Electric Vehicle Charging Solutions/Smart Powered Lanes

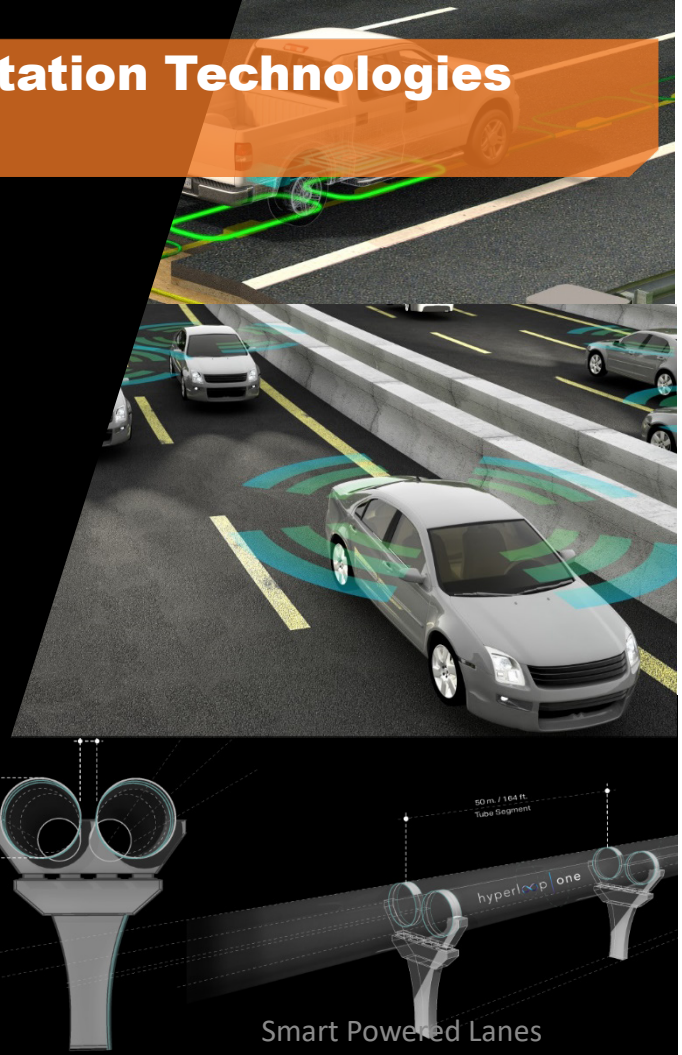
February 26, 2019

Emerging Transportation Technologies

- Connected and Automated Vehicles
- Electric Vehicles
- Mobility as a Service
- Hyperloop

Impacts

- Planning, Design, and Construction of Infrastructure
- Policy and Regulation
- Funding and Monetization



