

## **THE EFFICIENCY AND RELIABILITY OF EV BUSES**

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**Abstract:** This article examines the effectiveness of electric buses compared to diesel buses. A study in Bengaluru, India revealed that electric buses offer higher profitability thanks to lower maintenance costs. Moreover, electric buses emit fewer pollutants, making them a sustainable and environmentally conscious choice. They also feature fewer moving parts, reducing the likelihood of malfunctions and resulting in a quieter, less polluting ride. Nonetheless, limited range and charging infrastructure present significant obstacles to their widespread adoption.

When comparing the practicality of electric buses, it is important to analyze its cost effectiveness compared to diesel buses. The Bangalore Metropolitan Transport Corporation attempted to calculate whether it would be worth replacing their diesel buses with electric buses, they did a study shown in Table 1 for three months in the city of Bengaluru, India. Electric buses have a higher initial cost when compared to diesel engines, however their lower upkeep and greater popularity among the citizens meant that the electric buses also had higher profits per day than their counterparts. This profit was not enough to have a shorter return on investment period, but the electric buses also have other benefits that may shorten the gap between them.

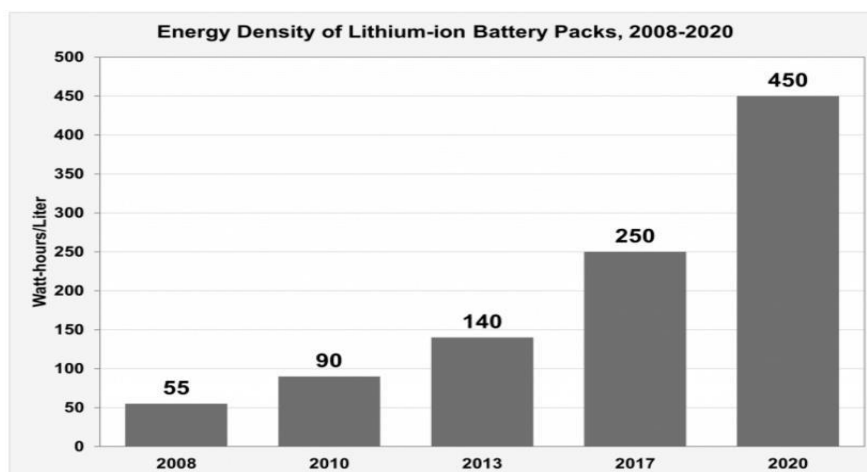
Besides having lower upkeep, the buses have smaller emission levels compared to diesel powered ones. One diesel bus will emit approximately 77 tons of CO<sub>2</sub>, whereas an electric bus, through charging and not through use, will release

approximately 25 tons less than the former in a year. That number can be reduced even more if the charging stations are powered by other means (such as solar power).

Cost Comparison	Electric	Diesel
Initial Cost	\$365,230.09	\$103,481.86
Average Profits Per Day	\$118.30	\$52.89
Net Annual Profit	\$46,182.68	\$25,258.50
Return On Investment	7.90 years	4.09 years

**Table 1 Bangalore Metropolitan Transport Corporation Data**  
(Values converted from INR to USD)

In addition to lower emissions, electric buses offer a range of other advantages. With fewer moving parts than their traditional counterparts, these vehicles are less likely to break down and easier to repair when issues do arise. Additionally, the reduced number of moving parts results in quieter operation and fewer vibrations, creating a more enjoyable ride for passengers while reducing noise pollution throughout the city. However, there are also some potential downsides to electric buses. One challenge is that they cannot be quickly refueled like diesel buses. Instead, they require charging time and typically need to be plugged in overnight. Additionally, the battery capacity of electric buses is limited by current technology. To achieve higher capacity and longer operating range, more batteries must be added to the vehicle, which increases weight and reduces passenger capacity. Overall, the decision to switch to electric buses requires careful consideration of these factors and others. While they offer clear benefits in terms of emissions reduction and maintenance costs, the limitations of current technology must be weighed against the specific needs and demands of a given transportation system.

