



WAVE

Wireless Advanced Vehicle Electrification

We solve the battery problem.

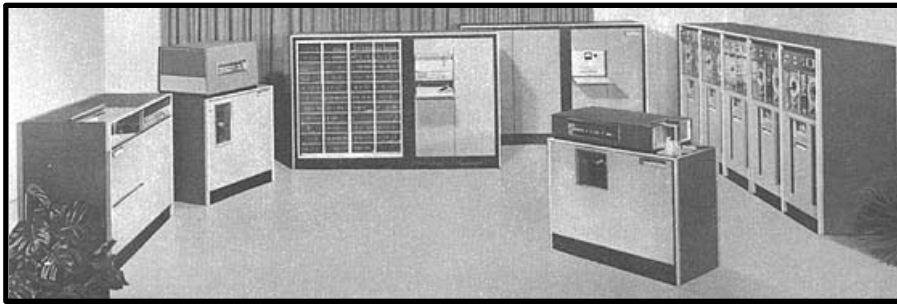
The Battery Problem

Battery Holding Back The EV

1958

2013

Personal
Computer:



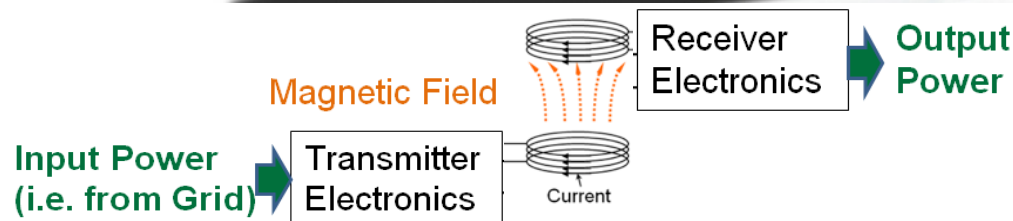
Battery:



WPT safely transfers power through road materials, snow, air gaps

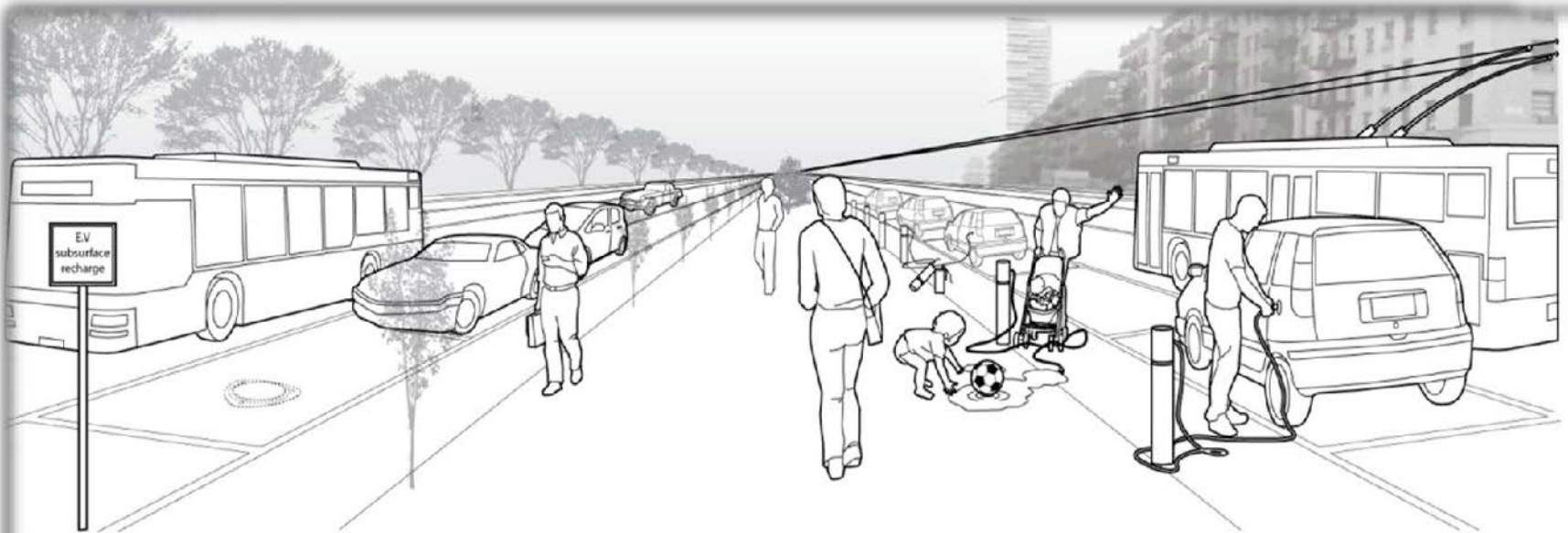
WAVE Technology

- ❖ High power transmission: 5kW - 100 kW
- ❖ Large air gap: 6" to 10"
- ❖ High system efficiency (grid to battery output): $\geq 90\%$



Why Wireless?