Smart Powered Lanes

Google

amazon web services

miovision
rethink traffic

Peloton

Technology Adoption

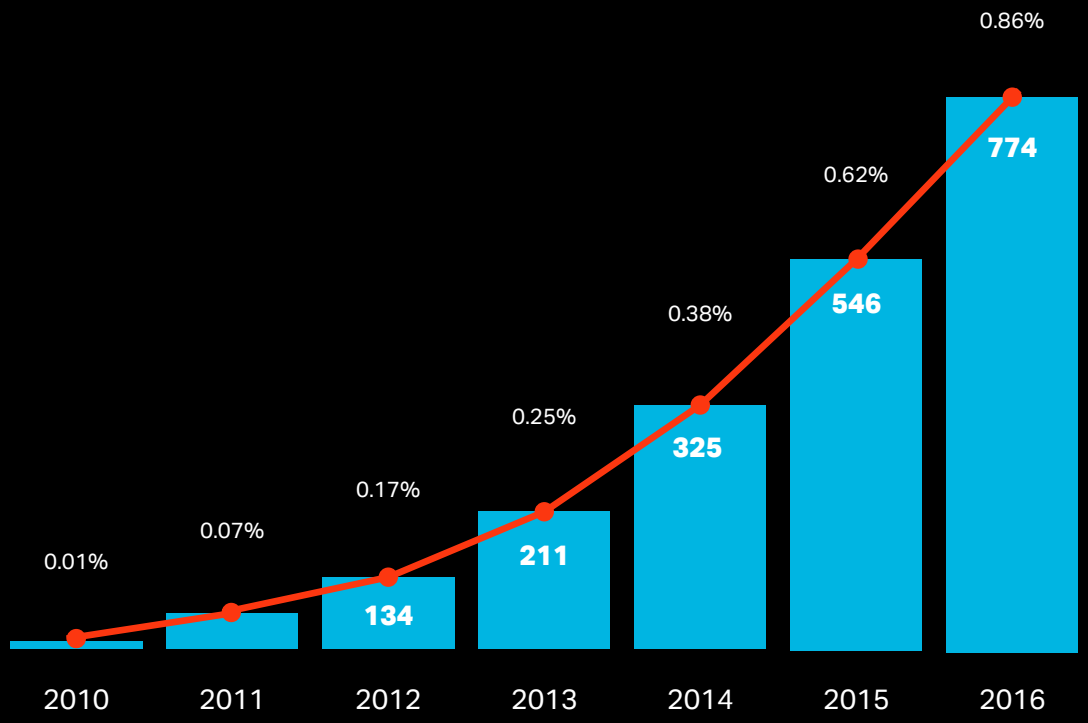
Electric Vehicle

Connected Technologies

Automated Technologies

Hyperloop

Electric Vehicle
Light Duty Vehicle Adoption



GLOBAL EV STATISTICS

2016 EV SALES
774K

2016 GROWTH
42%

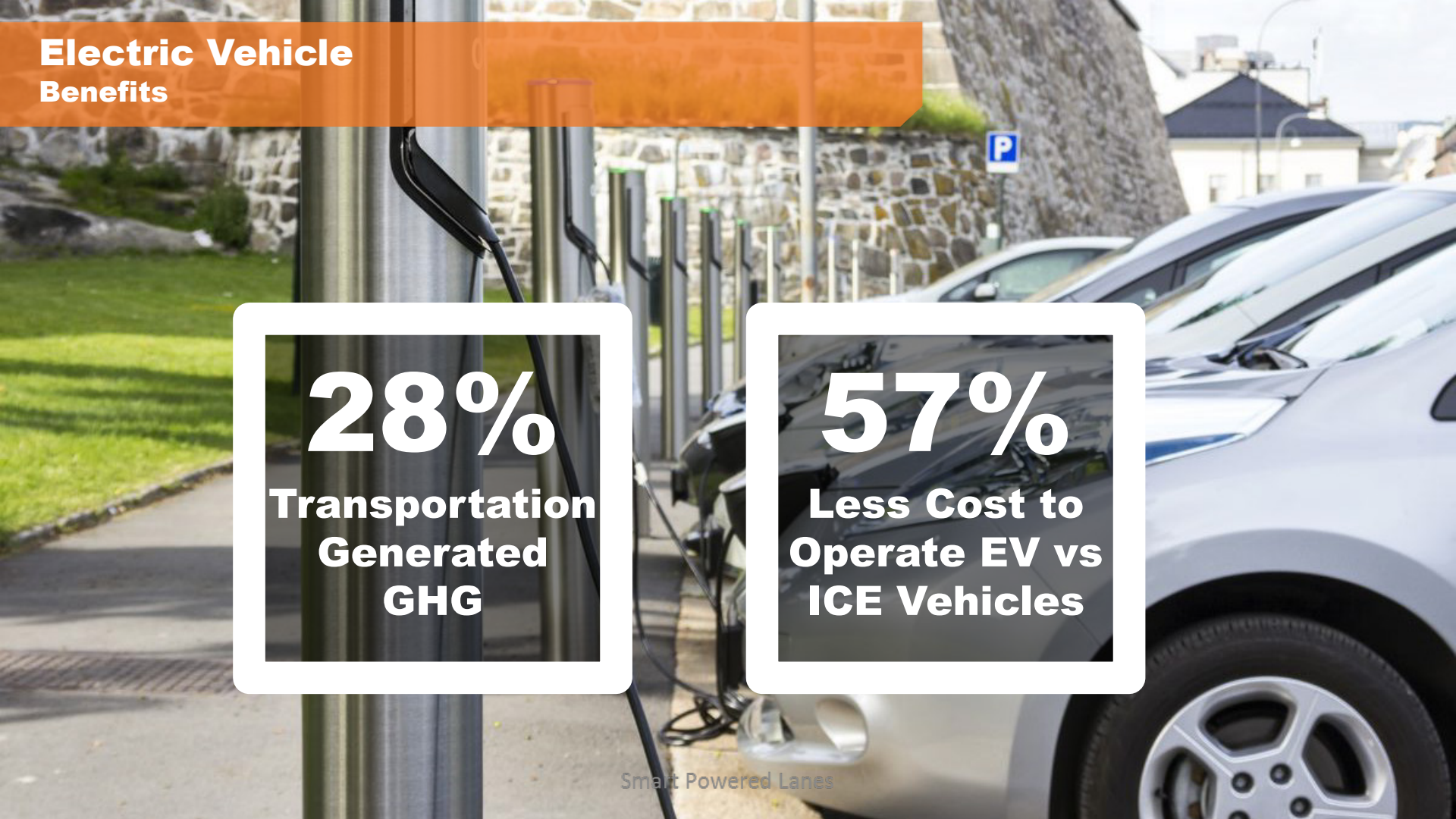
EVs ON THE ROAD
2M

EVs ON THE ROAD BY 2017
3.1M

EV OEMs
>40

BATTERY COST REDUCTION
50%

Electric Vehicle
Benefits



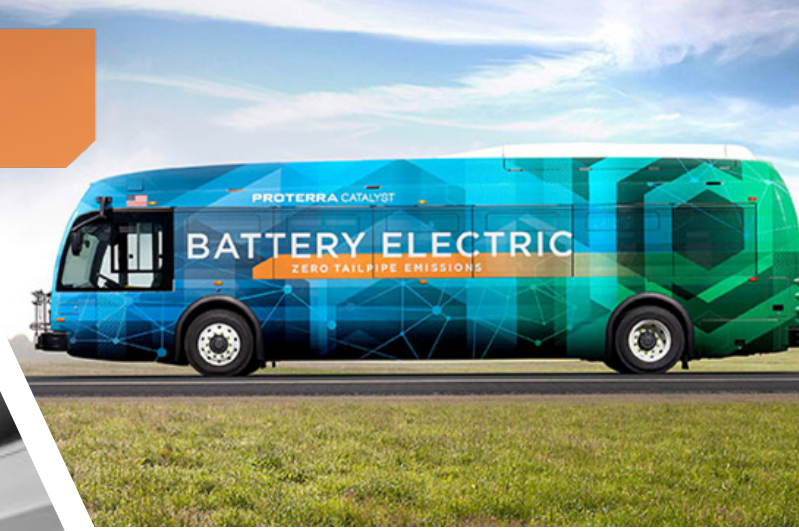
28%

Transportation Generated GHG

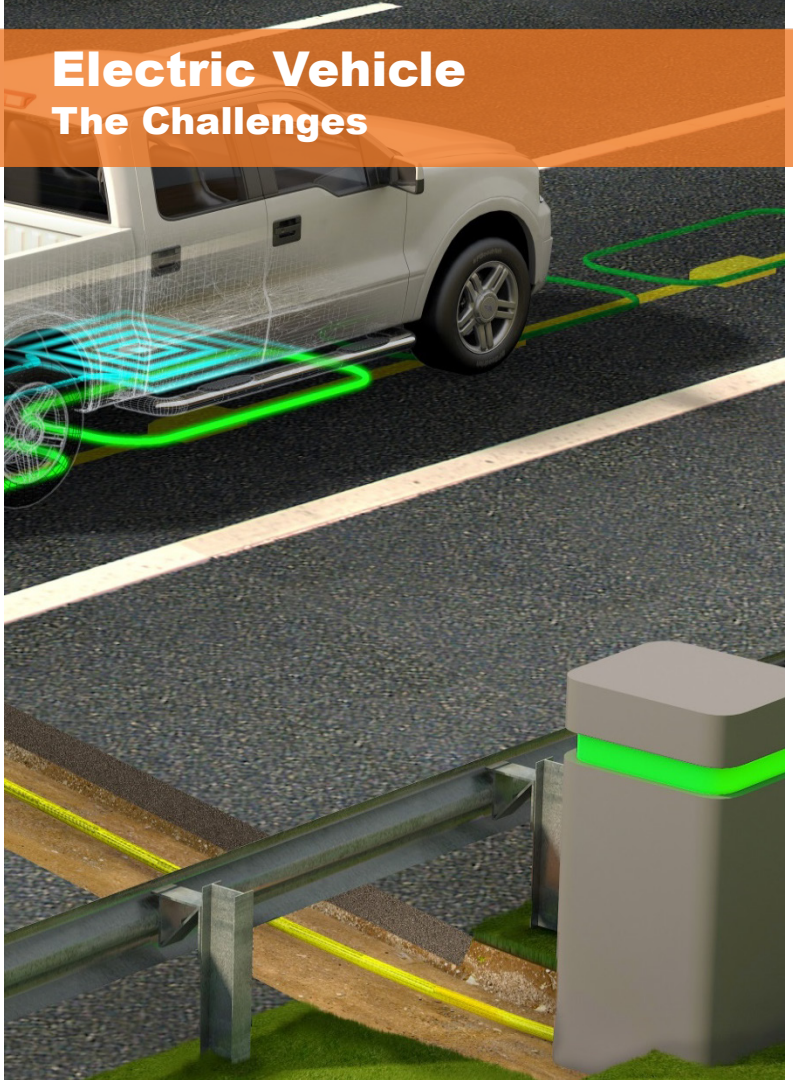
57%

Less Cost to Operate EV vs ICE Vehicles

Electric Vehicle
Fleet Mix



Electric Vehicle
The Challenges



01 Battery Size and Cost

02 Additional Charging Infrastructure

03 Cost to Integrate

Electric Vehicle
The Challenges

10M

Number of Vehicles the World supply of Lithium can Support

10x

Battery Cost per kWh for larger vehicles versus LDVs

25K

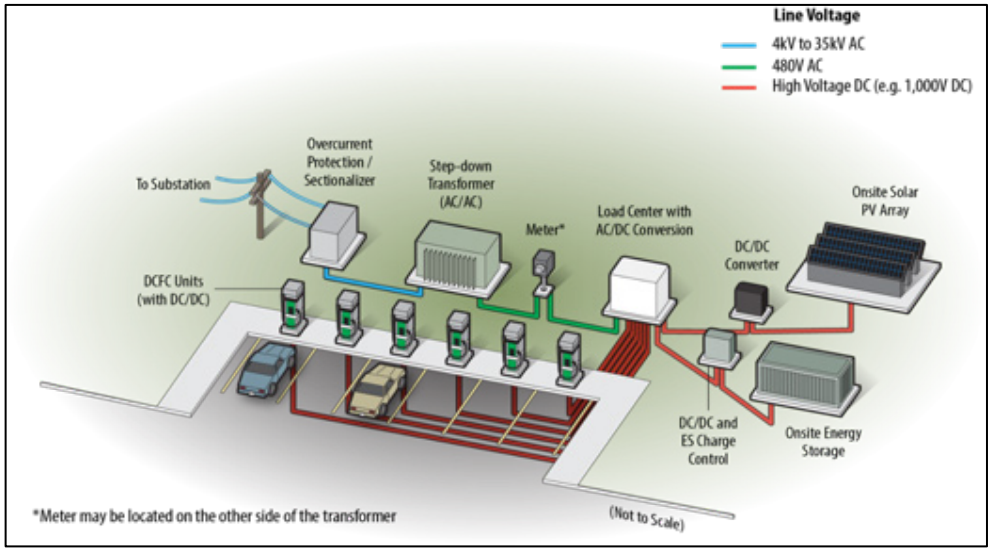
Curb Weight of BEBs

Electric Vehicle
The Challenges

- Slow vs. Rapid Charging
- Interoperability
- High Cost- Infrastructure and Fueling

