reliable in terms of energy supply [1]. Electric commercial vehicles are currently available with Gross Vehicle Weight up to 12 tonnes, and benefit from lower running costs and taxes than conventional ICE vehicles [2].

The first volume manufactured battery electric vehicles (the Mitsubishi i-MiEV and Citroen C1 ev'ie) were originally expected be released in the UK towards the end of 2009 [3], but are now going to be released in 2010-11. A significant number of large electric cars are already available or will become available in the next couple of years. Other early BEV models are likely to be small cars since the lower mass allows smaller and

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