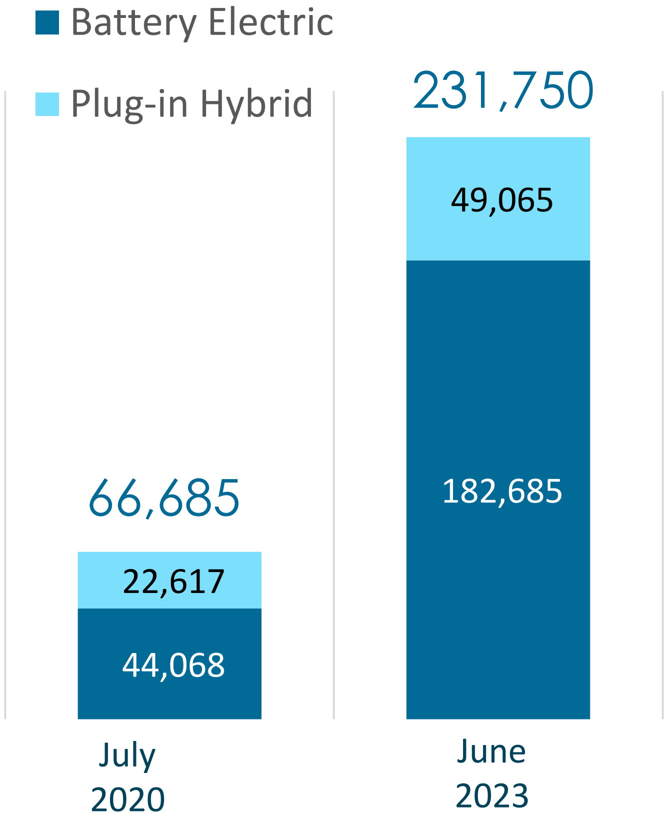
2023 FAV Summit: Alternative Fuel Vehicle Infrastructure

Moderator: Raj Ponnaluri, PhD, P.E, PTOE, PMP
Manager, Emerging Technologies
Florida Department of Transportation

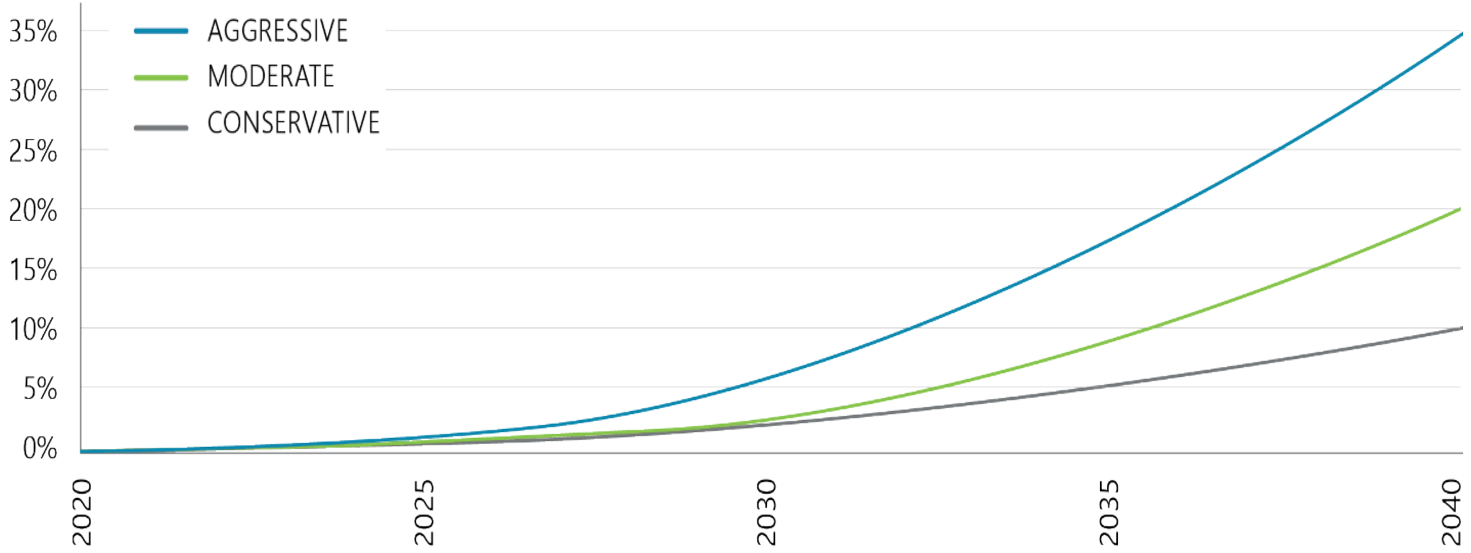
Friday, September 8
10:30 am-12:00 pm

Current Florida's EV Market Adoption

Florida EV Registrations

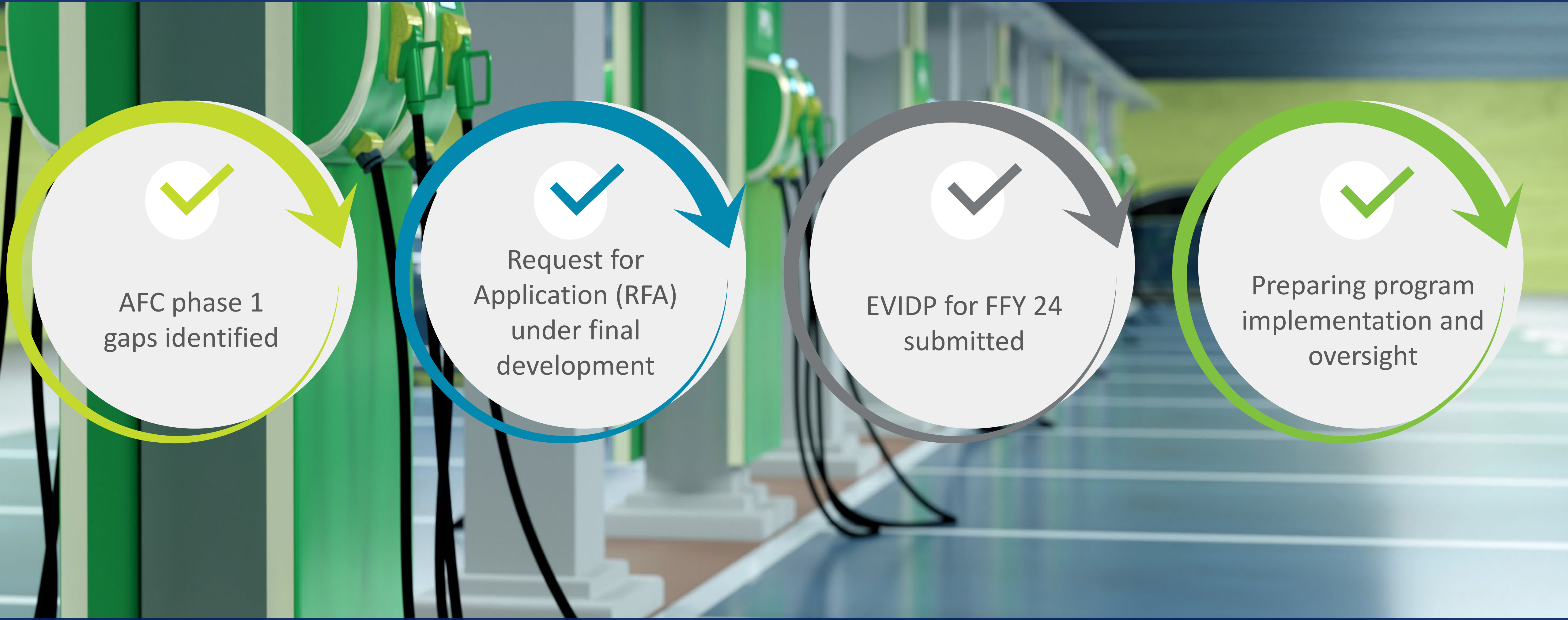


FDOT MA3T Model with Industry Projections



Major entities such as Volvo, Ford, Honda, GM, Toyota and others have been announcing their plans to expand into the EV market over the next two decades.

Florida's EV Deployment Progress

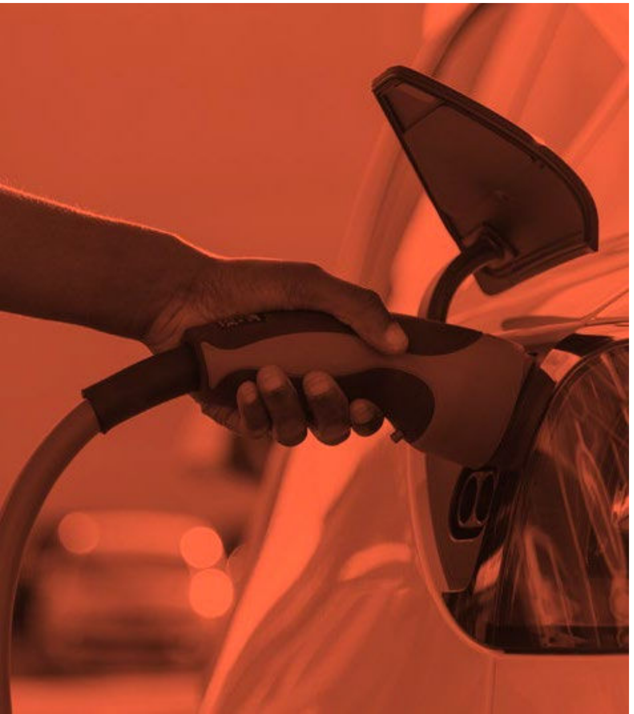


Charging Ahead: Powering Progress in EV Infrastructure Deployment and Operations

Jennifer Szaro

President & CEO

AESP



Charging Ahead: Powering Progress in EV Infrastructure Deployment and Operations

2023 Florida Automated Vehicle Summit

Jen Szaro
President and CEO, AESP
jszaro@aesp.org

4,900+ Members

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Focused on customer-centric energy efficiency, demand response, and DER offerings and enabling technologies