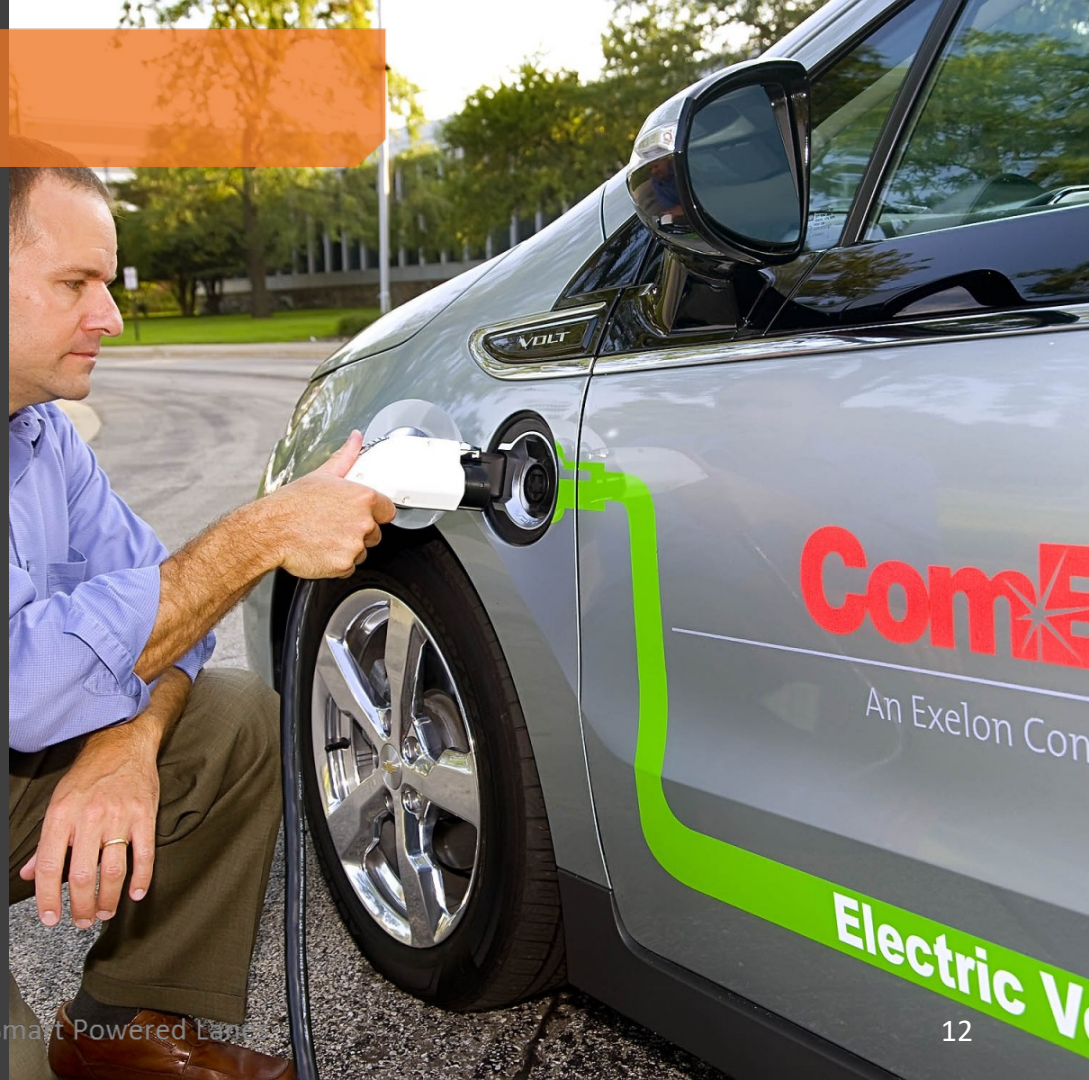
Fast Charging
The Challenges

- Conventional paradigm
- Target: 15 min charge
- Costly infrastructure and demand charges
  - INL study: huge investment for “station” model
  - Anticipated $5-6 per gallon equivalent energy costs
- Rapid battery degradation with repeated fast charge
- Not as suitable for larger vehicles, fleet vehicles, or autonomous vehicles

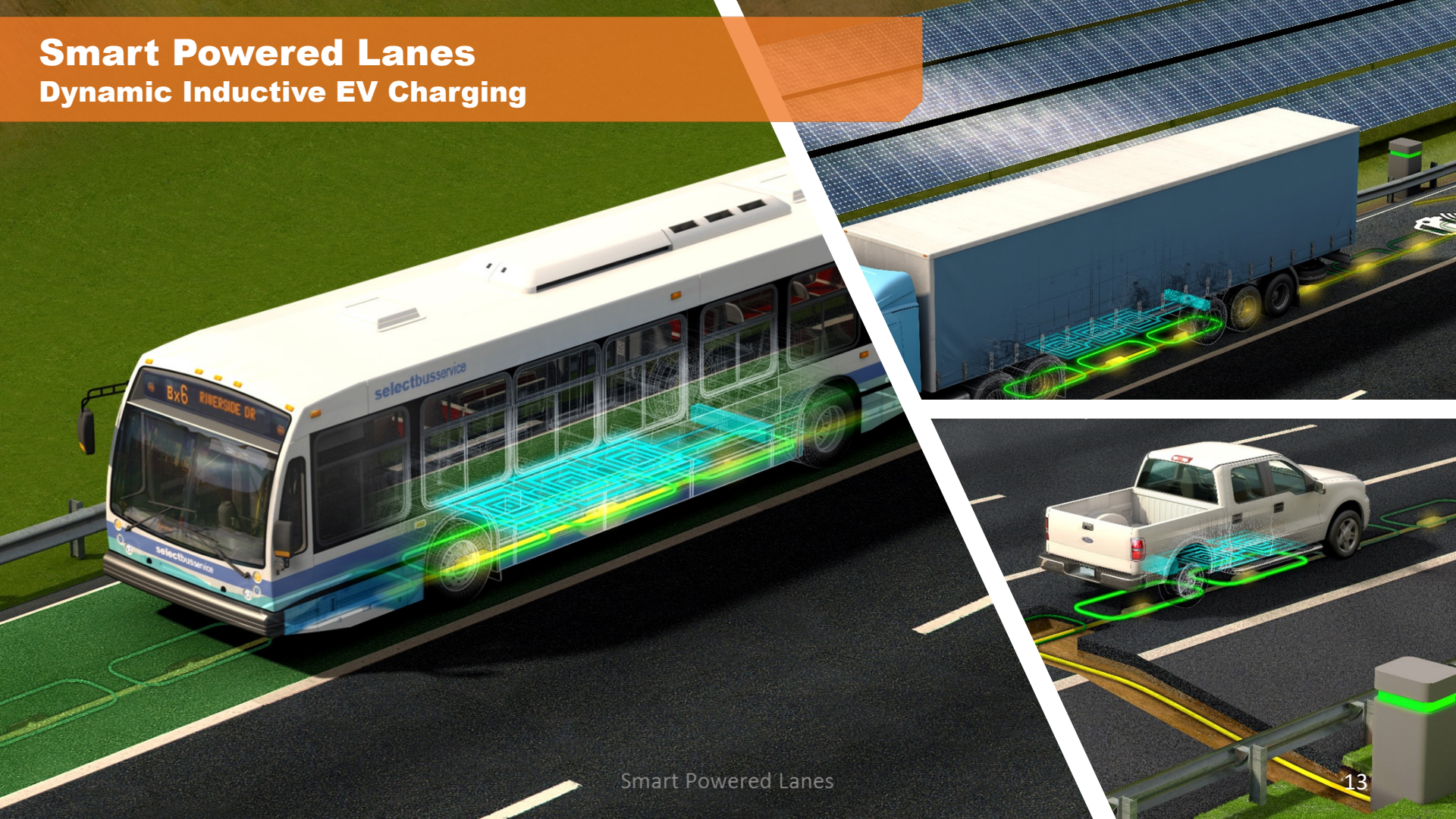


Utility Impacts
The Challenges

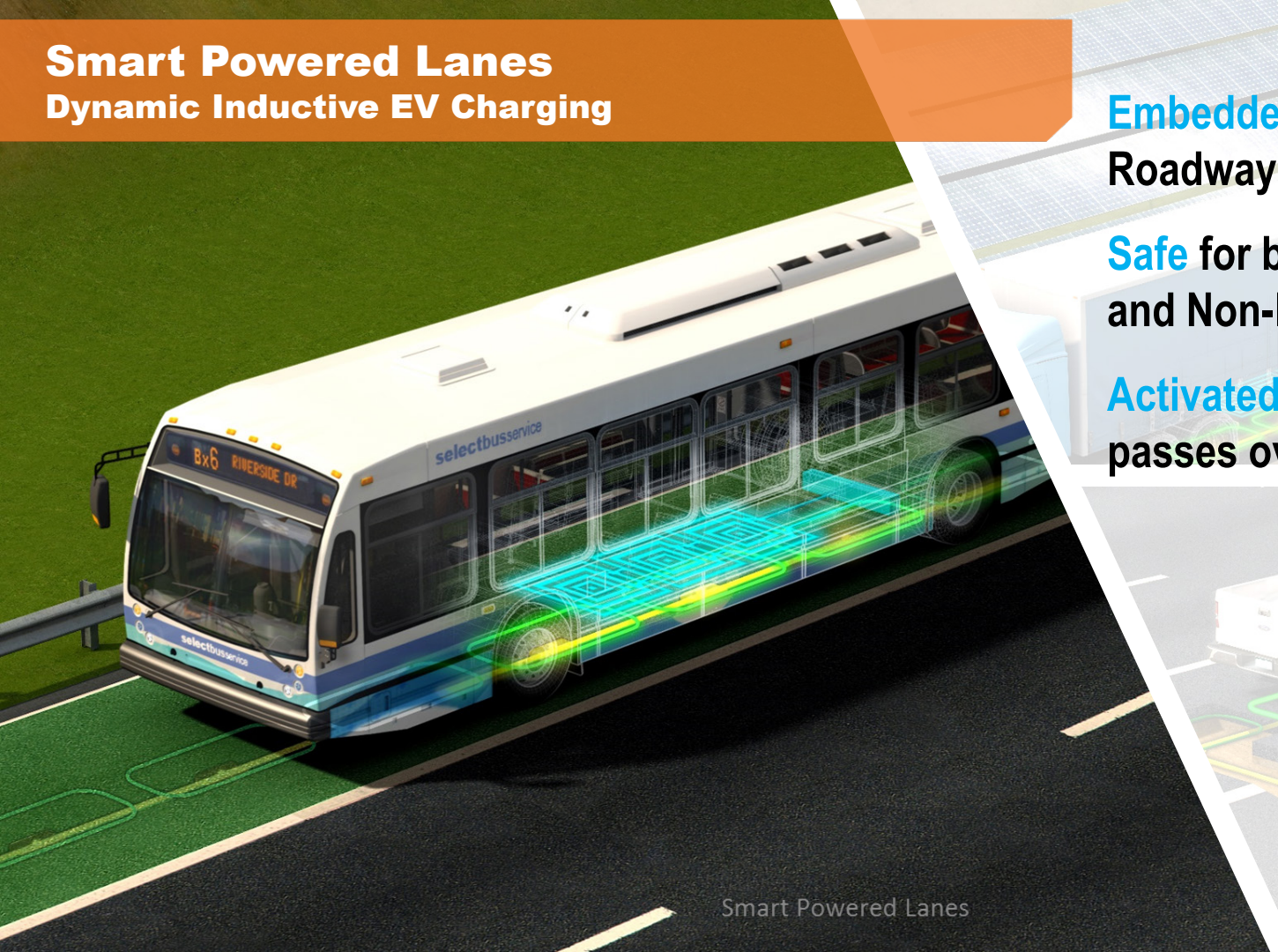
- **Changes** to tariffs and rates
- **Charge-Ready** Infrastructure Needs
- **Modernization** of their Grid Infrastructure