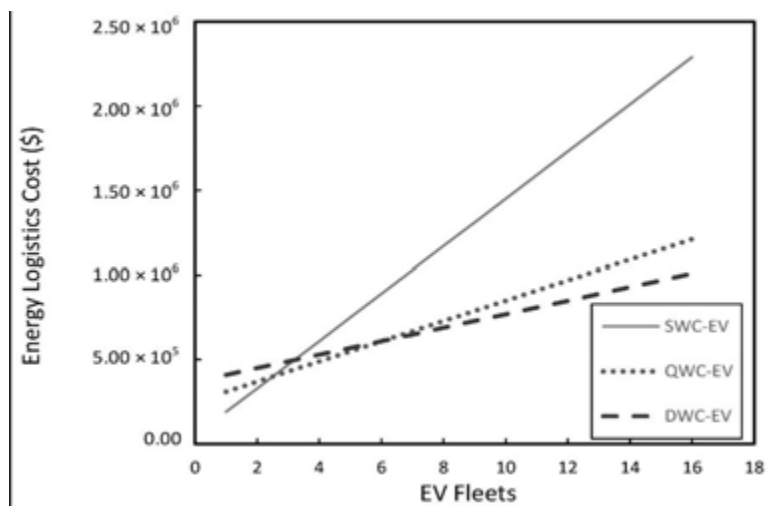


**Figure 1 Battery Density per Year**

At present, electric buses represent only around 4% of the total global fleet size, with significant hurdles to large-scale adoption. The primary challenges are twofold: limited range and charging time, and insufficient charging infrastructure. In

terms of the first issue, gasoline currently boasts an energy density of 9700 WH/liter, whereas current battery technology falls short. To address this, there are two potential solutions. The first option is to wait for scientific advancements to improve battery technology, as depicted in Figure 1. By interpolating the data, it appears we are X years away from reaching a reliable level for bus networks. Alternatively, technology can be employed as a workaround to compensate for the low energy density of lithium-ion cells. One such solution is wireless charging between vehicles, which holds promise but requires further safety testing and greater efficiency at high ranges.

However, it allows a bus that has finished its route to transfer extra energy to another vehicle which boosts efficiency. There are also methods that use special vehicles and external power cells, but with these methods there is no difference between their power supply and a redesigned bus with extra battery capacity. The other advanced technology that can allow for electrical buses is induction charging infrastructure under the roadways capable of charging while the vehicle is in motion. These are separated into three categories SWC, QWC, and DWC. The difference is stationary charging, slow movement or fast, but all based on induction. The costs of the relative methods are shown in Figure 2.



**Figure 2 Costs of the relative methods**

The chart clearly illustrates that, in general, the dynamic inductive charging system is the most cost-effective solution when a sufficient number of electric vehicles are employed. However, it is essential to note that these results are based on specific example locations and are subject to alteration based on factors such as bus routes, infrastructure, and location. Another potential solution is a boosted wired charging rate, but this approach faces similar obstacles to the charging density problem and is unlikely to be implementable anytime soon based on current scientific understanding.

The current Electric Buses used in public transport are only just starting to see major adoption in different cities. However, despite this they are showing promise with a wide range of different applications of electrification of public transport. The major different versions of EV Buses are: Battery electric buses (BEBs); these buses are powered by a battery and are the most common type of electric bus used for

public transport. They can be charged overnight or during the day using fast-charging infrastructure. Hybrid electric buses (HEBs); these buses have both a battery and a traditional internal combustion engine. The battery is charged using regenerative braking, and the engine can be used to extend the range of the bus or provide additional power. Plug-in hybrid electric buses (PHEBs); these buses are like HEBs, but the battery can also be charged from an external power source, providing additional flexibility and reducing emissions. Fuel cell electric buses (FCEBs); these buses use a fuel cell to convert hydrogen into electricity to power the bus. They produce zero emissions and have a longer range than battery electric buses, but they are currently more expensive and require hydrogen refueling infrastructure. Trolleybuses: These buses are electric buses that are powered by overhead wires, similar to trams or streetcars. They are most commonly used in Europe and Latin America. These different types of buses can be selected to choose the one that best suits the local needs and available infrastructure. The country that has put the most amount of effort to building an EV Bus fleet is China. China has 99% of all currently active Electric Buses in operation and is expanding their fleet. The city of Shenzhen has committed to having 100% of their bus fleet be electrical. One of the current more popular models in North America is the Proterra ZX5 which incorporates many innovative features. It has a 340-mile range, streamlined frame, better shock absorbers for more frequent stop and starts, and top of the line battery security, runs far quieter than its internal combustion engine counterparts and a production line designed to produce large batches far more affordably for the consumer. There are 2 variants of the ZX5, the 10.6-meter and the 12.2-meter (35 and 40 ft) buses. These have different capabilities and can seat 29 and 40 people respectively. The charging times are shorter for the smaller bus, but this comes with a tradeoff with having a shorter range. Using these numbers to estimate industry standards and factoring things like regenerative braking, the modern Electric Bus is at least competitive with its largely diesel counterparts.

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