Safety, Convenience, Aesthetics



Wireless Power Transfer (WPT)

Products Today



Inductively Coupled Battery Charger



Induction Cooktop



Semiconductor Materials Handling



Electric Toothbrush

Vehicle Applications

► In-Motion Charging

- Korea
- Germany
- Belgium



Prototypes

► Stationary Charging

- London
- Genoa & Turin, Italy
- Logan, Utah



Vehicle Applications



Campus, airport shuttles & transit buses



Trolley buses and trams



Garage & parking lot charging

Inductive Power



24/7 operations



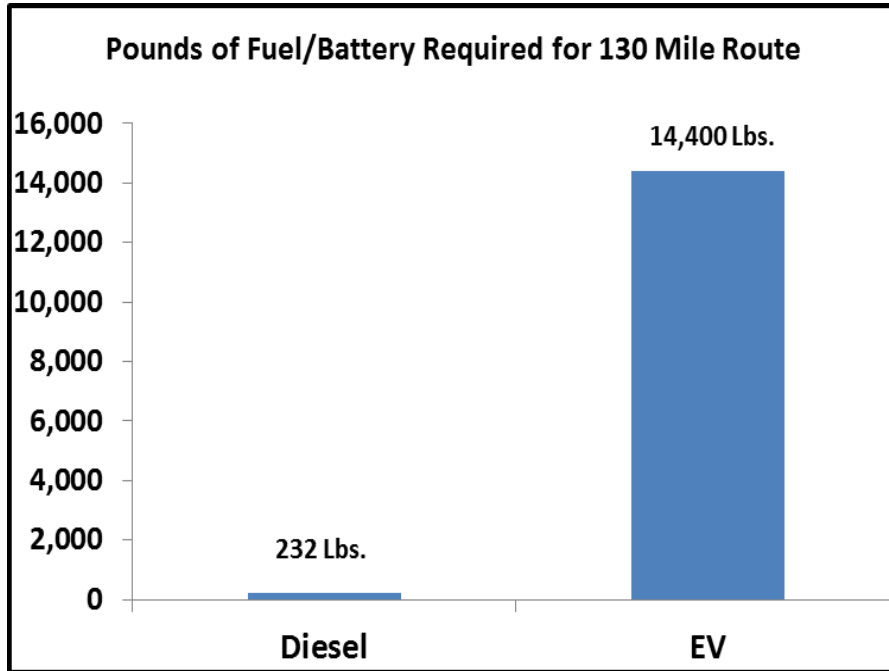
Fleets



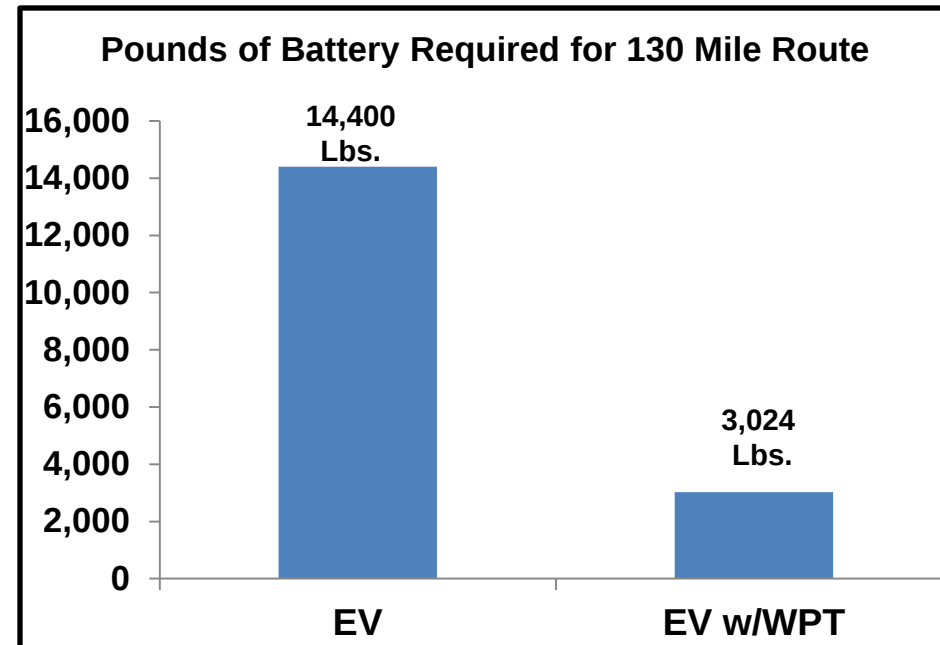
Off-road industrial

Smaller battery, extended range

Value Proposition



- **Diesel** = Diesel bus
- **EV** = Plug-in electric bus
- **EV w/WPT** = Electric bus with wireless power transfer charging



