**Comprehensive concept to commissioning report on electric bus operations**

Abstract

Introduction

**B. Battery Electric Vehicles (BEVs)**

Various types of electric buses have been demonstrated globally. The Trolleybus is a type of electric bus powered by overhead electric lines. The “Gapbus” (another electric bus) is powered by electric lines embedded underground (Wikipedia 2015). This report considers BE buses for analysis. Figure 2.7 provides the schematic of power generation and transmission in BE buses. In a BE bus, the on-board battery provides the entire energy needed for bus operations. Unlike hybrid buses, BE buses have only one energy source in the form of battery and a single energy transmission path. The motor/generator is also used to recharge the battery during deceleration and braking. The battery size and type must be selected to meet the range and power requirements of these buses. BE bus batteries are typically larger than the batteries used in hybrid buses. Therefore, the energy efficiency of the vehicle is very high. With use of clean renewable sources such as solar and wind energy, BE buses would emit minimal quantities of GHGs. Prototypes with on-roof solar Photovoltaic (PV) panels have been attempted; however, the total energy provided by these panels is insufficient to fully charge the battery (Wikipedia 2015).

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Application of BE buses: city-drive conditions.

The current generation of BEVs has a lower range (distance covered in-between charges) due to battery limitations. After the predetermined range is covered, BEVs cannot be refueled in minutes like conventional vehicles; this leads to range anxiety issues. The current charging time is about 5 h for typical BEVs. This limits its long-range transport applications. Therefore, BE buses have better utility in city-drive conditions. State-of-the-art LIBs require significant improvement in relation to energy density to meet the light-weighting aspects of EVs. Moreover, the battery is the biggest component of the total cost of these vehicles.

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| **Table 2.7 Advantages and disadvantages a of BEV Advantages** | **Disadvantages** |
| Less expensive than HEVs | Limited range |
| Zero requirement of fuel | Long charging time |
| Highest well-to-wheel efficiency | NA |

According to a study by Aalto University, a diesel bus has more energy distribution losses than an electric bus (Lajunen 2015). Therefore, a BE bus is more efficient in terms of a well-to-wheel efficiency comparison. After considering conversion and transmission losses, electric buses showcase more energy efficiency overall, especially in stop-and-go traffic, where regenerative braking minimizes energy wastes. Table 2.9 represents the quantum of energy losses in diesel and BE buses. The energy consumption of a diesel bus is determined to be 3.64 kWh/km and that of a BE bus to be 1.02 kWh/km (weight of the buses being 14,250 kg) (Lajunen 2015).

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| --- | --- | --- |
|  | **Diesel Bus (Wh/km)** | **BE Bus (Wh/km)** |
| Aerodynamic losses | 90 | 90 |
| Braking losses | 370 | 20 |
| Wheels losses | 350 | 350 |
| Transmission losses | 130 | 270 |
| Ancillary equipment losses | 480 | 270 |
| Engine/battery losses | 2,220 | 20 |
| **Total consumption** | **3,640** | **1,020** |

OPPORTUNITY PAGES GOVERNMENT PRIVATE SECTOR CIVIL SOCIETY

1. Interoperable transport data: central data sharing institution and

unified metropolitan planning authority 52–55 ✓ ✓

2. Metropolitan planning councils 56–59 ✓

3. Networked city-level innovation and incubation centres 60–63 ✓ ✓ ✓

4. Feebates 64–67 ✓ ✓

5. Zero Emission Vehicle (ZEV) credits 68–71 ✓ ✓

6. Policies that encourage Mobility as a Service (MaaS) 72–75 ✓

7. Regulations that enable Electric Vehicle Supply Equipment (EVSE)

deployment and Vehicle-Grid Integration (VGI) 76–79 ✓ ✓

8. Manufacturer consortium for batteries, common components,

and platforms 80–83 ✓ ✓

9. Integrated transport hubs 84–87 ✓

10. Enhanced fiscal incentives 88–91 ✓

11. Nonfiscal incentives 92–95 ✓

12. Standardized, smart, swappable batteries for 2- and 3-wheelers 96–99 ✓ ✓