501 c(3) educational non-profit,
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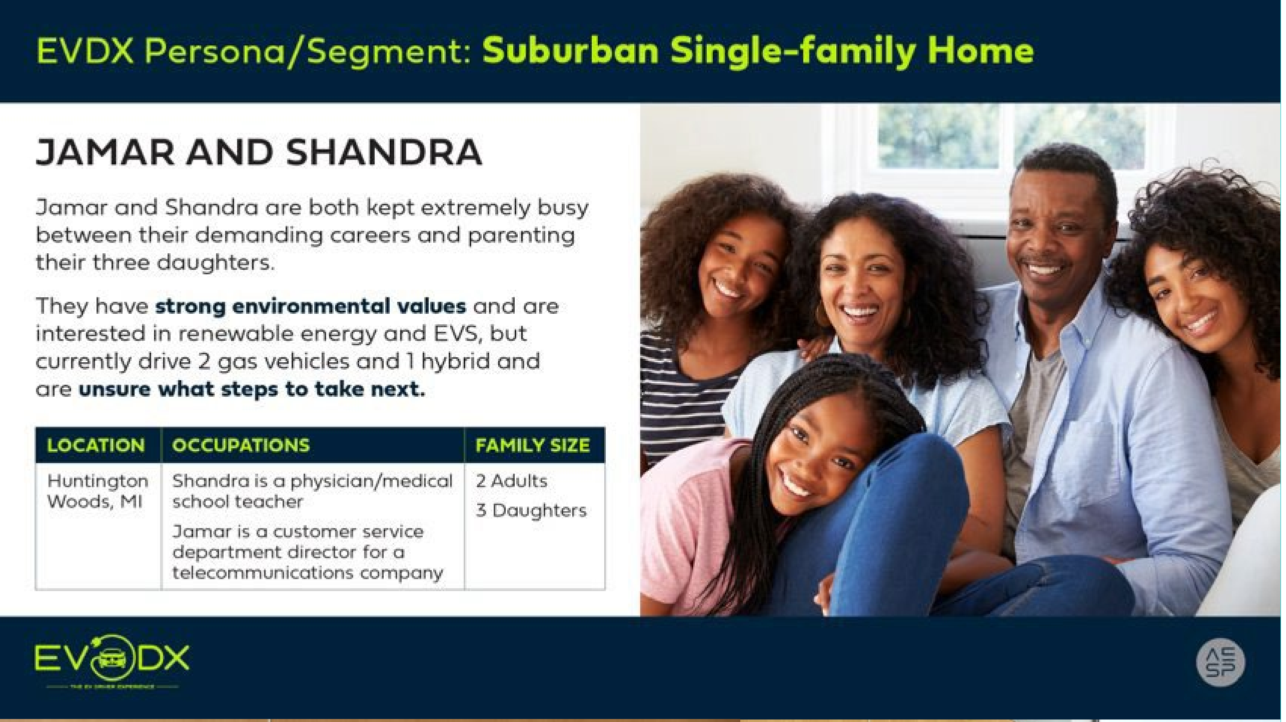
We advance the energy industry by providing critical knowledge and professional development resources to clean energy professionals across North America



THE EV DRIVER EXPERIENCE

The Electric Vehicle Driver Experience Initiative, or EVDX, will work with the energy industry to help identify key pain points in the EV Driver Customer Journey and then work collaboratively to develop solution sets that ease the transition from gas vehicles to clean, electric transportation.

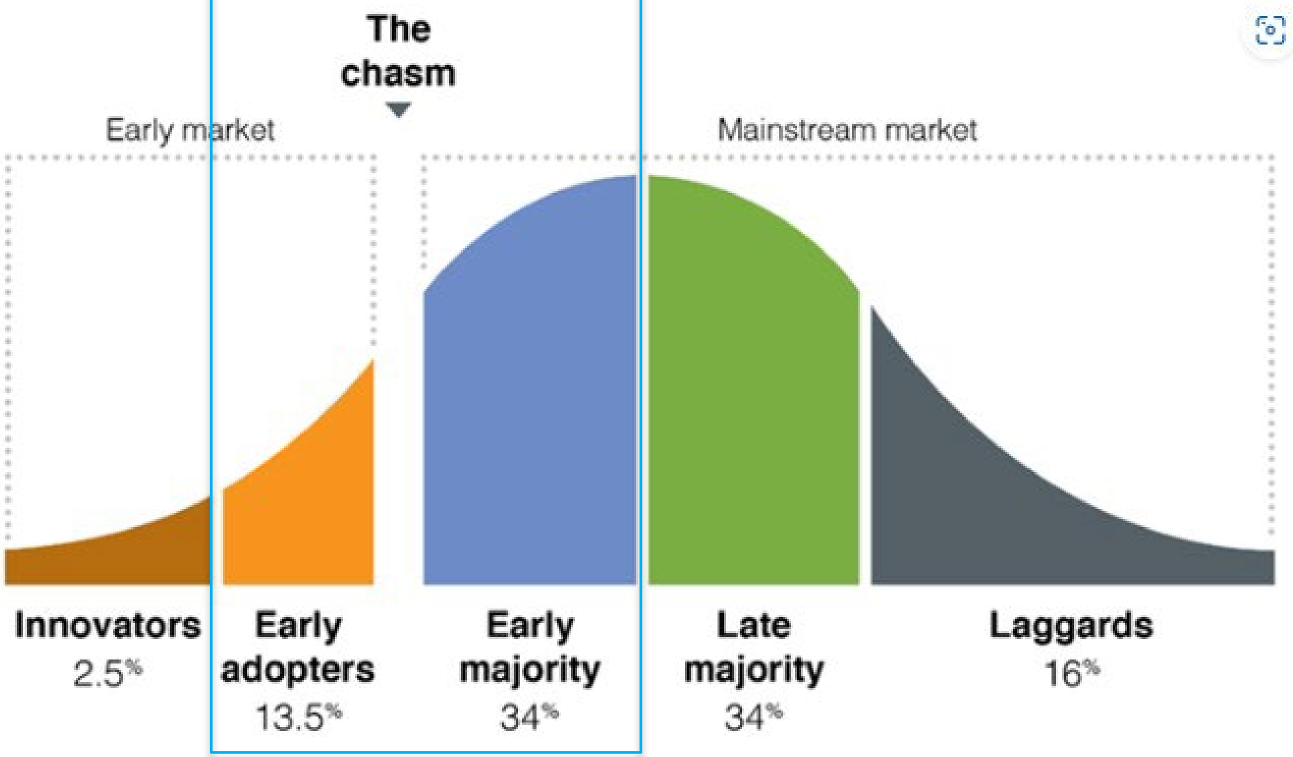
Learn more at AESP.ORG/EVDX

EV Diffusion Curve

Broader adoption will require a better driver experience

Figure 1: Rogers's diffusion of innovation curve

Because they want the newest technology before anyone else, innovators are willing to accept an imperfect experience. But broader adoption requires a great CX.



© E Source; adapted from Everett Rogers

“Common Customer” EV Buyer Persona Journey

Awareness → Research → Purchase → Pick-up → 1st Driving Experience → Driving Optimization → Advocacy

Light-duty EV Customer Journey

- Kevin’s neighbor buys an EV. Kevin sees EV ads on TV.
- He talks to his neighbor & goes on YouTube to research EV options & costs.
- Visits two local dealerships where the EV reps know less than he does. He reserves his EV b/c he already knows what he wants to buy. He’d prefer to buy online.
- Kevin picks up car. Critical EV info and tips are not shared, leaving him excited, but wary.
- He researches and buys a home charger, finds electrician, feels unsure about decision, and doesn’t know there is a utility EV rate.
- Kevin wants to try public charging, so he does research, downloads the PlugShare app, searches for charger locations, drives to charger, and it is broken, creating stress and concern.
- Calls utility 1 mo. later after extremely high-bill & wants gas equiv’t kWh comparison & home charging advice. IVR struggles to direct him; agent has limited EV knowledge to support his questions & concerns.
- Kevin really enjoys his EV. Charging between home & office works well. He has a good feel & routine now. Public charging problems have made him wary though. He is unclear on what charging he can trust. The dearth of EV data makes him unclear on whether he made the “smart choice”.
- Overall, Kevin is happy, feels good about his cool tech & positive contribution to the environment. He shares his EV experience online whenever he can.

CX insights

- Social networks and norms create general awareness of EVs and normalize their position as a credible (if not attractive/aspirational) option.
- Online EV research & purchase critical to buyers. Dealers & reps are key, but lack focus & training to support early majority market.
- Finance Sales CX is bad, but unactionable. Car walk-through is a KMOT where reps training & support can reinforce key EV concepts. Currently minimal home charging resources.
- Public charging is a critical KMOT that’s failing; threatens to erode current & future EV customer adoption.
- IVR intro is lengthy, customer repeats info multiple times & struggles to get solutions to EV bill & charging concerns
- EV customer ongoing engagement & optimization/improvement support does not exist today. Limited cross-industry support for satisfied EV drivers to share their experiences, advocate locally, and collectively build and engage the local EV community.

Opportunities

- Generate EV micro-cohorts. Design cross-industry messaging & alignment to amplify impact of EV social networks, online influencers, & on-the-ground advocates..
- Design in-store signage & car info materials for early buyers. Dev & fund EV rep training to curate buyer CX for any car brand.
-
  - Design cross-industry EV walk-through process & car materials.
  - Fund rep EV training & dealer/rep support.
  - Design seamless hand-of/sign-up between dealer, utility, charging co’s, cable & others.
- Collaborate on developing and supporting performance standards. Align apps EV charging support CX.
-
  - Design clear EV program options
  - EV training, tools & support for reps
  - EV charging trade ally resources
  - EV IVR tree update
-
  - Design coordinated EV customer support plan to ensure customer success & satisfaction.
  - Collaboratively design and fund customer experiences, campaigns & channels…

Credit: E Source

We've Moved on From Range Anxiety to Charge Anxiety

Range anxiety is the fear that an electric vehicle (EV) will run out of battery power before reaching its destination or a charging station. Charge anxiety is the feeling of uncertainty about whether you will be able to charge at a charging station.

In their words…
Reliability

"Private corporations simply don't maintain their equipment as they should and don't stay on top of outages like they should. Public investment in private infrastructure is a problem of accountability."

"Non-Tesla DCFC has a long way to go from an interoperable and reliability standpoint. No one wants 5 apps that have to constantly be updated, and we need stations with a minimum of 62.5kW to actually deliver that level of power and not be broken."

Quotes from EV drivers asking *what their most difficult situation encountered in their EV journey*. Via LinkedIn request from Bill LeBlanc, Rolling Energy Resources.

In their words…
Waiting/Etiquette

Recently we drove I-5 to Northern Calif and had to wait over an hour for others to finish charging… Luckily, there were four chargers. In both cases, other owners were charging past 80% which I consider quite impolite as well as not so good for their cars. We need chargers to remind people to be considerate. (2019 Kona EV)

"Driving up to a fast charger on the Turnpike where there is one plug, it's the only one within ~50 miles, it's occupied, and you need juice. … so if you catch somebody at the beginning of their charge cycle, you're waiting well over an hour to start your longish charge. With very few destination chargers, it was anxiety-inducing at times."

Quotes from EV drivers asking *what their most difficult situation encountered in their EV journey*. Via LinkedIn request from Bill LeBlanc, Rolling Energy Resources.

In their words…

Apartment Life

EVDX
THE EV DRIVER EXPERIENCE

"Then we [moved into] an apartment for 6 mo. The level 2 free charger at the mall had a 2-hour limit, so at best a 20% charge, and we had to leave the car there a lot longer than we would ever shop."
(2019 SV 62 kWh Leaf)

"The County put in free level 3 chargers, but the ChargePoint app was wonky, didn't always 'see' the vehicle, etc. It takes a simple swipe of any charge card and less than 5 minutes to gas up my hybrid at stations everywhere. That's the baseline."

Quotes from EV drivers asking *what their most difficult situation encountered in their EV journey*. Via LinkedIn request from Bill LeBlanc, Rolling Energy Resources.

In their words...
Borrowing/Renting

"I was actually using a friend's EV. She showed me how to charge it, and where to go, and even gave me her membership details of a certain charge provider. …no matter where I went, I had trouble with the charge station - The payment terminal didn't work, the charge port didn't work, the charging would start, then would stop for no reason, the tap reader didn't work with her fob. Can you imagine if I were renting an EV!?"

Quotes from EV drivers asking *what their most difficult situation encountered in their EV journey*. Via LinkedIn request from Bill LeBlanc, Rolling Energy Resources.

In their words...
Charge Speed

"The DC fast charger that was most conveniently on the way had a dramatically lower charge speed than the rating on the unit. 30 KW versus 350 KW. Not a disaster but added an hour + of unexpected downtime." 2022 Hyundai Ioniq 5

"I would suggest a new charging standard that explains the average charging rate and not the maximum. It's terribly misleading."