Batteries in Pure Electric Vehicles

Batteries In WPT Electric Vehicles

Expensive



up to 50% cheaper

Heavy & big



up to 80% lighter/smaller

Limited range



No range limits

Slow recharge



En route charging

User input required

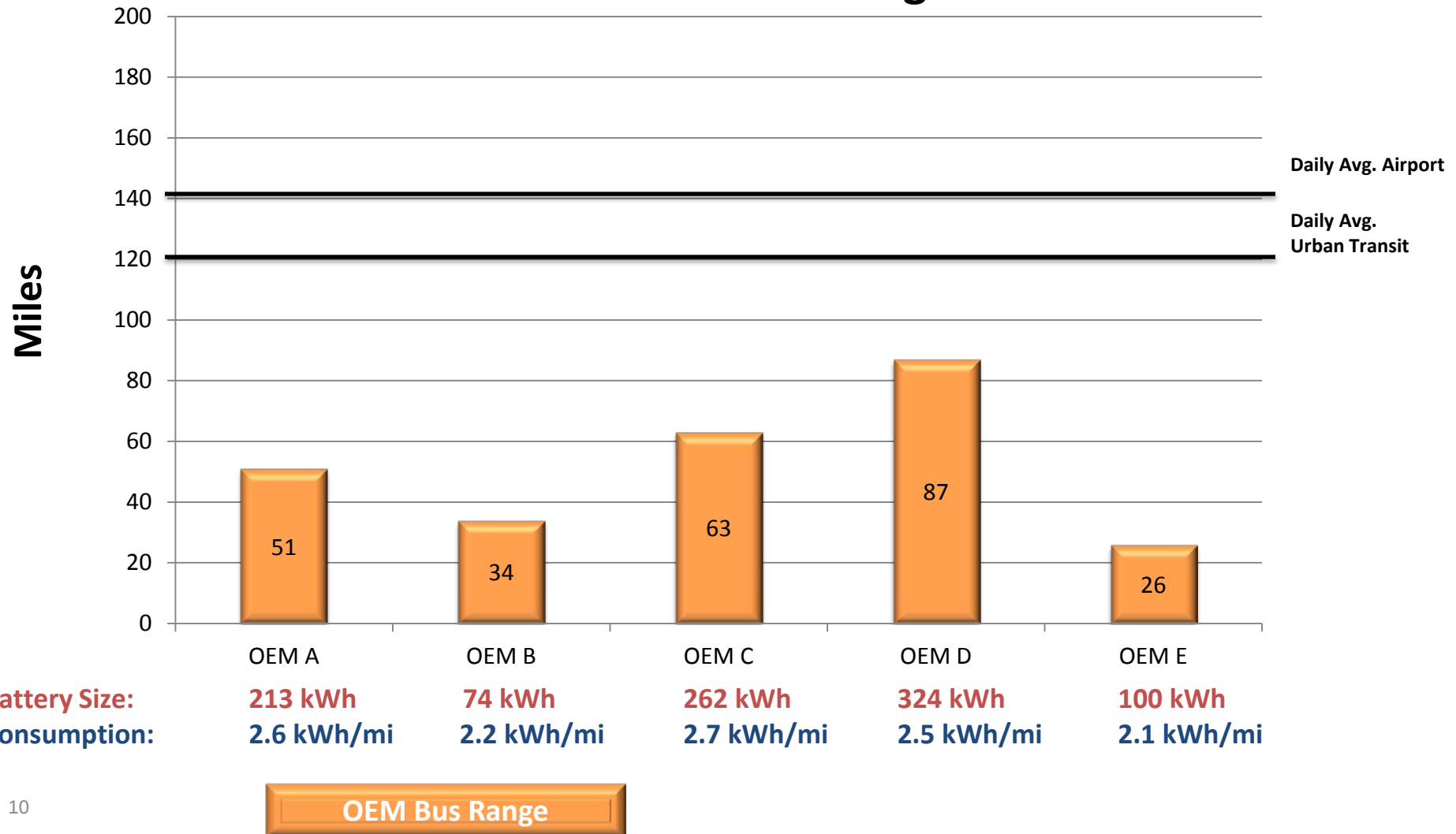


Automated system

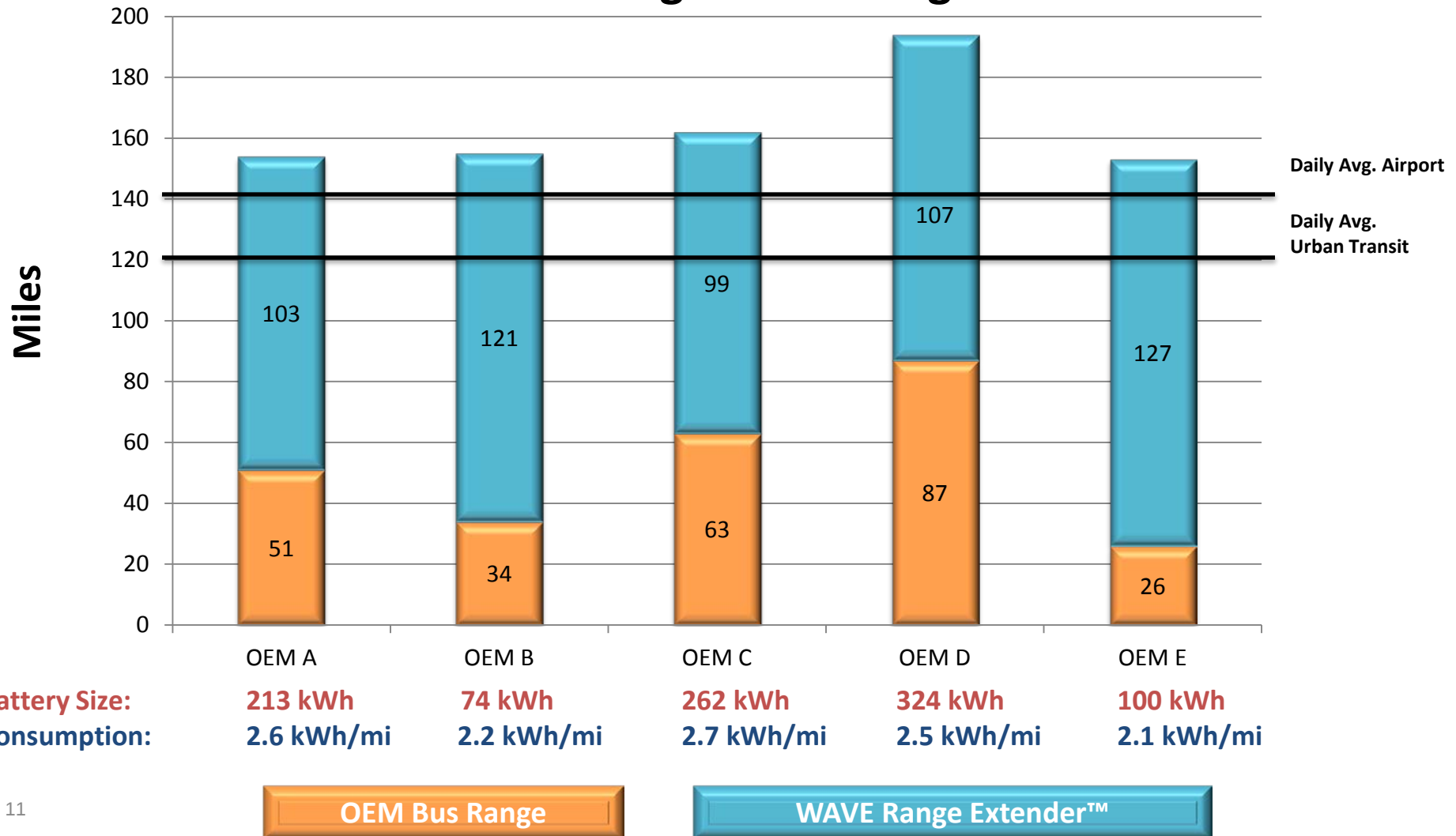
Electric Buses (currently available)

