Wireless Advanced Vehicle Electrification (WAVE)

By John Benson, October 2021

1. Introduction

The title of this paper is the name of an en-route wireless electric vehicle charging technology, and a company that makes it. It is specifically designed for medium to heavy electric vehicles (M/HEVs), mostly buses, but also some trucks. Most buses and trucks rely on depot-charging. That is, charging at a central location during times when they are not being used. However, some daily routes have very long travel-distances, and thus depot charging will not work with the current generation of M/HEVs, so with WAVE they can quick-charge en route. WAVE also can be used for trucks that spend quite a bit of time being unloaded / loaded, or otherwise are parked for a minimum ten or twenty minutes (for a quick-charge)

Recently I posted a three-part series on the subject vehicles. Part 1 was on trucks and part 2 on buses. Each of these two parts were mainly about currently or soon to be offered models from various M/HEV manufacturers. These are posts linked below.

https://energycentral.com/c/ec/2021-electric-truck-bus-update-part-1-trucks

https://energycentral.com/c/ec/2021-electric-truck-bus-update-part-2-buses

This paper is a review of WAVE Technology, where it is applicable, and how it works.

2. Alternatives

Most of the vehicles covered in the above linked posts have a maximum range of under 200 miles. This is too short for many routes.

In general, en-route charging will only work for EVs that have fixed routes. This applies to most transit buses, and some trucks, like refuse trucks, trucks that operate in a confined location. Also trucks that have a fixed end-point (like drayage trucks) can benefit from the convenience and safety of hands-free charging.

Although most buses have a range under 200 miles, at least one manufacturer (Proterra) makes models with a range of slightly under 300 miles, and another (New Flyer) makes models with a range slightly over 250 miles. Although these ranges will significantly increase the routes to which these buses are applicable (using only depot charging), since medium to heavy vehicles already require a large number of batteries, it will also dramatically increase their prices.

Also, a large majority of routes are not over 200 miles, so a transit agency may just need a few long-range buses, decreasing their flexibility in scheduling their fleet. By using en-route charging, all buses can have the same range, and charging points can be incorporated into the longest routes.

However, if a given transit agency (or applicable truck-fleet manager) decides that en-route charging is best for them, the next question is which solution?

3. En-Route Charging Solutions

Let's take one possible solution off the table up-front. Normal EV charging stations will not work for M/HEVs for a number of reasons: the stations are not physically designed

for transit buses nor medium / heavy trucks, and mostly don't have the required output for a quick-charge for a medium or heavy vehicle.

This leads to two possibilities: (1) an en-route plug-in charger, or (2) a hands-free wireless solution like WAVE.

The owners of light EVs can handle plug-in solutions, the typical light EV commercial charger (think Tesla Superchargers or EVgo stations) is designed for personal charging. It is highly likely that the chargers used for M/HEVs (like those used for depot charging) will have a much higher capacity, but will normally be plugged / unplugged and operated by trained technicians, not bus drivers.

There are issues with vandalism and other security concerns with a cable and plug, even if it is locked in an enclosure when not in use. There are also issues for bus drivers with ice, snow and other problematic weather.

The charging sequence with WAVE technology is performed by the driver without leaving his seat, and the charging pad is very robust, as described in the next section.

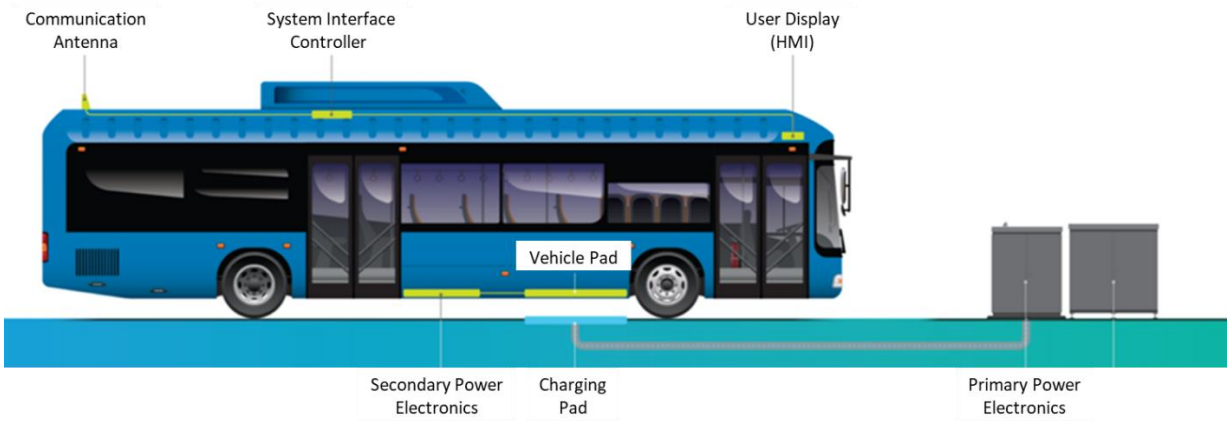
4. WAVE Technology

The company in question is linked below.

https://waveipt.com/

WAVE was spun out of a university in Logan UT in 2011. Per a 2016 article: *Utah State Energy Dynamics Laboratory has been studying wireless charging for some time. In 2013 it demonstrated the Aggie Bus, a 20-passenger bus powered with a 20-25 kW stationary wireless charger, with efficiency greater than 90%. Since then, WAVE has doubled the power of its system to 50 kW, while maintaining a similar efficiency level (for comparison, a typical wired connection might achieve efficiency of 92-95%).*[1]

Currently WAVE has systems ranging from 125kW to 500kW, and a 1MW charger is in development. They also have eight deployments, all at transit agencies. See below for the WAVE system's configuration.



[1] Charles Morris, Charged Electric Vehicle Magazine, "WAVE wireless charging helps transit agencies save money by going electric,", April 26, 2016, https://chargedevs.com/features/wave-wireless-charging-helps-transit-agencies-save-money-by-going-electric/

The driver uses the in-bus user display and other visual information to align the bus over the charging pad, and then start the charging. The table below shows the quick-charge "miles added" for various charging times with a 250 kW WAVE System.

Bus Size	Battery Consump. (kWhr/mi)	Miles added in five-minute charge	Miles added in ten-minute charge
40-foot*	1.5-2.0	10-14	20-25
60-foot	2.4-2.6	8-10	16-18

* Power delivered can be less than 250kW and is subject to control by the bus battery management system.

The system is unaffected by snow, ice, moisture, and heat, and the charging pad is very robust (see picture below). Free of moving parts, connectors, or cables means there is nothing to break or freeze.