"Pulled into a parking lot that had the only fast chargers. Tried all 4 chargers - after 3 wouldn't work, my hands were shaking hoping the 4th one would work and it did, phew. Otherwise, I was staying for lunch AND dinner and maybe dessert for an L2 charge before driving on to my destination."

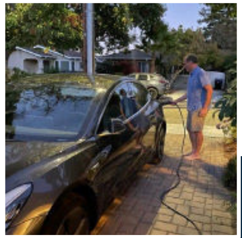
(2017 Chevy Bolt)

Quotes from EV drivers asking *what their most difficult situation encountered in their EV journey*. Via LinkedIn request from Bill LeBlanc, Rolling Energy Resources.

Key Pain Points Identified in User Charging Infrastructure Experience

Installation of Charger(s)

- Determining location and minimum service requirements
- Severe delays if utility provider not engaged early in planning
- Understanding bill impacts and rate options
- User training sparse



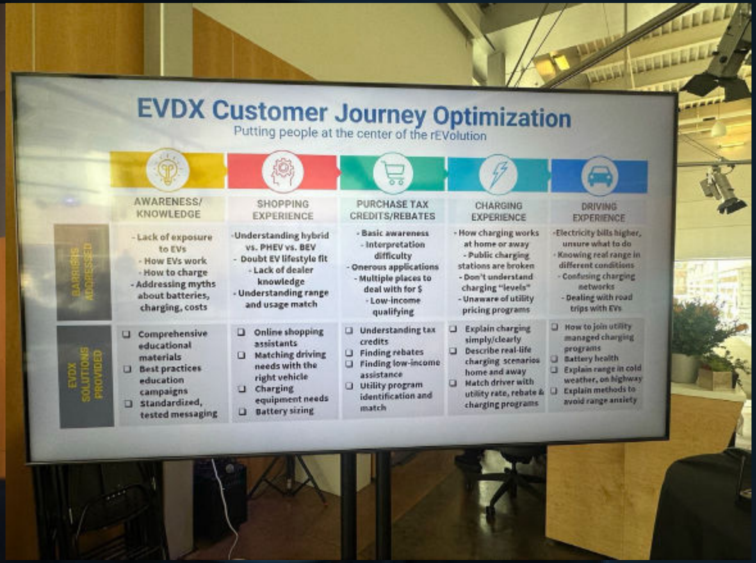
Access to Charging

- 31% of housing is multi-family in the U.S.
- 35% of the U.S. population rents housing
- 33% of U.S. housing units do not have a garage or carport
- 32% of current EV drivers do not have access to a level 2 charger at home

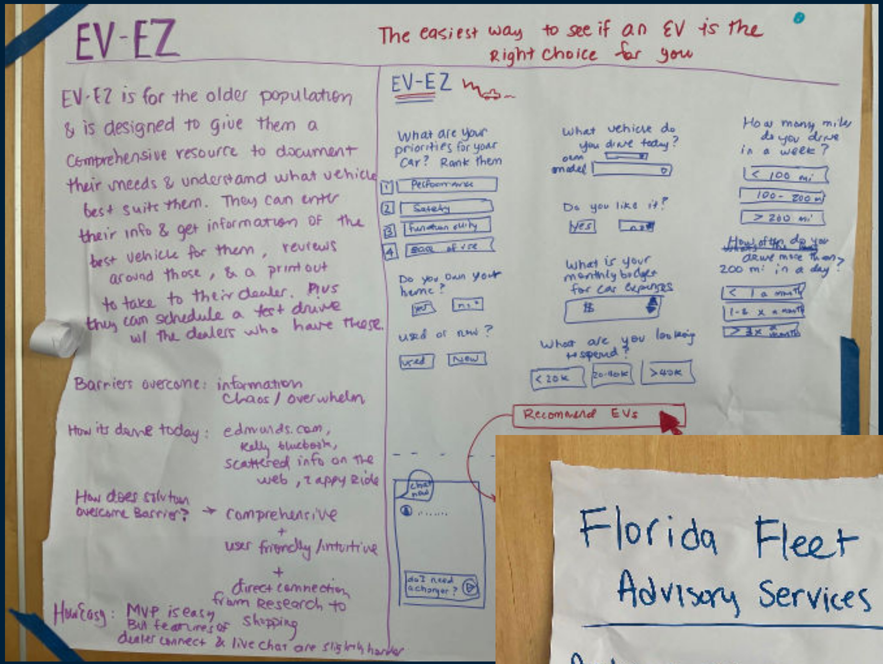
Poor Public Charging Experience

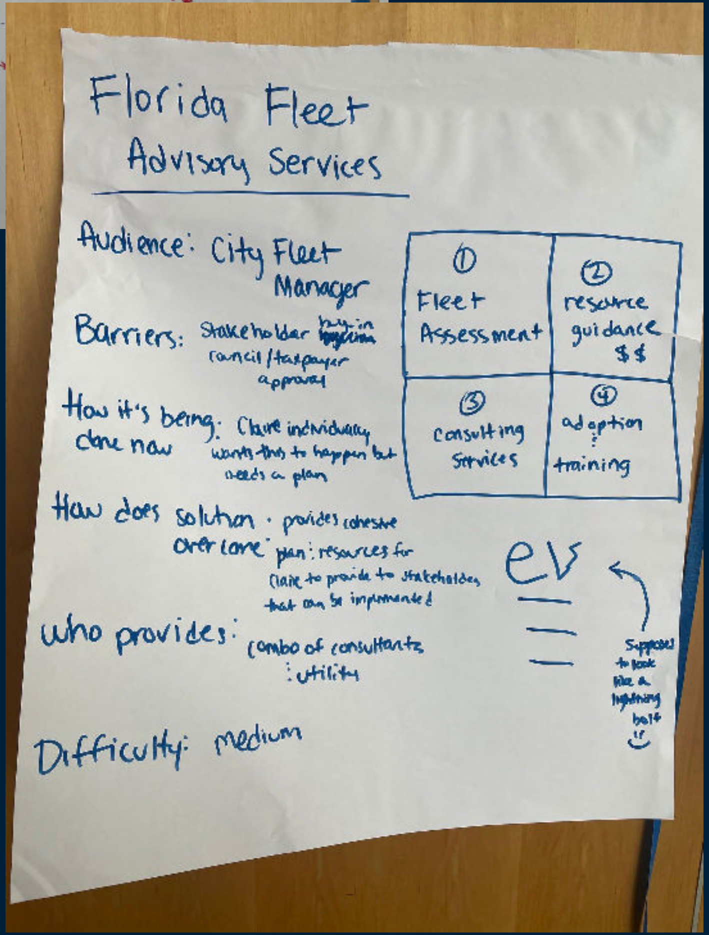
- Not the right charger type
- Broken connectors
- Network failures
- Payment system failures
- Unresponsive screens
- Vehicle doesn't achieve stated charging rates
- Lack of interoperability between networks
- Parking access

The Solutions Lab



Sample Outcomes





- **EV Customer Concierge Services** for those who need a comprehensive support selection tool for both choosing a vehicle and selecting the appropriate charging strategy
- **Fleet Advisory Services** – Assesses the vehicle and infrastructure needs of a municipal fleet, guides customers through system upgrades, provides guidance and application assistance for applying for grants and incentives, and assists with fleet deployment

AESP

Up Next

Summary Report from 1st EVDX Solutions Lab

EVDX Special Interest Group

Regional Events in Florida, California and Toronto in 2024

E-Roads: It Takes a Village

P.T. Jones

Sr. Technical Professional

Oak Ridge National Laboratory

Oak Ridge National Laboratory

Electrified Roadways (E-Roads):