Smart Powered Lanes
Dynamic Inductive EV Charging



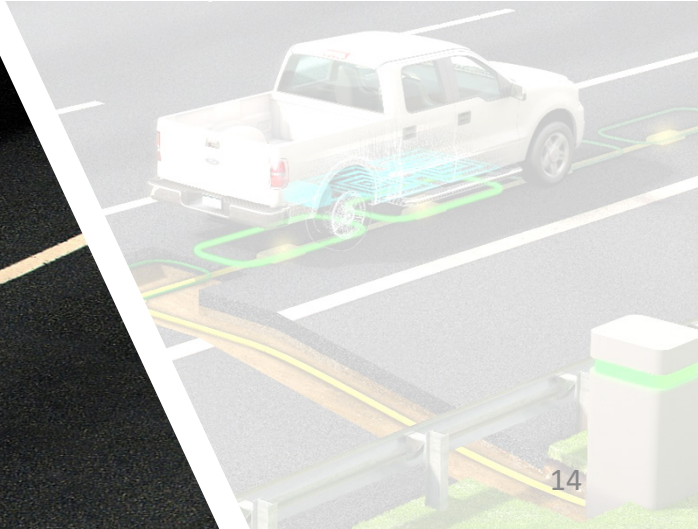
Smart Powered Lanes
Dynamic Inductive EV Charging