Limited Range

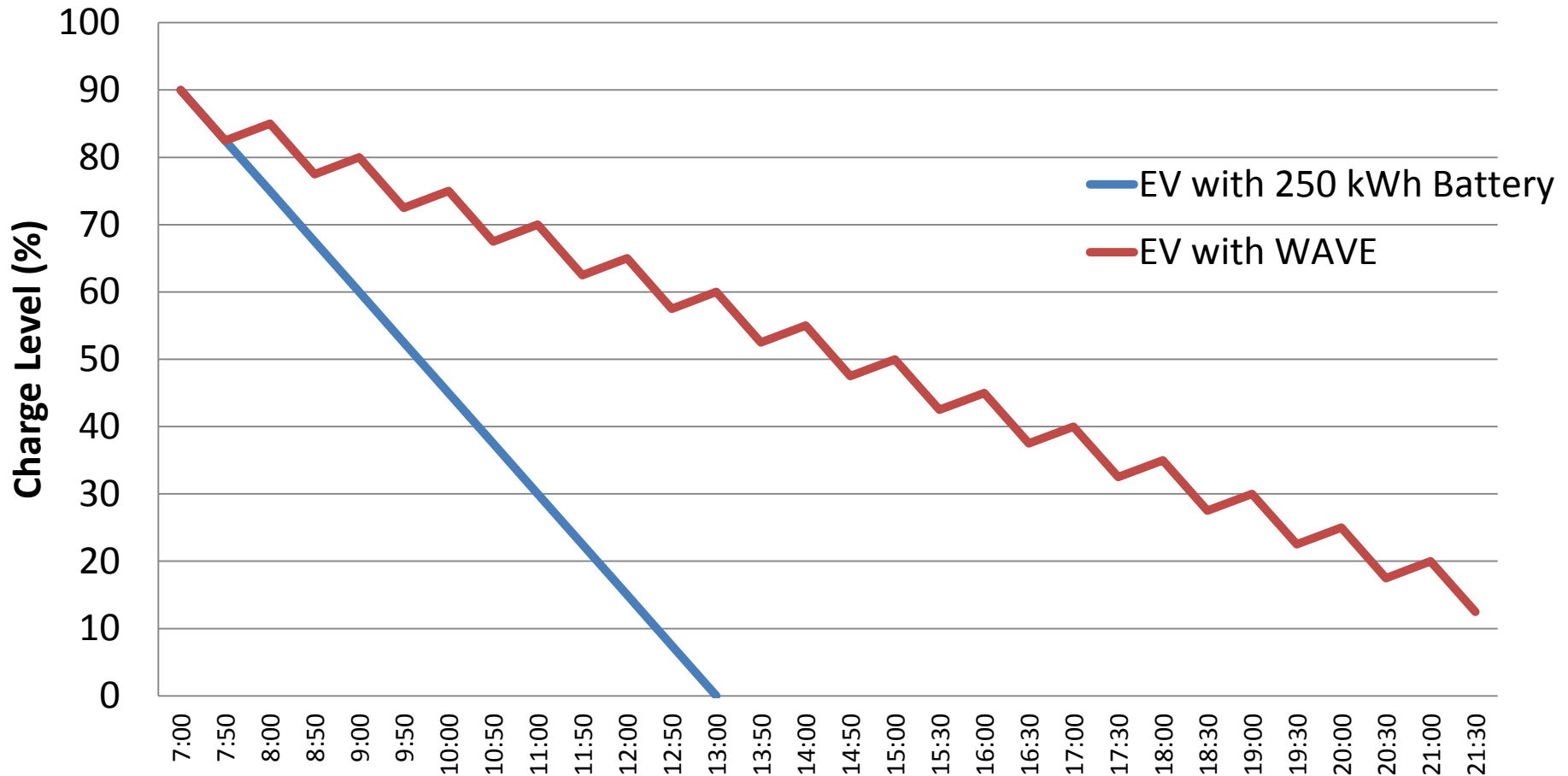
Electric Bus Ranges



Electric Bus Ranges with Range Extender™



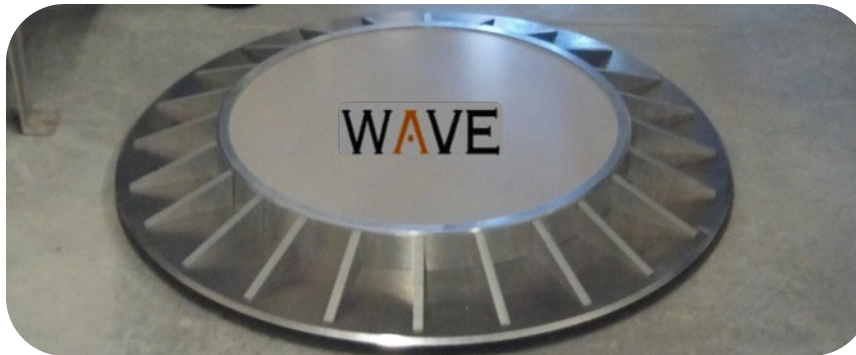
EV vs. EV with WAVE Charging



Minimal infrastructure required

Charging Station

- ❖ Product implementation is iterative: 1 bus/1 charging pad
- ❖ 1-3 charging pads per route
- ❖ Pad is completely sealed and protected from the elements