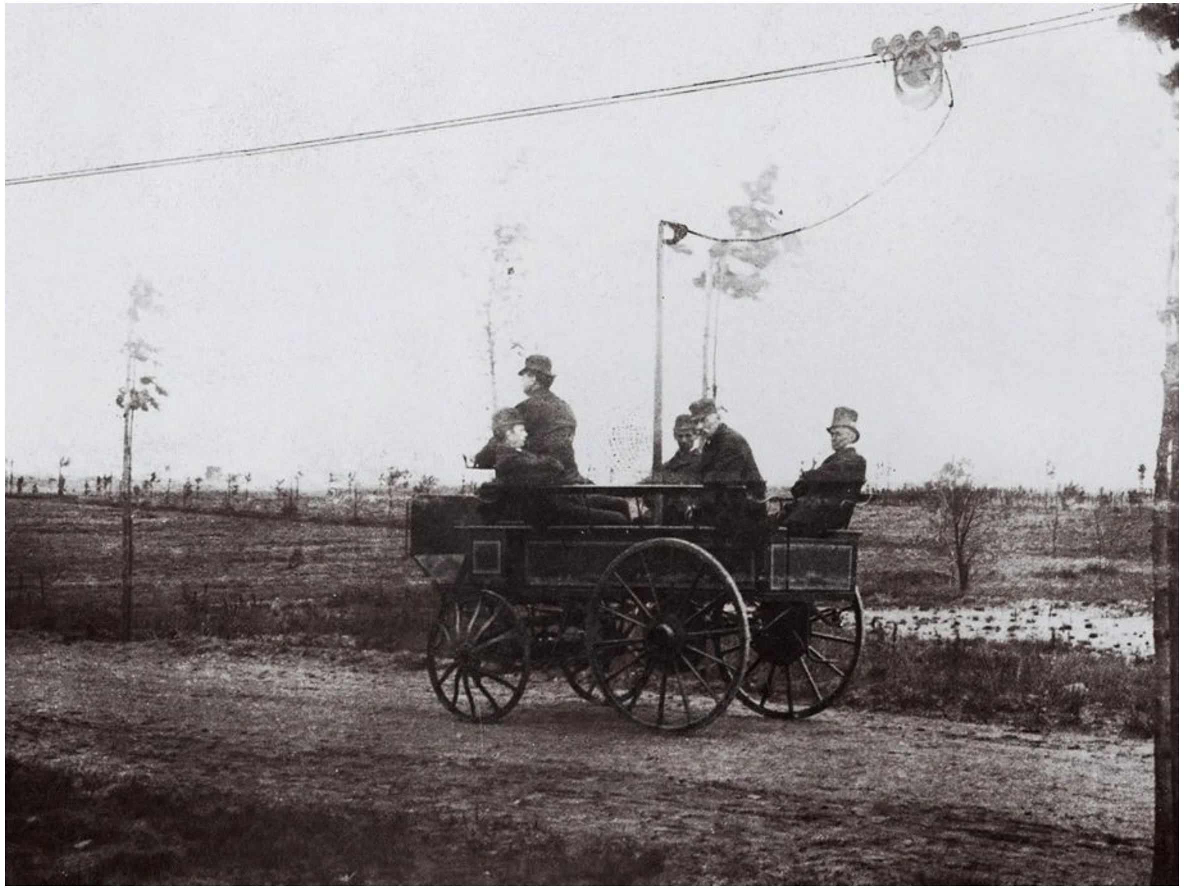
It takes a village

P.T. Jones
Sr. Technical Professional
Oak Ridge National Laboratory

U.S. DEPARTMENT OF ENERGY

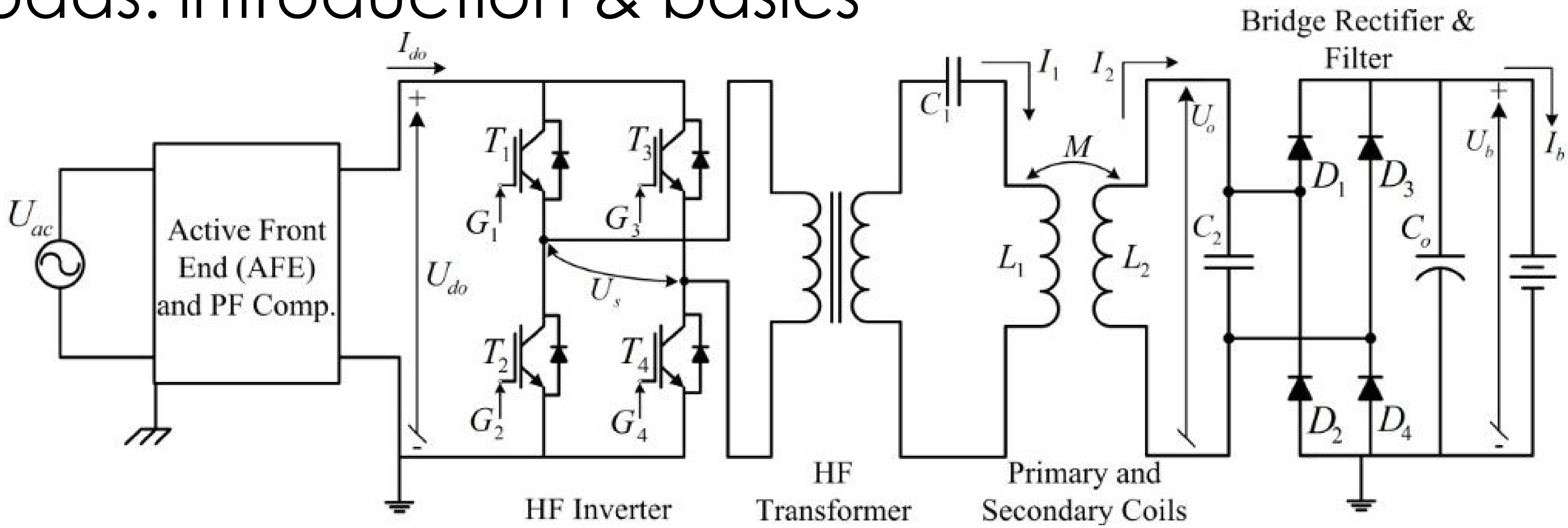
E-Roads: It takes a village

- Introduction
- E-Roads Technology types
- System of Systems / Perspective
- What's next?



Credit: Siemens 1882 near Berlin

E-Roads: introduction & basics

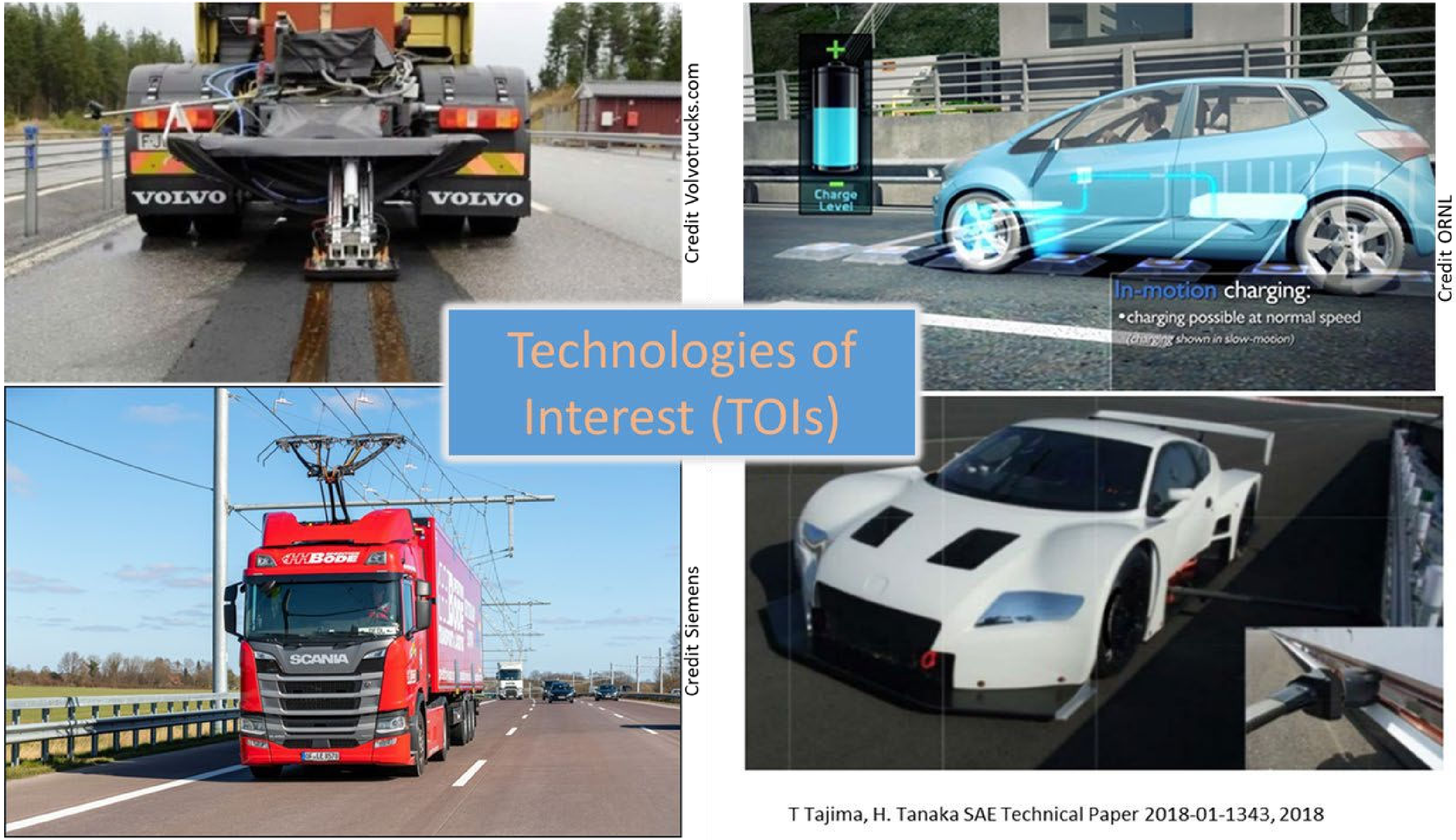


Credit: Dr. Omer Onar, ORNL et al.

E-Road - Any road that transfers power to a vehicle while the vehicle is in motion

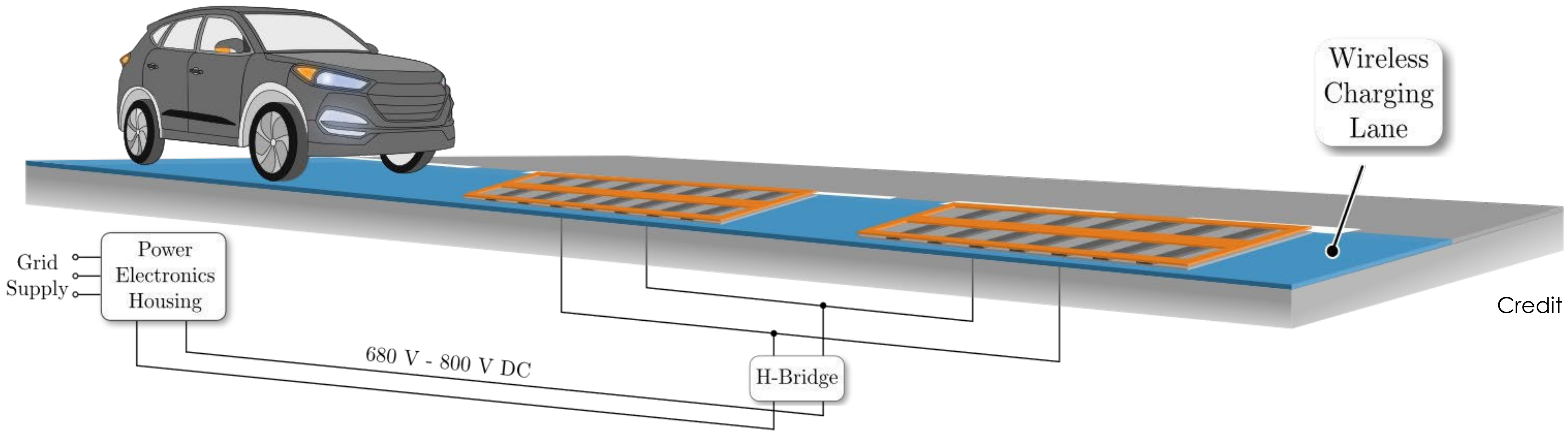
- Infrastructure impact of the electrification of transportation
- Attention to E-Roads (or ERS)
  - International Energy Agency's (IEA)
  Hybrid Electric Vehicle Technology Colaboration Programme (HEV-TCP)
  - Numerous international consortia (RISE, PIARC, others)

E-Roads Technologies



T Tajima, H. Tanaka SAE Technical Paper 2018-01-1343, 2018

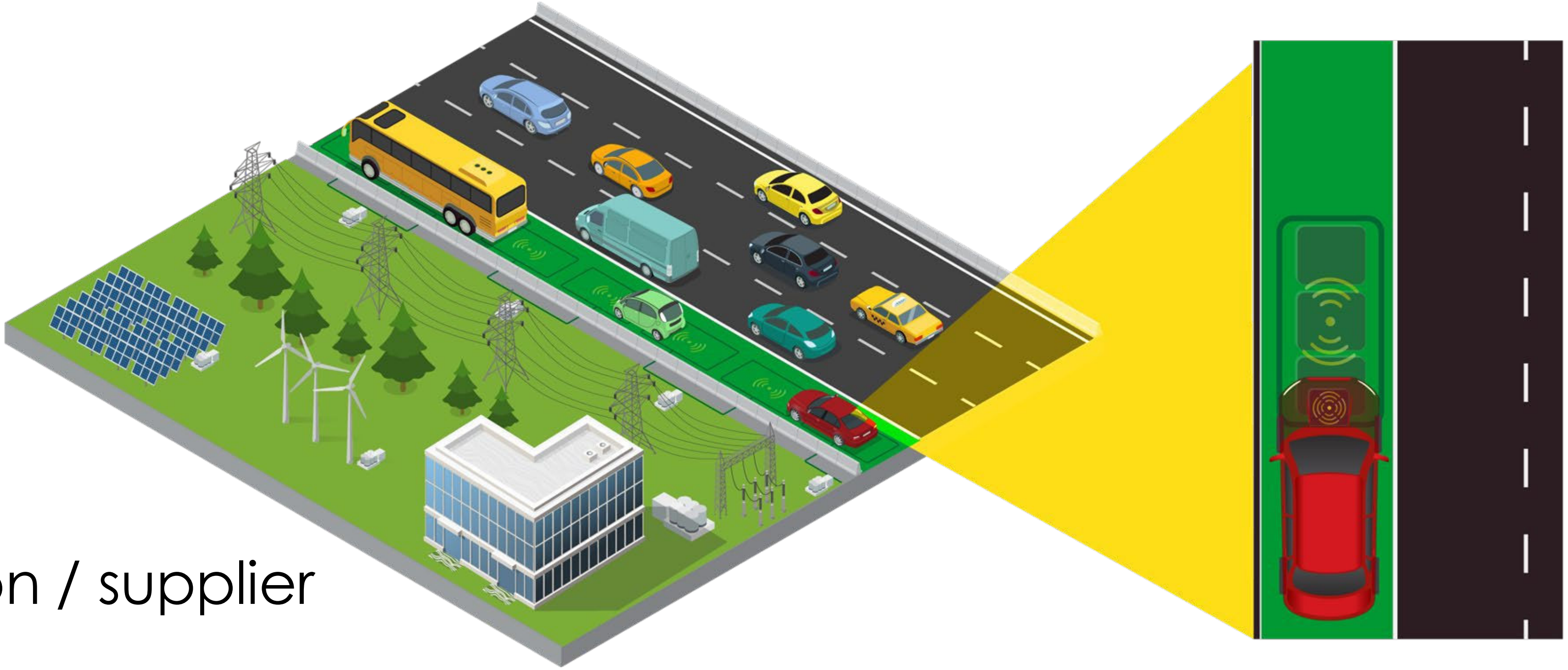
E-Roads: Power transfer technology



Credit ORNL

- Infrastructure for E-Roads means more than energy grid
- Criteria and requirements for safe & efficient transfer of power
- New organizations which currently don't exist
- Dynamic interface (an opportunity area for ADS)