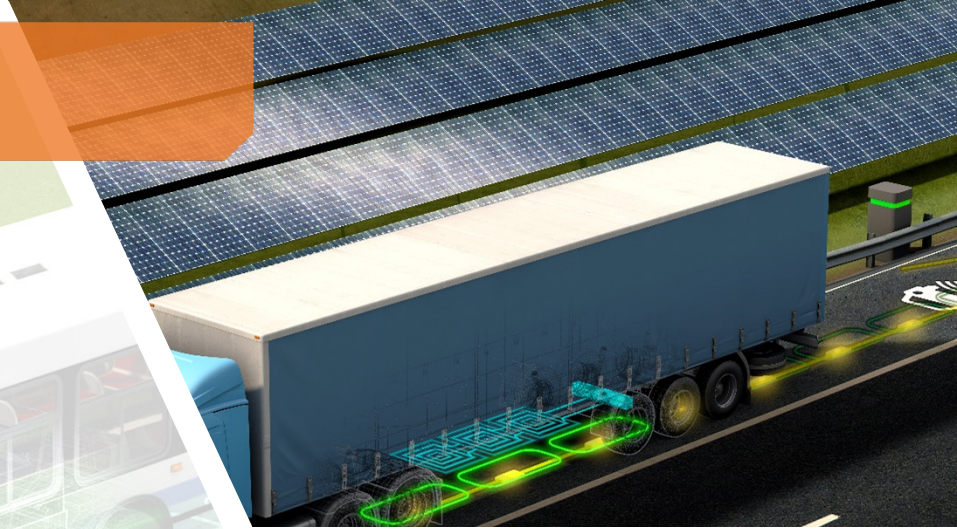
Embedded Inductive Roadway Technology

Safe for both Electric Vehicles and Non-Electric Vehicles

Activated only when receiver passes over the coils

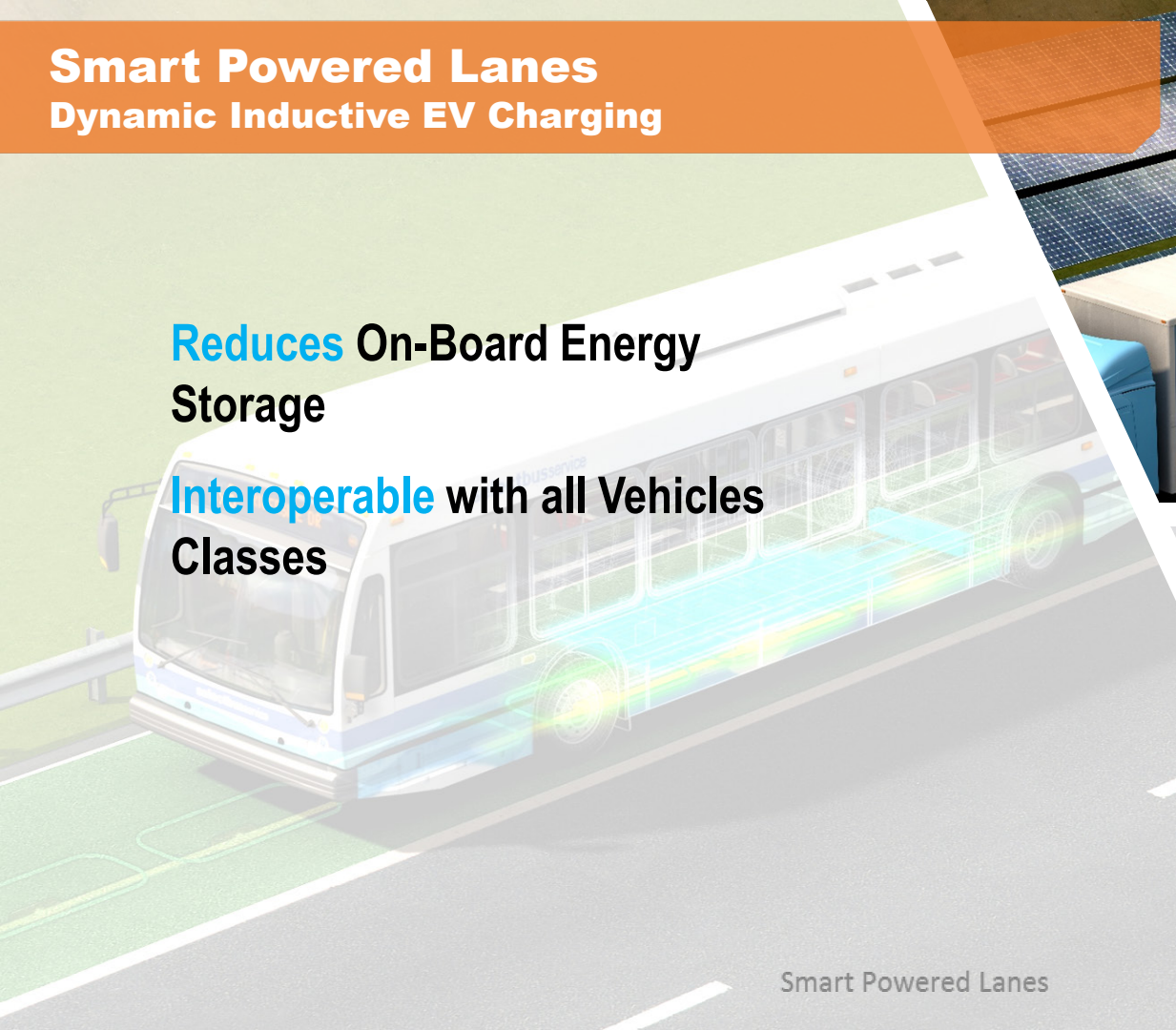


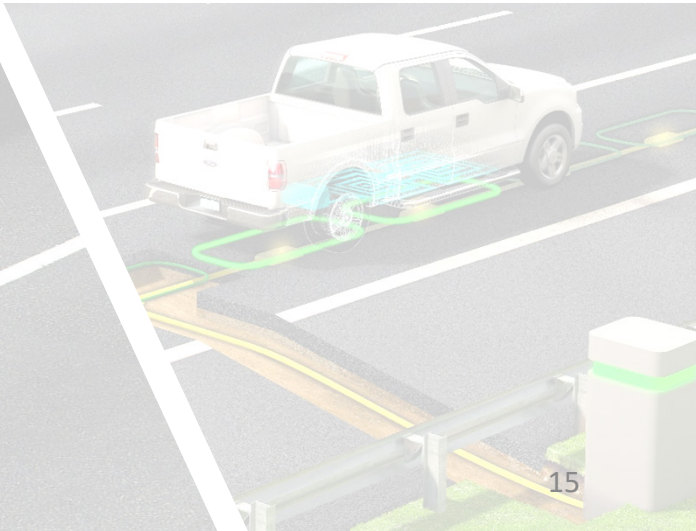
Smart Powered Lanes
Dynamic Inductive EV Charging



Reduces On-Board Energy Storage

Interoperable with all Vehicles Classes



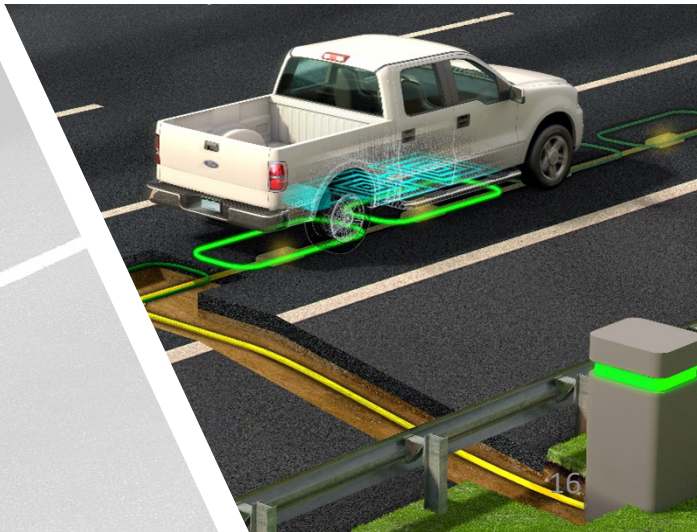


Smart Powered Lanes
Dynamic Inductive EV Charging

Ecosystem with Infrastructure Owners

Leverageable with Renewable Energy Sources

Starting Block for V2G Technologies

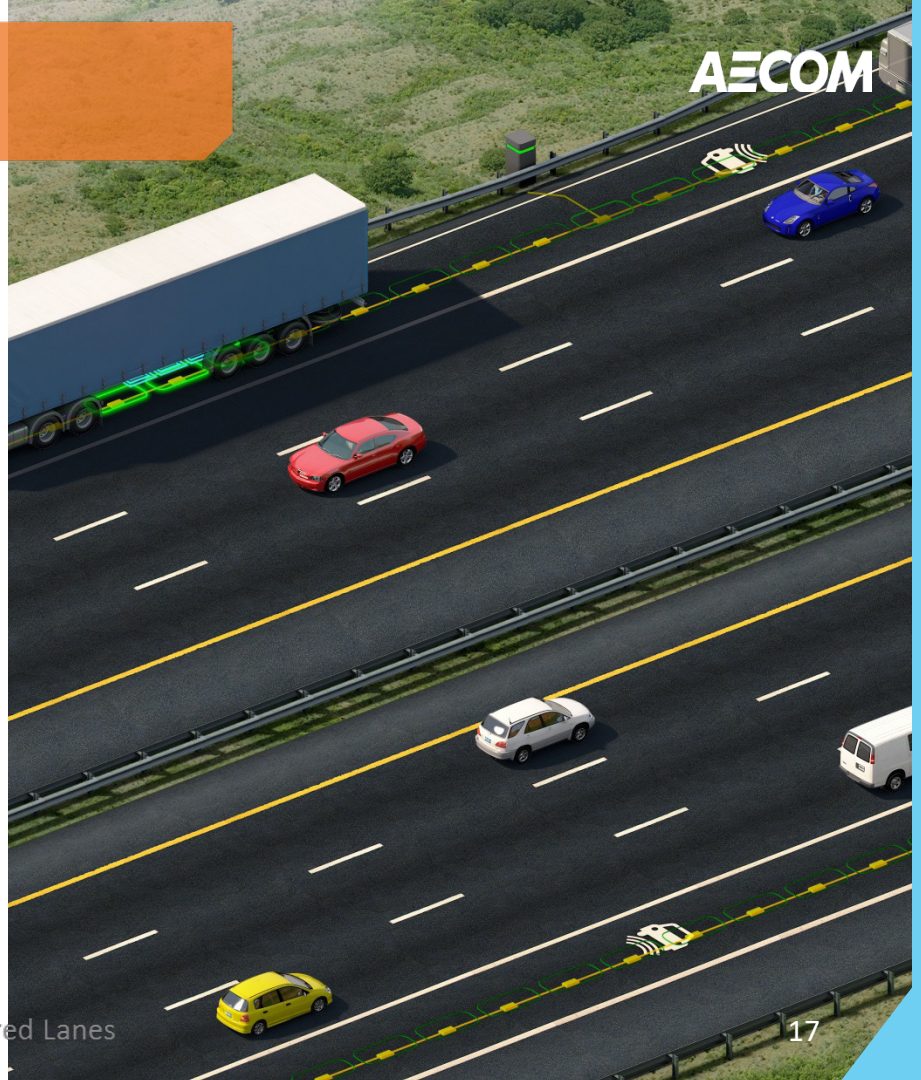


Smart Powered Lanes
Dynamic Inductive EV Charging

01 Energy storage shifted from battery to roadway

02 More consistent charging along a route

03 Lowers cost of electric vehicles with smaller batteries



Smart Powered Lanes
Dynamic Inductive EV Charging

Lower cost to electrify fleet vehicles

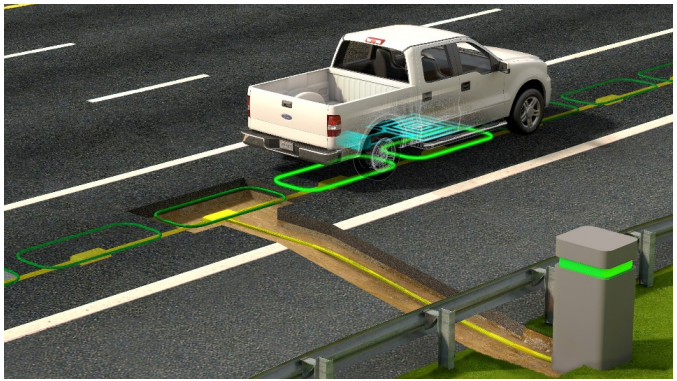
Better fleet efficiency with electric vehicles that don't need to stop to charge

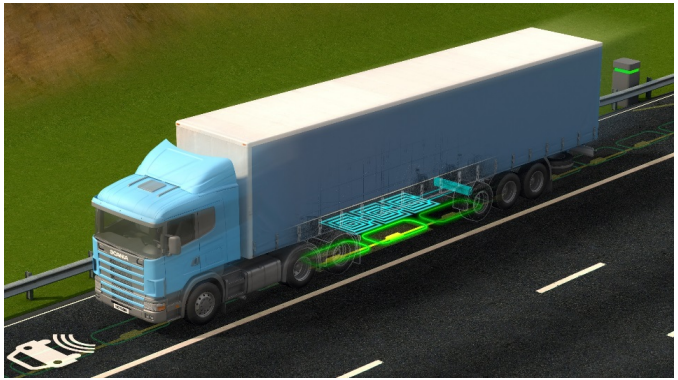
Cleaner vehicle fleets that are not reliant solely on fossil-based fuels

Reduce transportation operations costs

Minimal changes in operations, maintenance and required facilities

Smart Powered Lanes
Dynamic Inductive EV Charging





Concept

- Roadway embedded coils energize sequentially as vehicles pass over the pads
- Receiving coils on the vehicle deliver power to the drivetrain and charge the battery
- Reduces battery size on EVs and allows hybrid EVs to operate with zero emissions

Technical targets

- 50 kW per receiver coil, scalable to multiple coils for trucks
- Continuous power to the vehicle at highway speeds
- Target 90%+ average efficiency, grid to battery