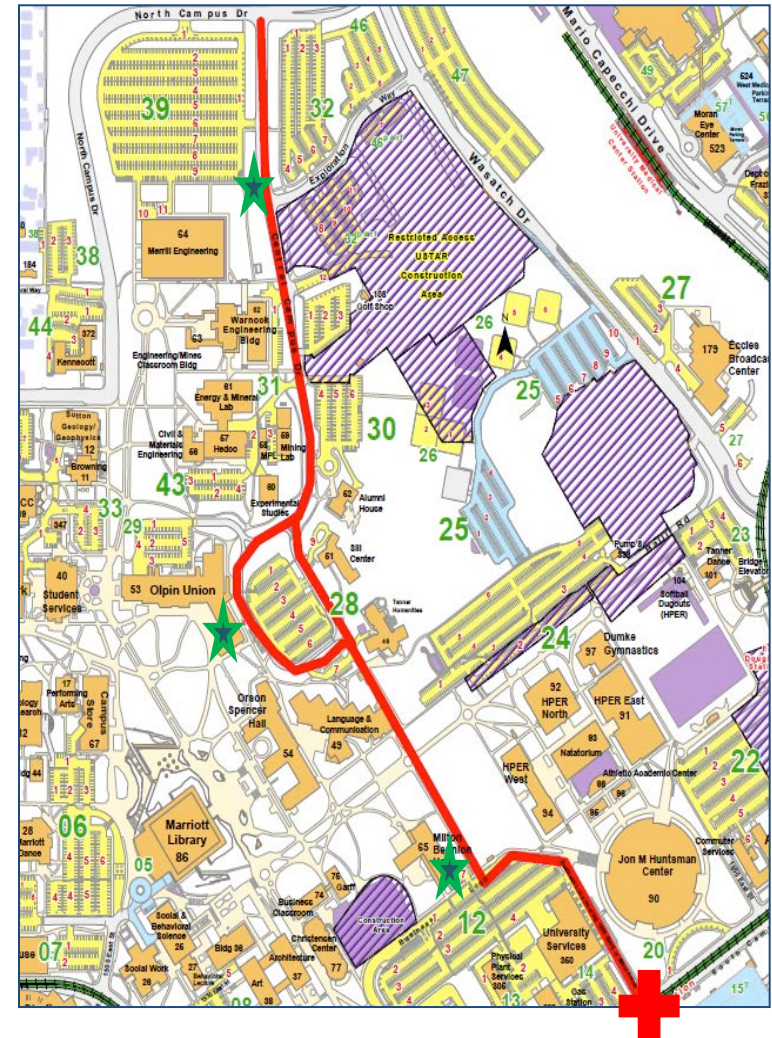


University of Utah campus

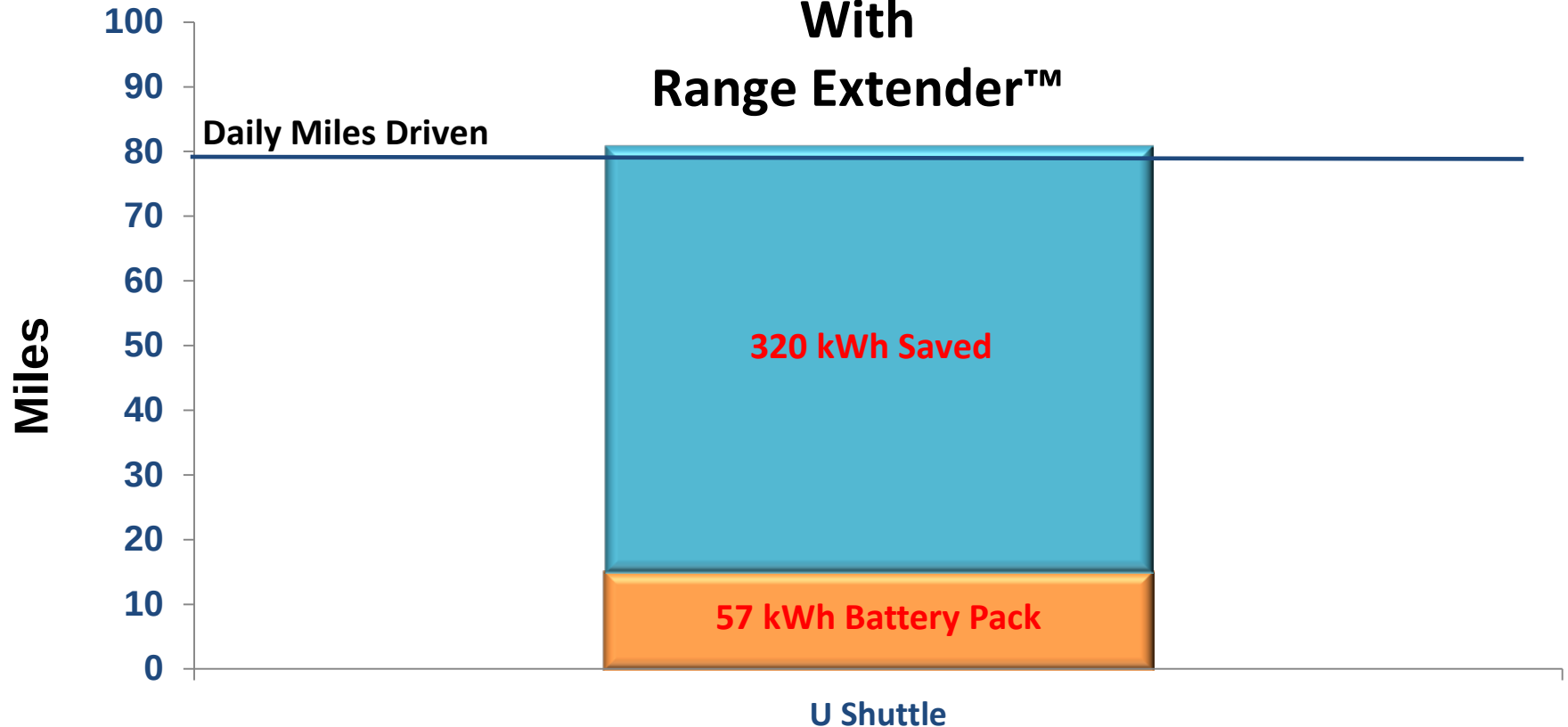
- ❖ \$3.2M project, fully funded
- ❖ 50 kW stationary charging system
- ❖ 1.5 mile route