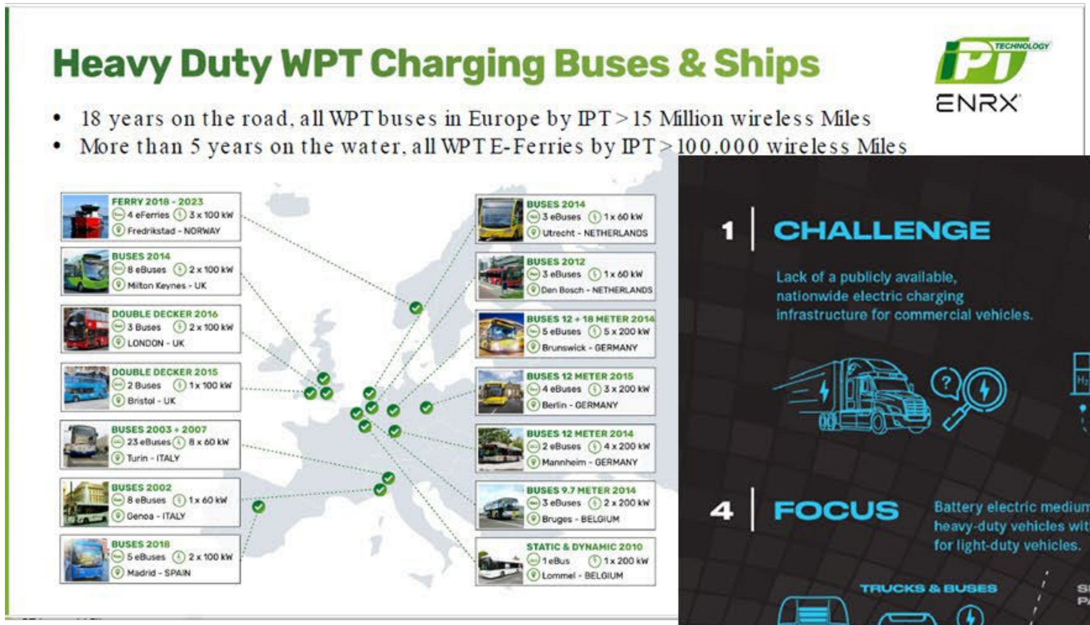
E-Roads: Partnerships/interfaces (a system of systems)



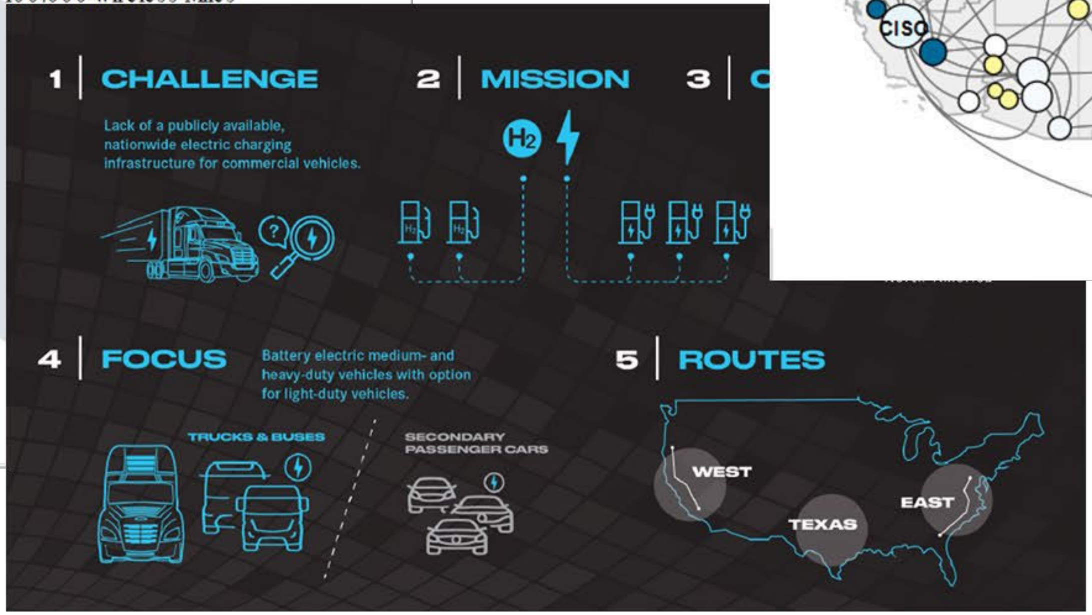
- The vehicle
- Electricity generation / supplier
- Power grid/distribution company
- Manufacturer of the power transfer systems / road technology
- E-Roads owner; operations and maintenance

E-Roads: systems for consideration

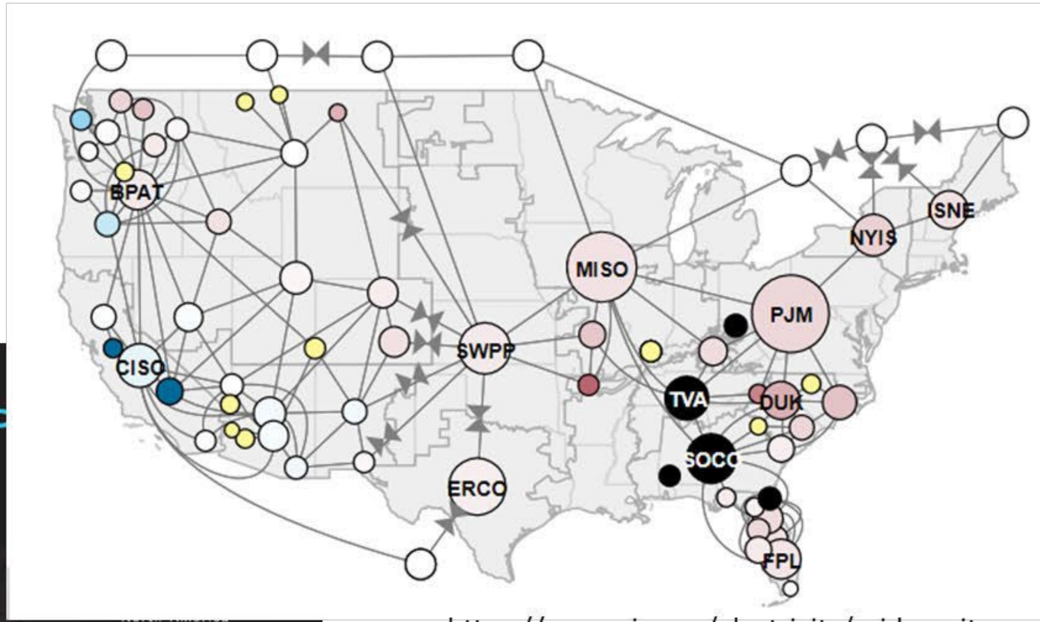
Deployments, Standards & Borders



Richard van den Dool – iPT ENRX: CERV 2023



Jed Proctor Daimler : CERV Presentation 2023



https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/US48/US48

E-Roads road planning perspective

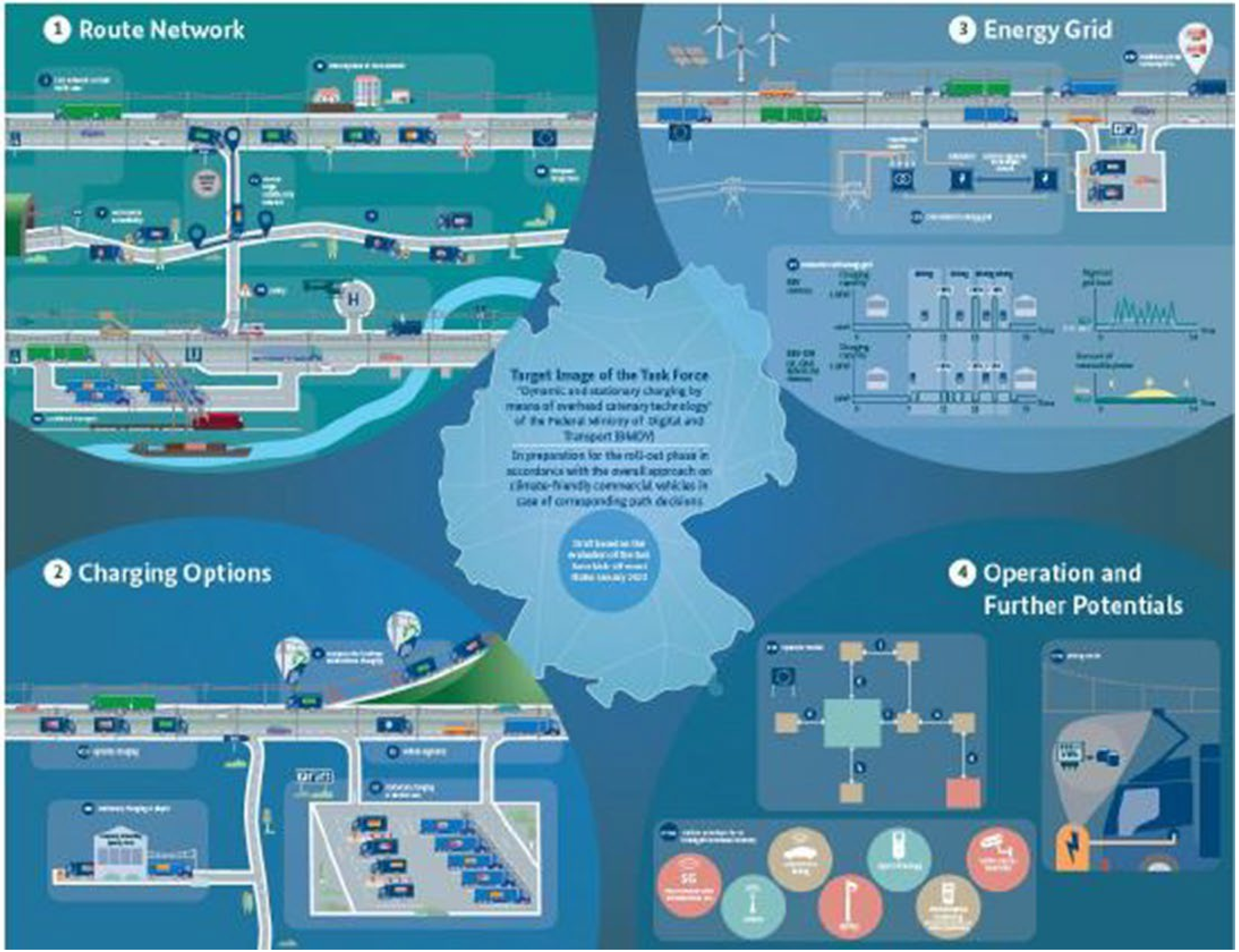


Figure 1 from Dr. Eichler's presentation on NOW-GMBH's approach to Climate-Friendly Commercial Vehicles

E-Roads standards and regulations

Credit ORNL

- Standards evolution and industry impact
- NEVI deployment and charging interface questions
- Infrastructure development and deployment an obstacle?