Grid impact

- Continuous and controllable load by averaging over long roadway sections of coils
- Off-peak loading by integrating energy storage at utility interface
- Local load for wind and solar power

Safety and Compatibility

- Meet ICNIRP standards for safety
- Compatible with light to heavy duty vehicles

Smart Powered Lanes
Thought Leaders

SELECT

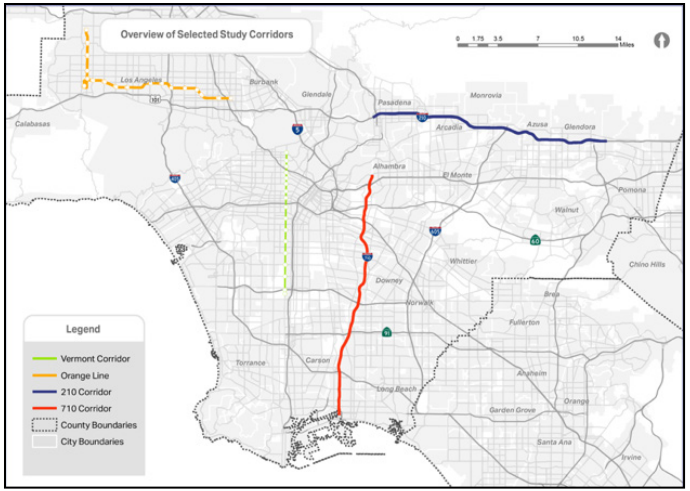
Sustainable Electrified Transportation Center
Utah State University

Smart Powered Lanes
Partners

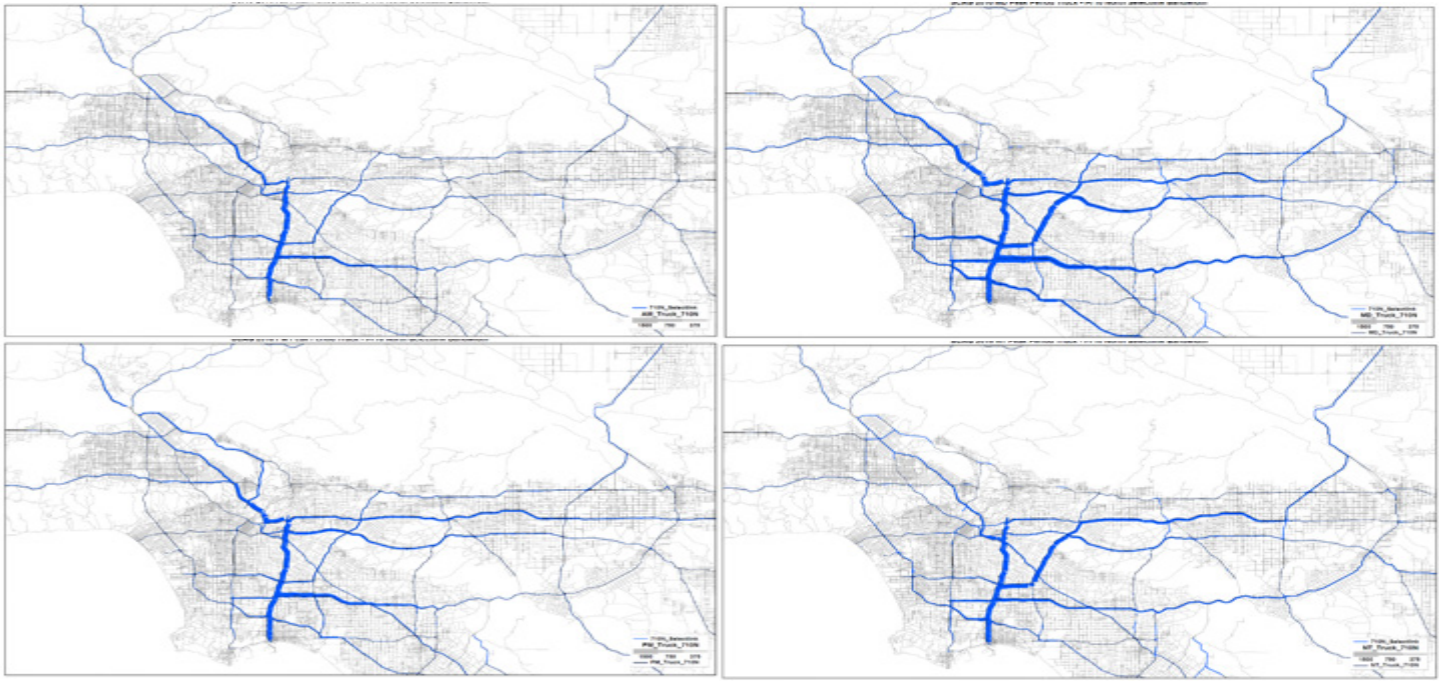
Smart Powered Lanes
Partners

Smart Powered Lanes
Feasibility Analysis

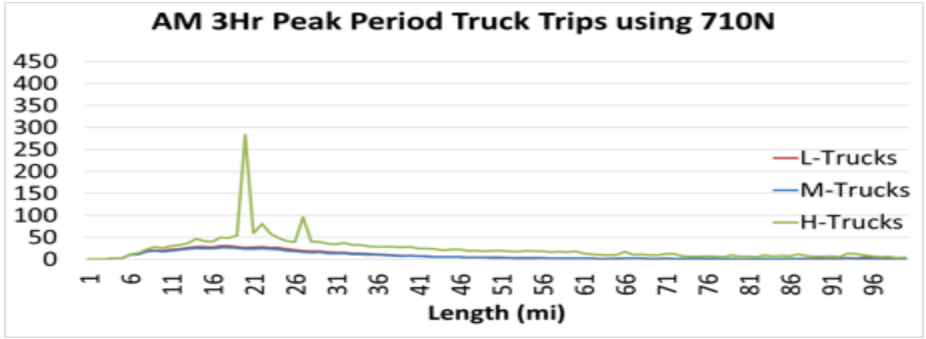
- DOE ARPA-E funding: analysis of freight and passenger vehicle corridors in lower Los Angeles County
- Evaluation of in-road inductive wireless and overhead conductive electric roadway solutions
- Results extended to other major US cities and interstates
    - Technology first adopters
    - Value proposition for incremental rollout
    - Technology gaps for accelerated market adoption
    - Localized impact on emissions reduction during rollout
    - Team: USU, CSU, Purdue, AECOM, So California Edison

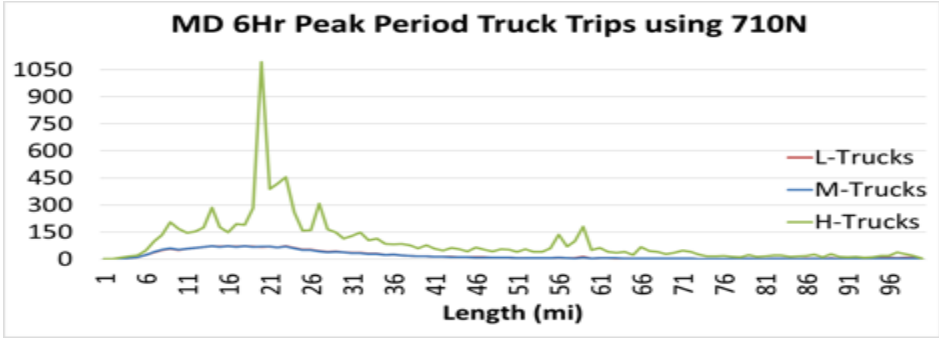


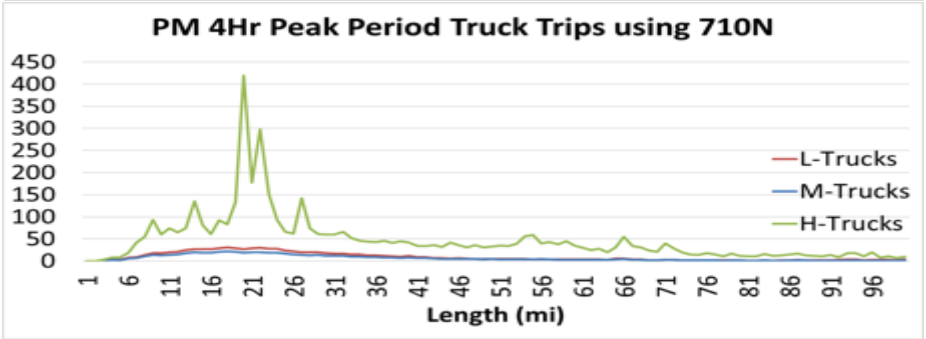
Smart Powered Lanes
SelectLink I-710 Truck Routes