First Commercial Demo



University Electric Shuttle With Range Extender™



Base Range

WAVE Range Extender™

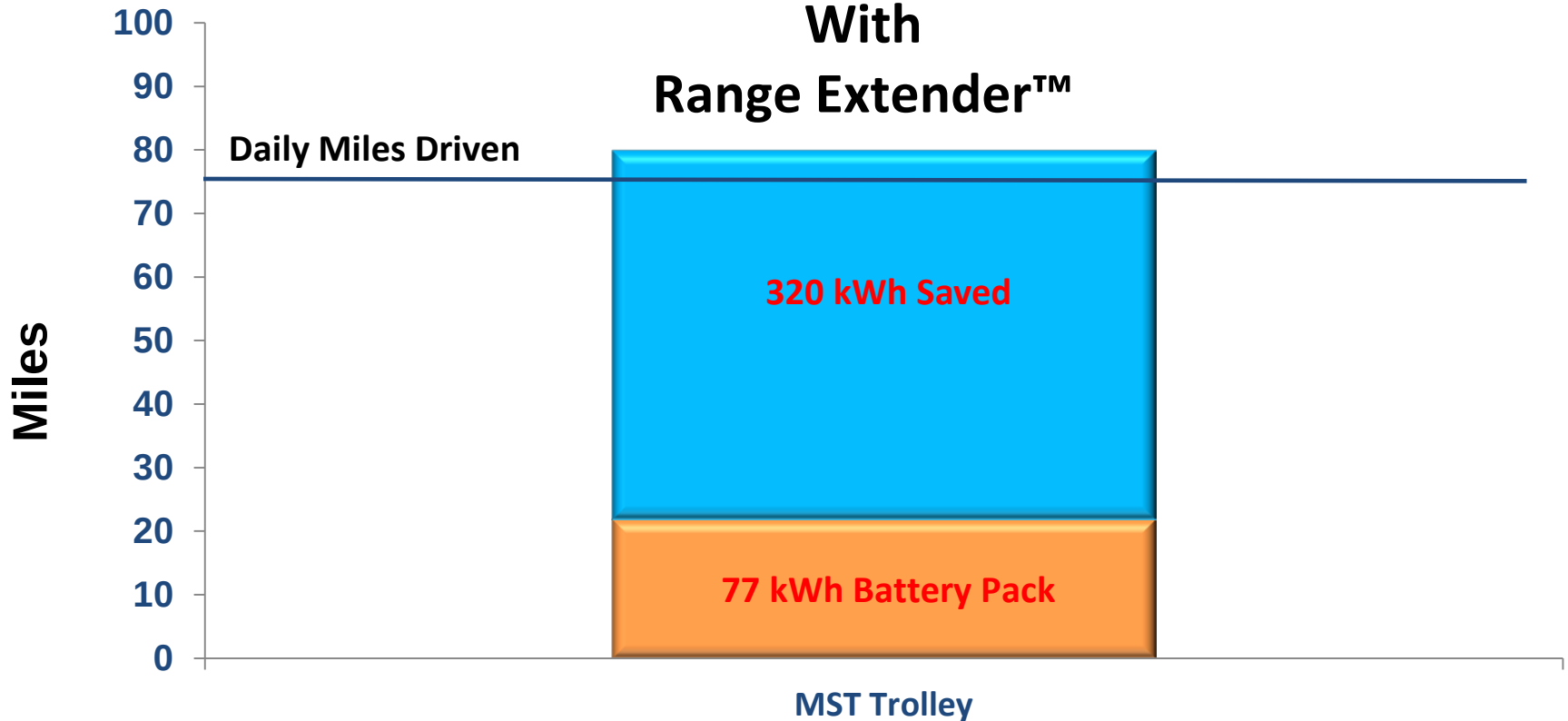
Monterey Waterfront Trolley

Monterey Trolley Project



- ❖ \$1.7M project
- ❖ All-electric trolley will replace current diesel trolley
- ❖ 4.5 mile route
- ❖ 1 charge location (*at Aquarium*)
- ❖ 9-10 hour operational day during Summer season

MST Electric Trolley With Range Extender™



Base Range

WAVE Range Extender™

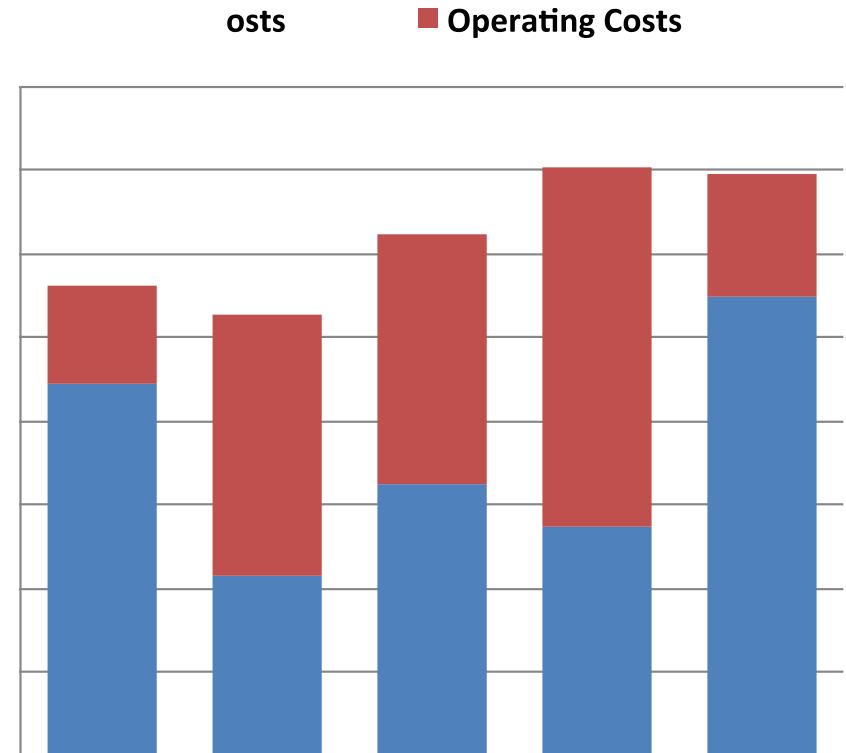
Per-Bus Cost Comparison

Total Cost of Ownership

Operating Assumptions:

- 9.4 mile route
- 44,603 – route miles/year
- 3 – # of buses on route
- 2 – # of 100 kW charging stations
- 5 min – charge time
- 16 hour – duty cycle
- 13 – laps per day
- \$3.85/gal – diesel
- \$2.80/GGE – CNG
- \$0.16/kWh – electricity
- **EV + WPT** = Electric bus with wireless power transfer charging
- **Hybrid** = Diesel/electric series system
- **CNG** = Compressed Natural Gas
- **Proterra** = 35' all electric bus
- **GGE** = Gallon Gas Equivalent

Per-Bus Cost Comparison



Net Present Value of total 12 year life cycle costs, including WPT infrastructure costs

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