E-Roads land use considerations

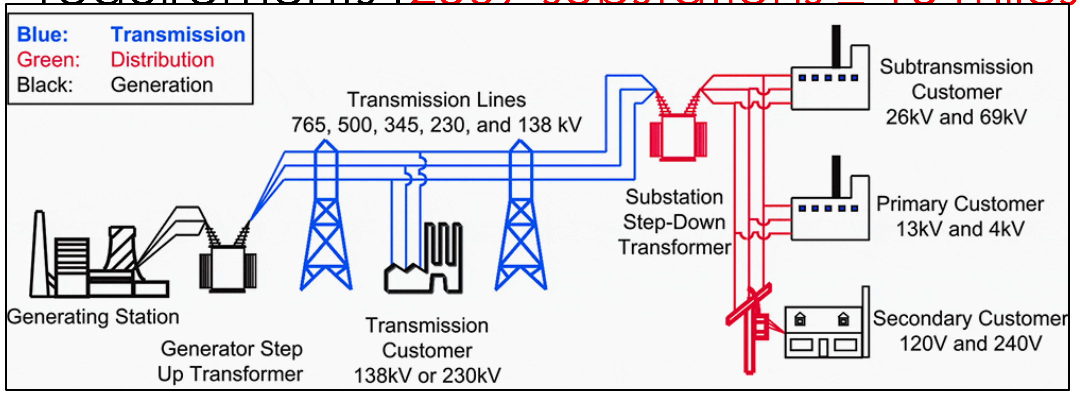
- ERS compared to Static charged eMobility (Competitive & Colaborative)
- Behind the fence control for fleets (Land space & Energy)
- Traffic Flow of vehicles (Manuevering, Parking, Reservation, Etc)

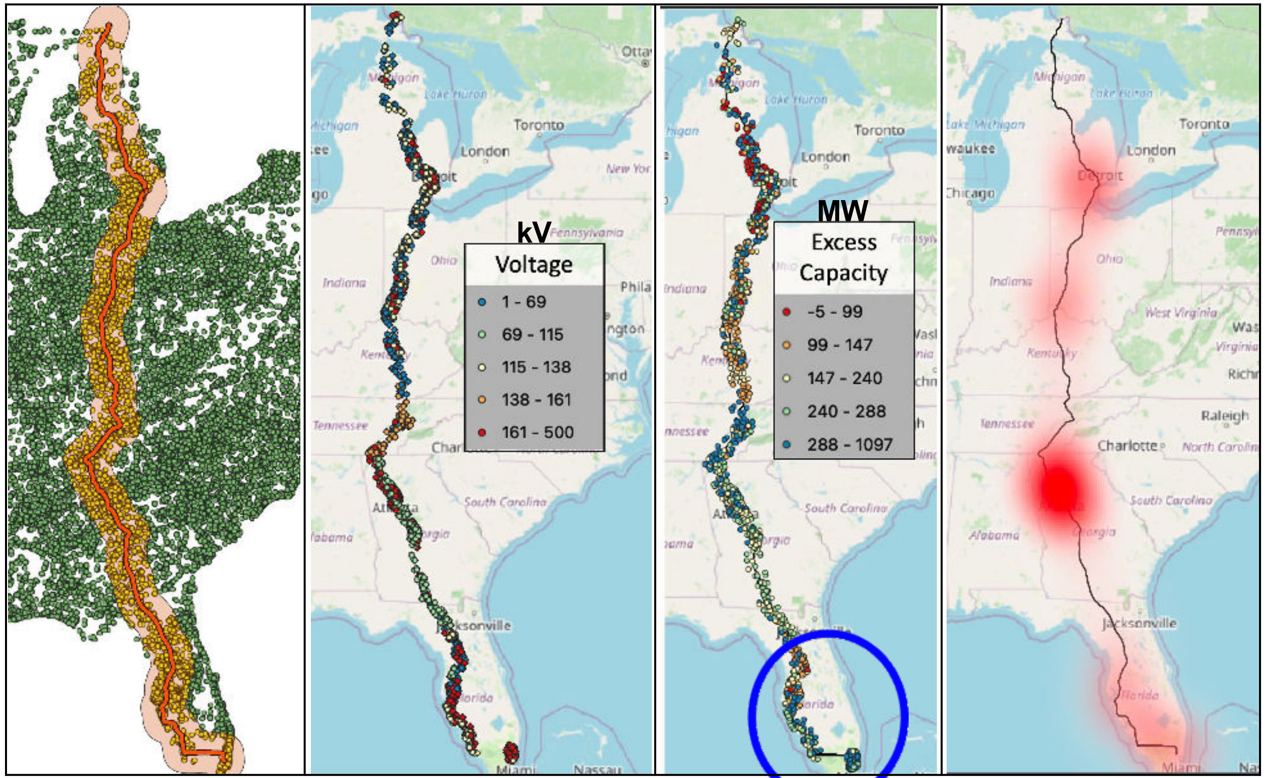
https://iowa80truckstop.com/about-iowa-80/

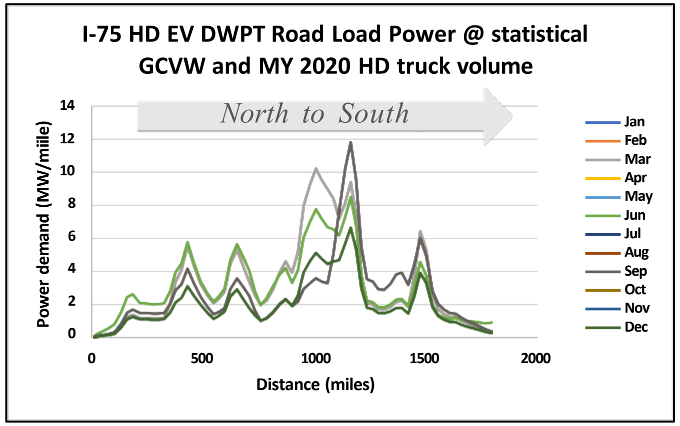
OAK RIDGE National Laboratory

Freight transport – I-75 Use Case Study – Electric Grid assessment

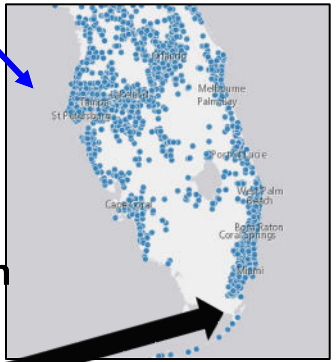
- OR-AGENT will integrate electric grid network capacity, cost, and carbon intensity
- At present, focus on transmission substations due to high roadway power requirements (2509 substations < 15 miles)







At 100% electrified Class 8 freight trucks



Limited transmission sub-station coverage

Credit Sujan, et al ORNL from WCX 2023

OAK RIDGE National Laboratory

E-Roads benefits

- Enabling eMobility adoption of hard to enable vehicles
- EV battery size reduction
- Grid smoothing and may reduce transfer losses

Figure A. Summary of transportation decarbonization strategies.

The U.S. National Blueprint for Transportation Decarbonization, pg. 4

E-Roads Florida

NEXT GEN Electric Roadway – CFX Florida

IPTs Dynamic Charge System for State Route 516 Highway in Florida

IPT TECHNOLOGY
ENRX

Project:

- First tested at the ASPIRE EVR Demonstrator Center in Utah >
- Implement 0.75 Miles of Electric Roadway for State Route 516 Highway in Florida.

Stakeholders:

CENTRAL FLORIDA EXPRESSWAY AUTHORITY

ASPIRE
NSF Engineering Research Center

Next Generation Electric Roadway Charging:

- High-power 200 kW
- Unique protection of the battery from peaks
- Highest protection against EMC radiation
- Optimized for the civil engineering
- Maintenance-free and long lifetime

Unique interoperability:

1. Power levels for different types of vehicles and batteries
2. Custom distance ground and vehicle (air gap)
3. Dynamic & static charging combined

Richard van den Dool – iPT ENRX @ CERV 2023

P.T. Jones   jonesp@ornl.gov

Questions?

www.machinedesign.com/automation-iiot/article/21213165/grape-harvesting-is-ripe-for-improvement