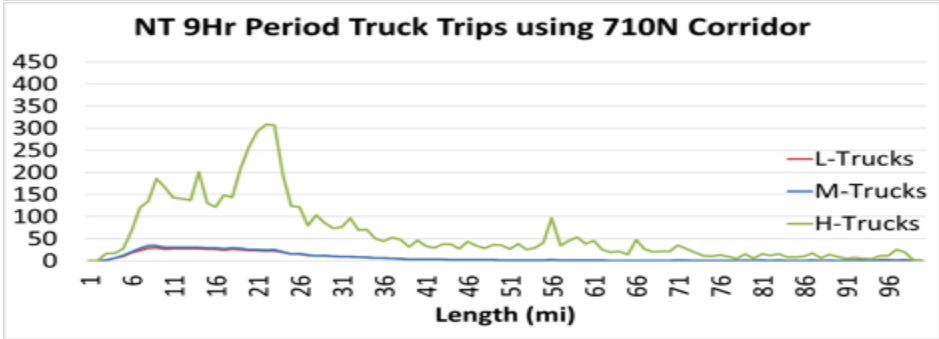


Smart Powered Lanes
I-710 Traffic Analysis



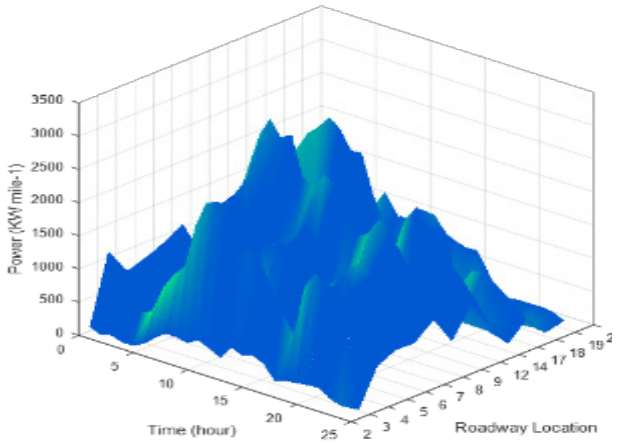




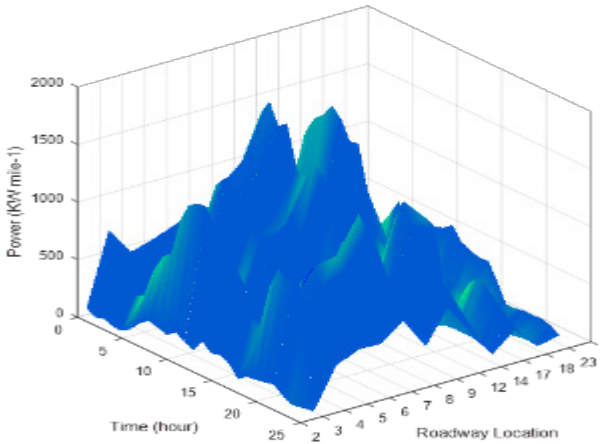


Smart Powered Lanes
I-710 Power Analysis

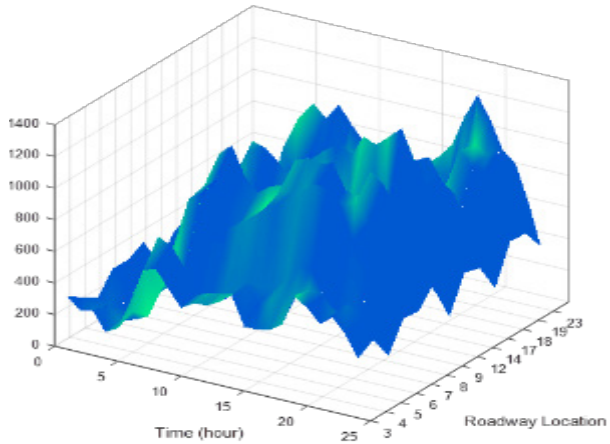
Loaded Trucks



Unloaded Trucks



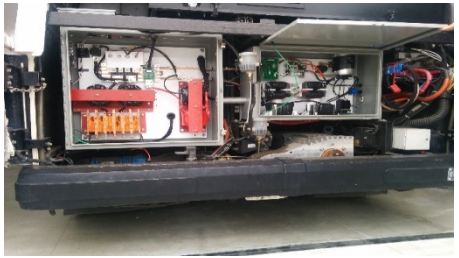
Cars

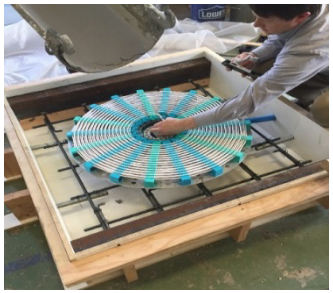


Demonstration Project
Utah State University

USU TEST TRACK

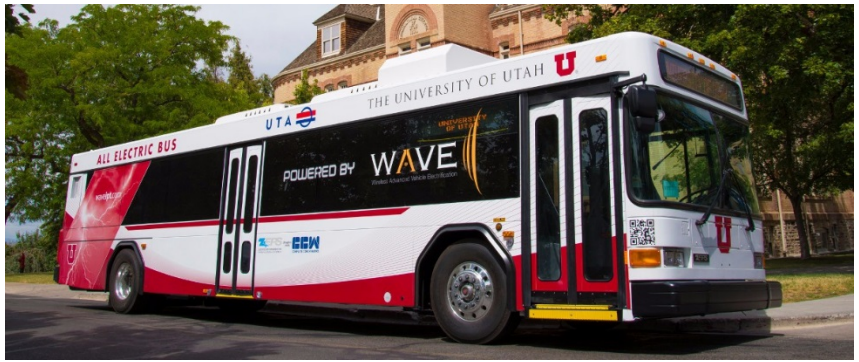
- In-motion charging demonstration at USU, 20-passenger electric bus
- 25 kW charging pads embedded in roadway
- 7-inch ground vehicle coil spacing
- Single receiving pad on electric bus
- Vehicle detection and communications
- Concrete coil enclosures
- Meets safety standards for magnetic fields
- Autonomous vehicle control





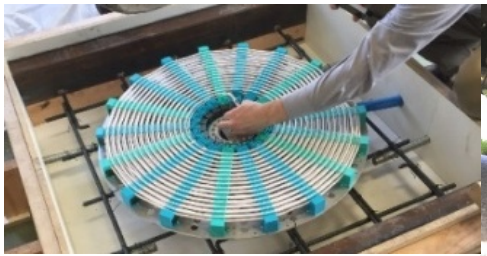
Utah's Wireless Charging Legacy
WAVE

- USTAR, DOE investment
- WAVE—USU spin-out 2012
  - First in the nation demonstration—50kW stationary wireless bus charging in SLC
  - Working toward first in the nation demonstration—250kW stationary wireless bus charging in Palmdale, CA
- Grown out of USU from DOE and State of Utah (USTAR) funding
- More than $11M in current contracts
- Expanding into new markets
  - Shipping/ports with Hyster-Yale
  - In-motion collaboration with USU

