Natural Resources Canada
Ressources naturelles Canada

Paper ID: 346

Advantage and feasibility of wireless charging electric bus systems

Kuanrong Qiu, Hajo Ribberink, Evgueniy Entchev

Natural Resources Canada, CanmetENERGY, 1 Haanel Drive, Ottawa, Ontario, Canada K1A 1M1

Introduction

Heavy battery pack is a critical challenge for improving vehicle fuel economy, especially for all-electric buses. The battery pack can comprise about 30% of the weight of an electric bus. Due to the large size and the high price of lithium material, the lithium iron phosphate (LFP) battery cost can be as high as 40% of the total cost of electric bus. An alternative charging method, EV wireless charging, an application of the wireless power transfer (WPT) technology, may overcome the problems of plug-in charging.

Concept

Through the magnetic field between two coil plates, one loaded on the bottom of the vehicle and the other embedded in pavement, the electric energy can be transferred wirelessly. Wireless charging can be stationary or dynamic. Stationary wireless chargers for buses can be installed in garages, parking lots, transit centres and bus stops. The goal of this feasibility study is to compare two charging scenarios for all-electric bus systems, plug-in charging and stationary wireless charging, in terms of cost, battery downsizing potential and energy consumption rate. This study models the differences between the two charging systems.

Concept of wireless charging EV

Modeling conditions

65kW wireless charger is separated into on-board portion (on-WC) and off-board portion, i.e., those installed on the ground (off-WC).

Bus systems serving Bayshore-Downtown area in Ottawa, via both Lincoln Field and Queensway, are selected for the bus system case simulation study.

Assuming 36 buses operate on 5 routes. Wireless chargers are located at major bus stops, transit centres and the parking lots.

Both wireless and plug-in chargers are assumed to last 15 years.

25% of the operation time is assumed to be available for wireless charging during the bus operation periods, due to a longer charge time at transit centers and busy bus stops

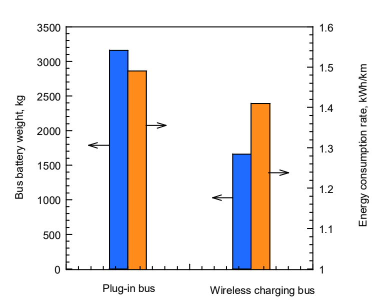
Model for battery downsizing due to wireless charging

The battery downsizing may be calculated as follows. C_a (kWh) is defined to be the battery capacity after capacity reduction.

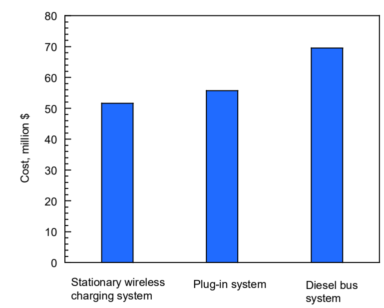
$$C_a = \frac{C_{or} - E_{ot}}{S_{cr}}$$

$$E_{ot} = \sum_{i=1}^{n} e_i = \eta P_e t$$

where C_{or} (kWh) is the minimum plug-in battery electricity amount requirement at start of each day for a bus; E_{ot} is the total amount of electricity charged during operation time (hours); S_{cr} is so-called state of charge range (%) that is defined as the percentage of the C_{or} relative to the whole capacity of a new battery (kWh); e_i (kWh) is the amount of electricity charged at charging stop i, n is the total number of stops for charging, η (%) is the average charging efficiency, P_e (kW) is the charging power and t is the total charging time at charging stops during the day.



Battery weights and energy consumption rates for plug-in and wirelessly charged buses



Life cycle costs of wireless charging bus, plug-in bus, diesel bus systems for the bus routes considered

Conclusions

- The wirelessly charged battery for electric bus can be downsized to 46% of the plug-in charged battery.
- The cost of wirelessly charged buses will decrease accordingly by up to 20% due to battery downsizing.
- Wirelessly charged battery electricity depletion rate is lower than plug-in charged battery electricity depletion rate.
- Energy consumption rates for wirelessly charged buses decreases by 5.3% as compared with plug-in buses
- Increased safety and city aesthetics

Canada