PSTA's Electric Vehicle Program

Henry Lukasik

Director of Maintenance

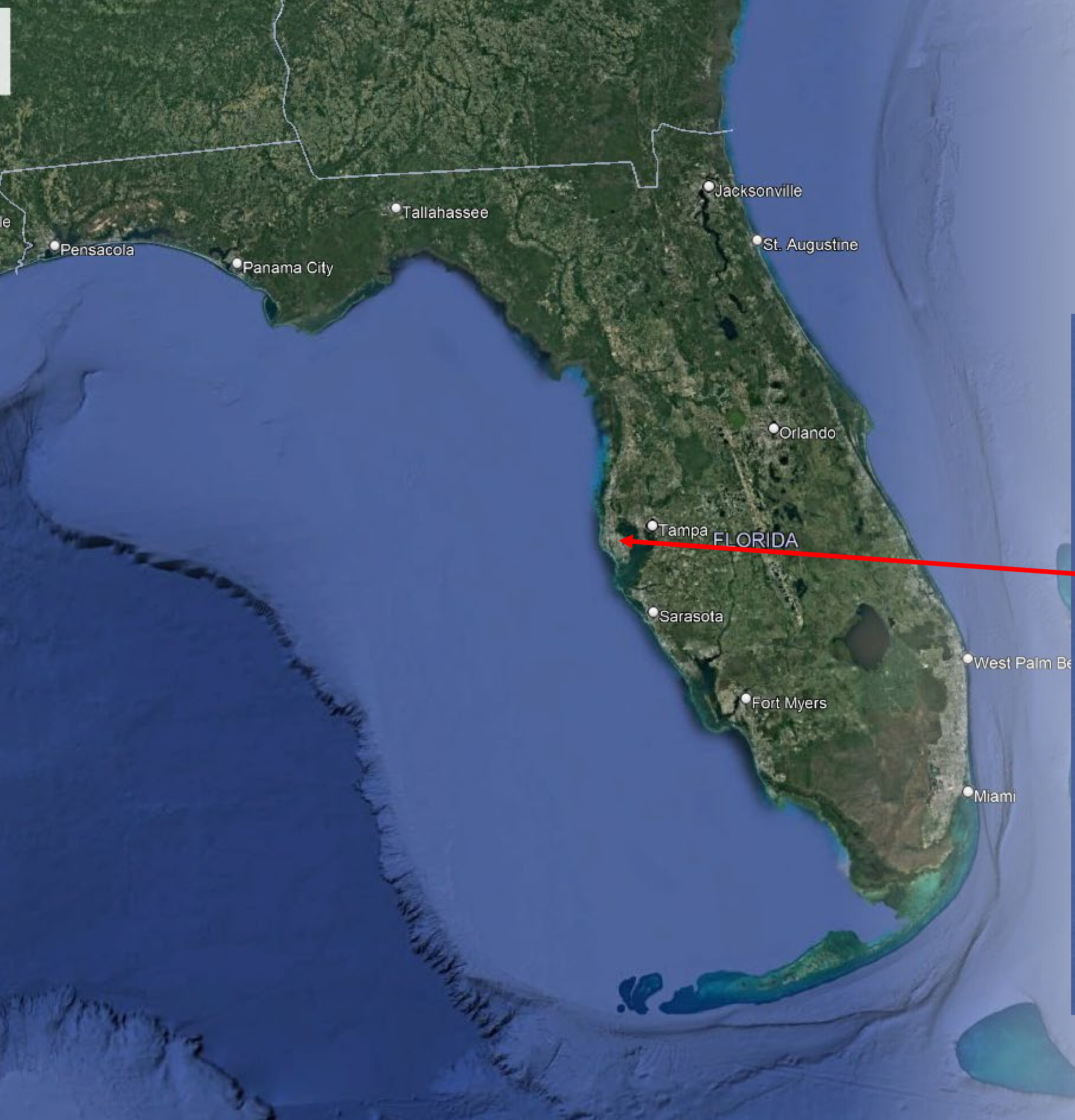
Pinellas Suncoast Transit Authority

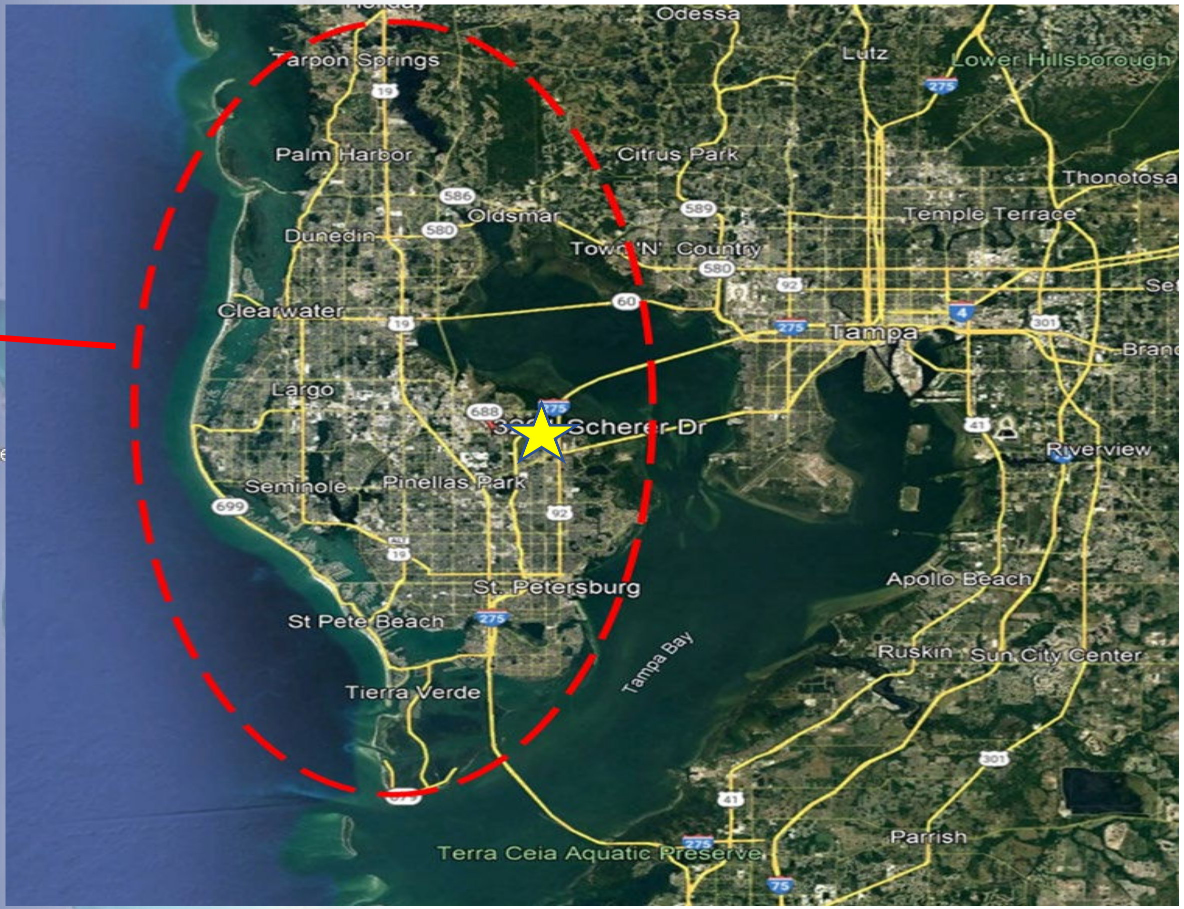
Battery Electric Bus Program
Yesterday, Today, & Tomorrow

FAV SUMMIT

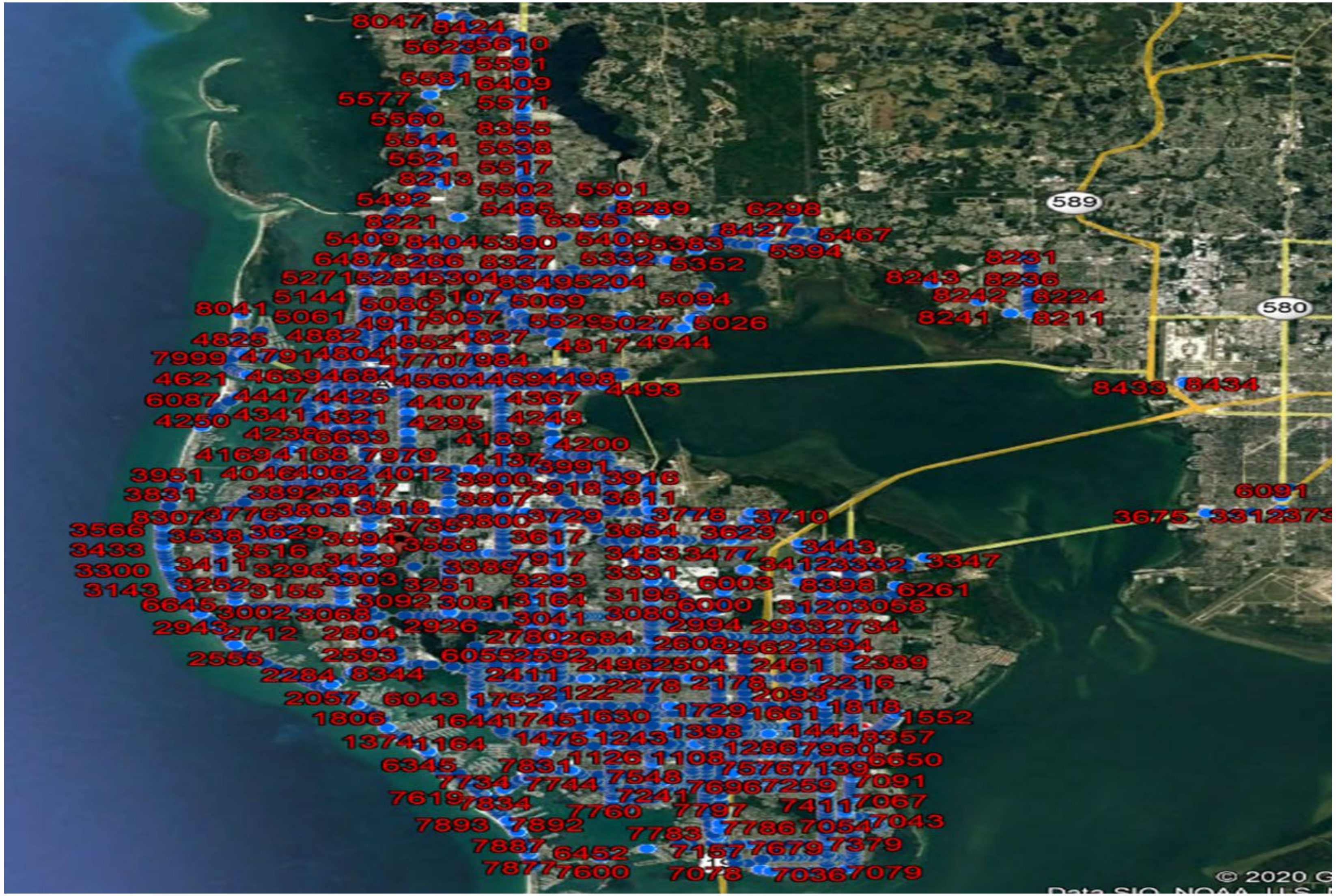
Pinellas Suncoast Transit Authority

PINELLAS COUNTY, FLORIDA





WHAT IS PSTA?



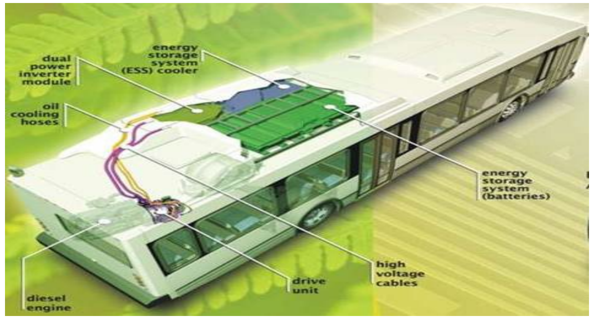
- 213 Fixed Route Buses
- 671 Employees
- 41 Bus Routes
- 9.4M Annual Ridership
- 29K Average Weekday
- 632K Annual Service Hours
- 11M Annual Miles
- 4,395 Bus Stops
- 4 Terminals
- 5 Transfer Hubs
- 2 P& R Lots

TYPES OF BUSES

DIESEL (2005—2009, 2020)—124 Buses (Gillig, Hometown Trolley, Freightliner)

How it works:

- Its diesel…nothing special.



DUAL-MODE SPLIT PARALLEL HYBRID (2009—2015)—53 Buses (Gillig)

How it works:

- Propulsion system has both a diesel engine and an electric drive unit.
- Engine power and electrical power are blended to provide the most efficient engine loading during acceleration events.
- Once the bus is up to speed and operating efficiently, electrical power is phased out.
- As the bus decelerates, the regenerative energy is captured through the drive unit and stored in the energy storage system for the next acceleration or cruise.

SERIES-E HYBRID ELECTRIC (2016—2021)—36 Buses (Gillig)

How it works:

- With Series-E, the integrated starter generator (ISG) is the prime energy source.
- Once the generator is turned by the engine, the generator provides power to the energy storage system (batteries) which in turn powers the electric drive motor.
- A secondary source of energy is realized from vehicle braking.
- As the driver decelerates, regenerative energy is reclaimed and stored for use in the energy storage system to drive the wheels.