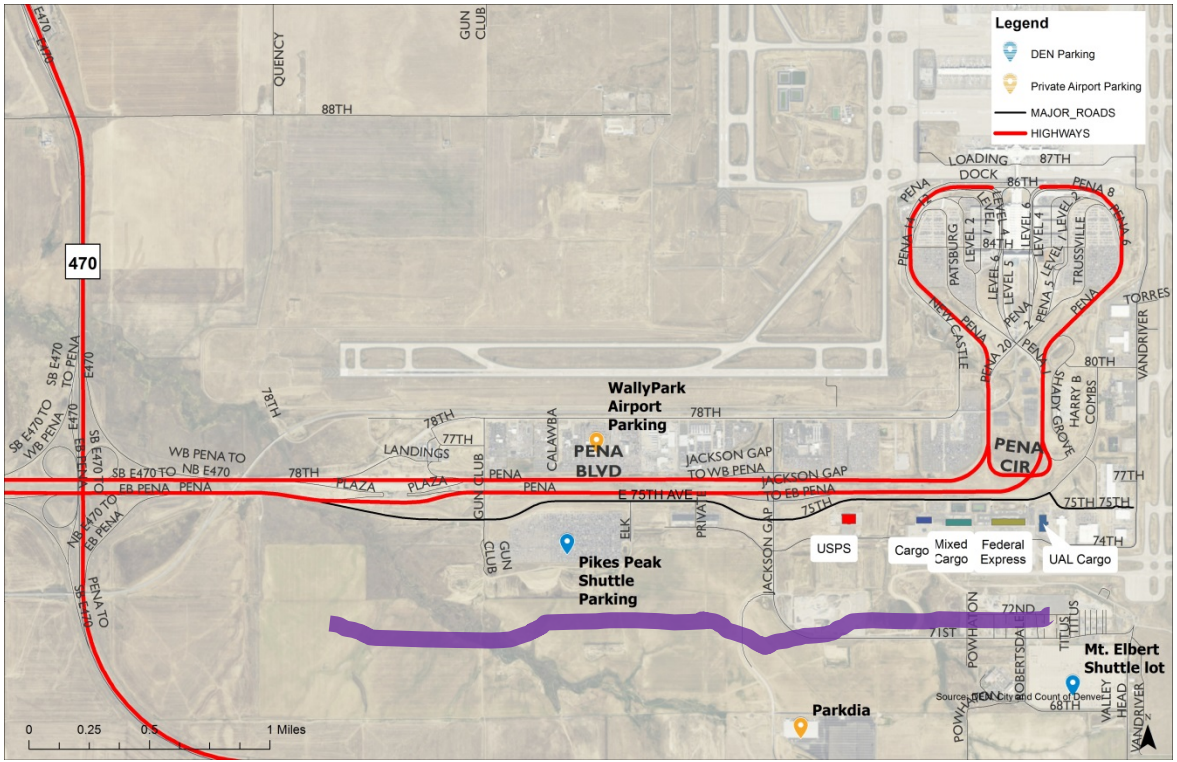


Next Steps for Scaling

- **EVR Prototype demonstration**
  - Develop, prototype, and manufacture roadway modules, embedded in concrete pads with 50kW output
  - Develop, prototype, and demonstrate vehicle retrofit kit including two 50kW receiver modules with 100kW output to battery pack
  - Manufacture/demonstrate complete modular electric roadway system on USU ¼ mile track (including grid tied power distribution converter, 30 series connected roadway transmitter modules)
  - CDOT pilot deployment in 1 mile roadway section in Denver, Colorado (e.g., near Denver International Airport)



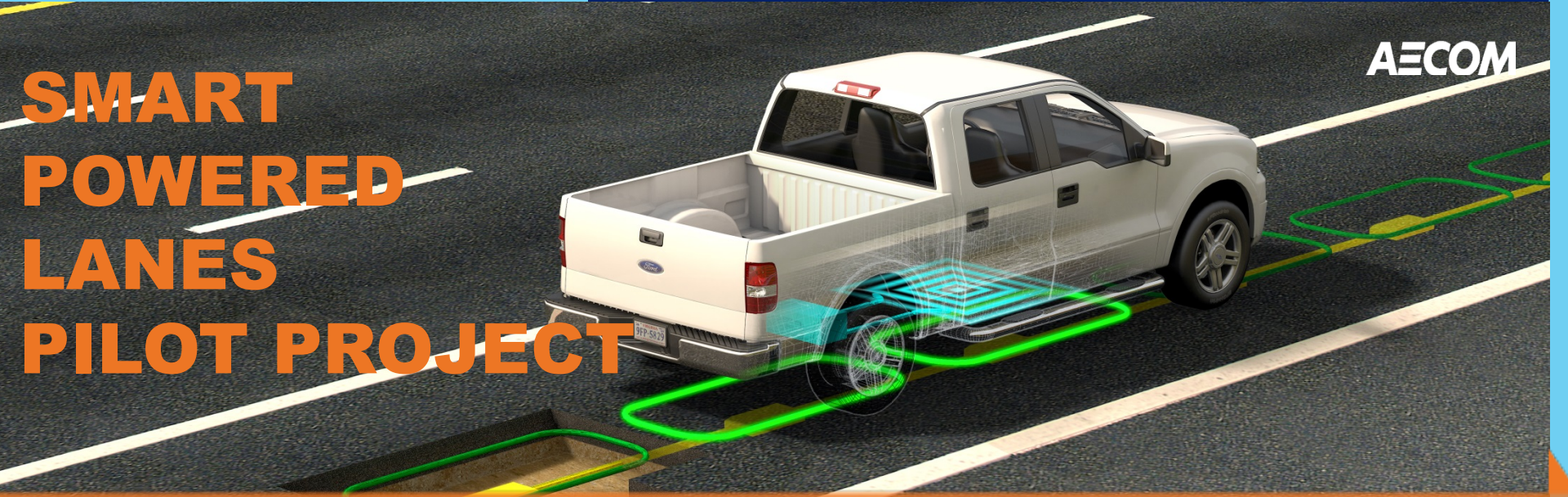
Pilot Project
Denver International Airport



Potential Uses

- Fleet Vehicles
- Operations Vehicles
- Trucks (UPS, FedEx, USPS, DHL)
- Shuttles (Parking)

SMART POWERED LANES PILOT PROJECT



AECOM

PARTNERSHIP FOCUSED

- *Enlisting partners early for pilot design*
- *Pilot focused on partner operations and feedback*
- *Pilot Project as a first step*

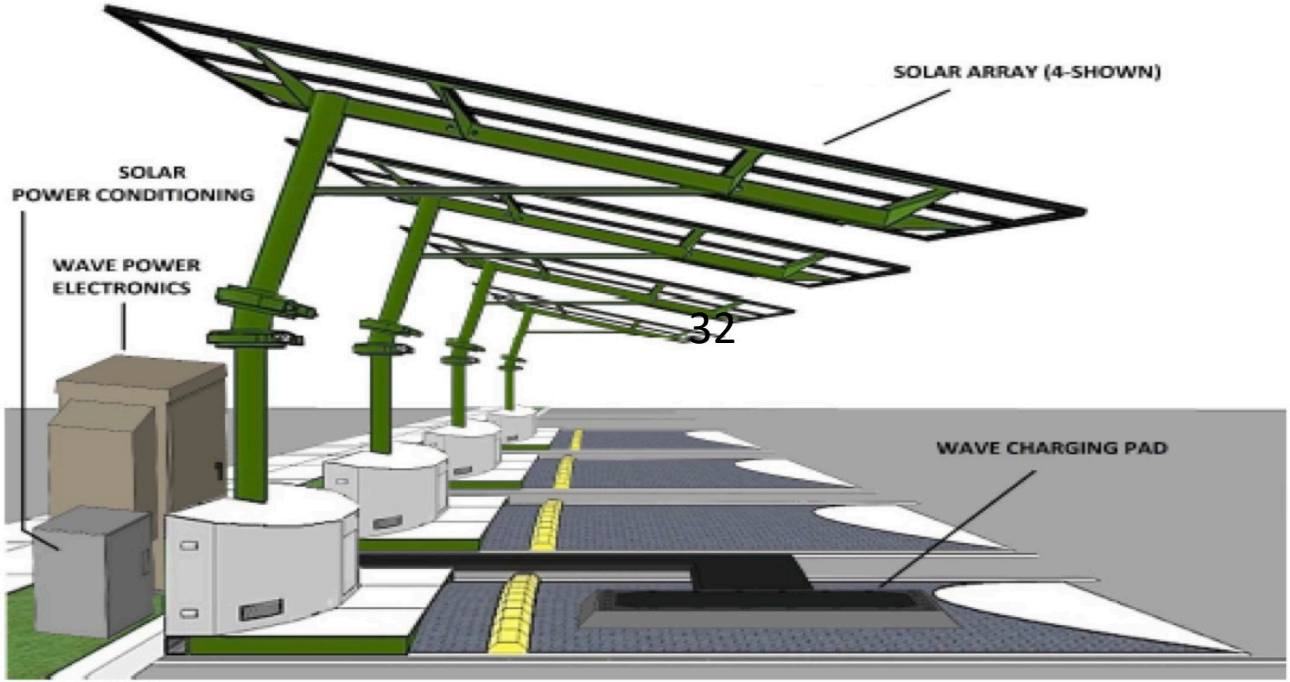
SAFE AND OPERATIONAL

- *No impacts to vehicles not participating in the pilot*
- *Adheres to safety standards for wireless power transfer*
- *No change in operations for fleet drivers*

LOW COST & LOW RISK

- *1-mile long roadway, along lane or shoulder*
- *A minimum of 3-5 vehicles to run on roadway*
- *No new vehicles required, retrofit kits for existing vehicles of any size*

Wireless Static Charging



Partnerships

Parcel delivery companies are all starting to look at electric vehicles to reduce their operating costs and their impact on air pollution.

> *"UPS is arguably leading the way on that front as it orders a fleet of 1,000 electric vans from Workhorse as it latest electrification effort. They are converting 'up to 1,500 delivery trucks' to battery-electric in New York, they've already bought some of Daimler's new electric trucks, and they've ordered 125 Tesla Semi trucks."*

Carlton Rose, President of global fleet maintenance and engineering for UPS, commented on the announcement:

> "UPS believes in the future of commercial electric vehicles. We want to support the research needed to make advances and the companies developing those innovative products. Performance is critical in our fleet. We are excited to get this vehicle on the road to test how it handles routes in and around Los Angeles."

Questions?


AECOM
Imagine it.
Delivered.