BYD ALL-ELECTRIC TRANSIT BUS

- 2018, 2020
- QTY 6 Buses

VEHICLE		35-ft
Dimensions	Length	35.8 ft
	Width	102 in
	Height	140 in
	Wheelbase	222.7 in
	Curb Weight	28,660 lbs
	Gross Weight	41,877 lbs
	Seats	32+1
	Wheelchair Positions	2 ADA compliant
Performance	Top Speed	62.1 mph
	Max Gradeability	≥ 18%
	Range	≥ 145 miles
	Turning Radius	42.7 ft
	Approach/ Departure Angle	9° / 9°
Chassis	Front Axle	ZF low floor beam axle RL75A
	Rear Axle	BYD in-wheel drive axle
	Suspension	Air suspension (with ECAS)
	Brakes	Front & rear brakes, ABS, Regenerative braking
	Tires	305/70 R 22.5
Powertrain	Motor Type	AC Synchronous
	Continuous Power	100 kW x 2
	Max Torque	550 N•m x 2
	Battery Type	Iron-Phosphate
	Battery Capacity	270 kWh
	Charging Capacity	80 kW
	Charging Time	3h–4h

GILLIG ALL-ELECTRIC TRANSIT BUS

Specifications	
Supplier	Cummins.
Motor type	9-phase permanent magnet alternating current (PMAC).
Drive type	Direct drive.
Operating voltage	Nominal 660 VDC; operating range 610 to 750 VDC.
Maximum mechanical output torque	2,582 ft lb (3,500 N-m) for 30 seconds.
Continuous output torque	1,519 ft lb (2,060 N-m).
Maximum mechanical output power	470 hp (350 kW) for 30 seconds.
Continuous mechanical output power	262 hp (195 kW).
Normal operating range	0 to 3,400 rpm.
Peak power	245 kW (328 hp).
Derating range	3,400 to 3,600 rpm.
Ingress protection	IP67.

- 2023—QTY 6
- 2024—QTY 43
- 2025—Qty 13

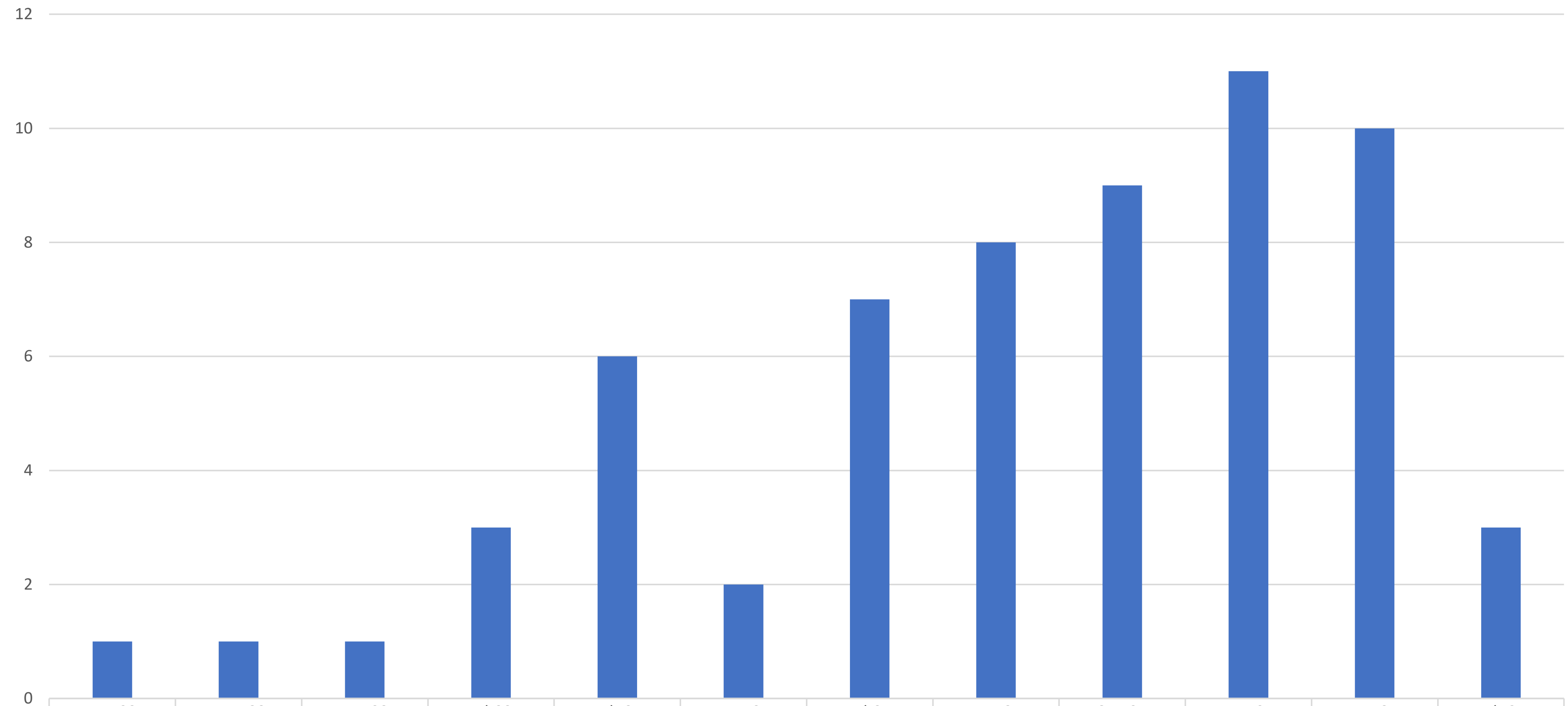
Vehicle Specifications:

- 40'
- 7 pack configuration 686 kWh
- 315 tires
- Gen 2.5 Design

Vehicle Weights:

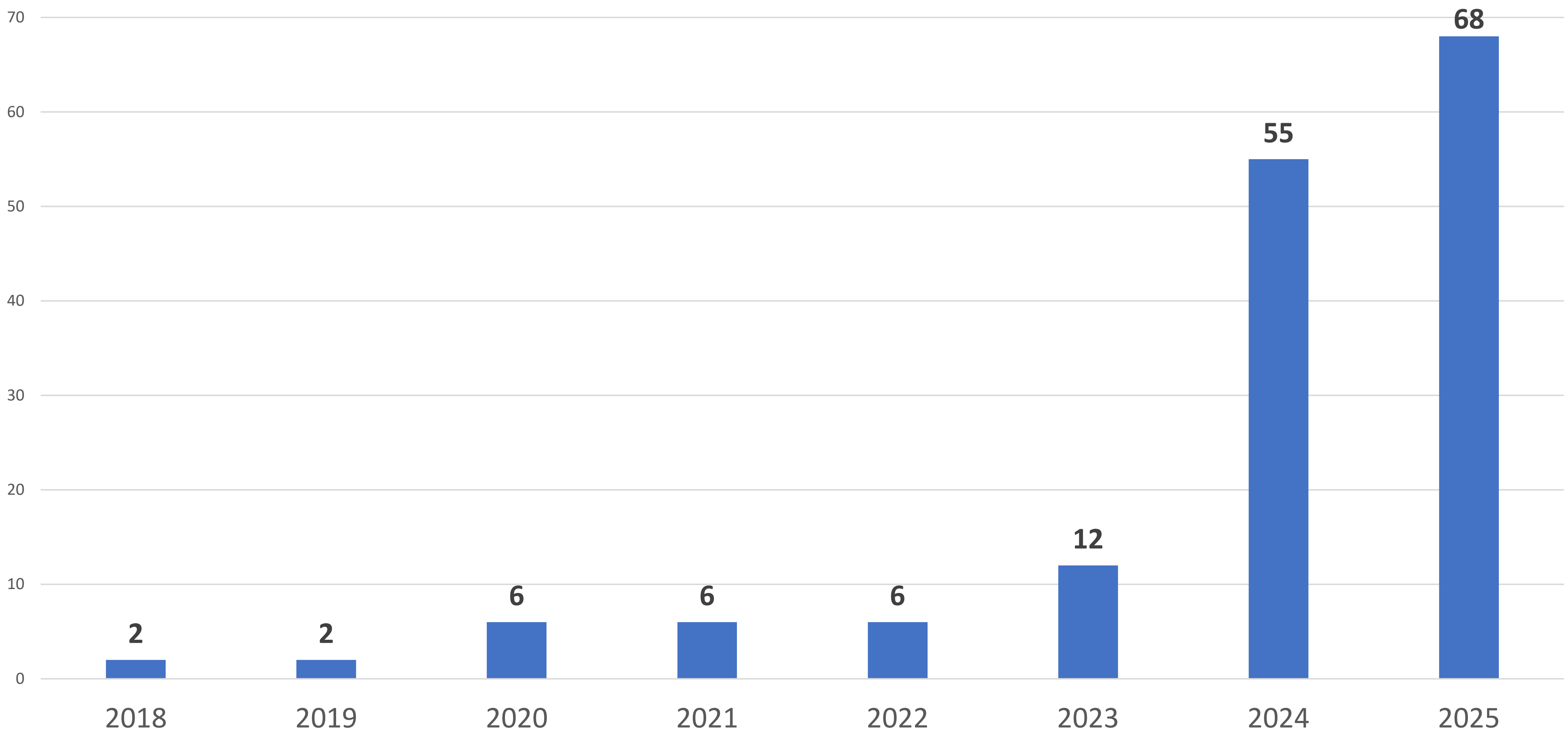
Curb Weight: 35,887
Seated Weight: 42,037
Gross Weight: 47,137
GVWR: 47,180

ELECTRIC BUS DELIVERY SCHEDULE



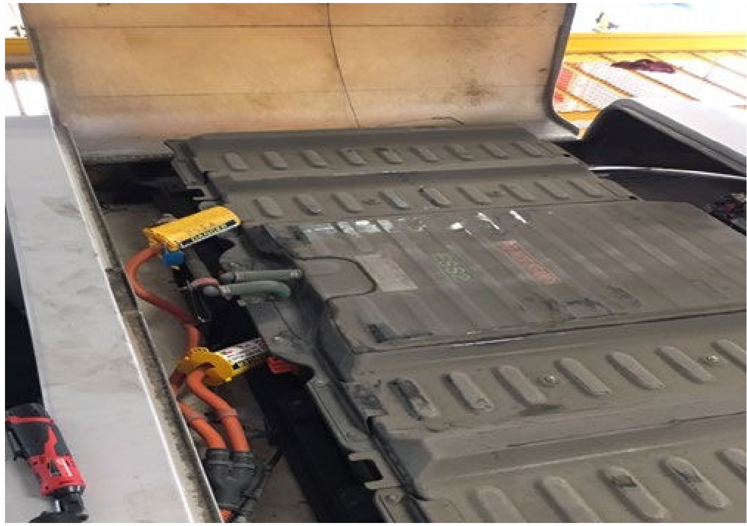
	Apr-23	May-23	Jun-23	Jul-23	Feb-24	Mar-24	Jul-24	Aug-24	Sep-24	Dec-24	Jan-25	Feb-25
Total	1	1	1	3	6	2	7	8	9	11	10	3

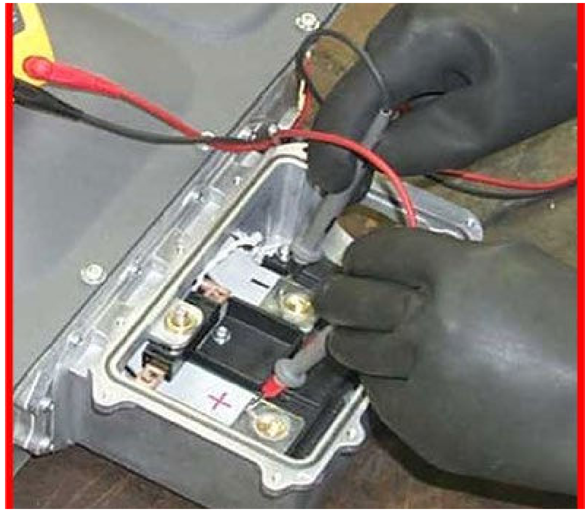
ELECTRIC BUS FLEET TRANSITION

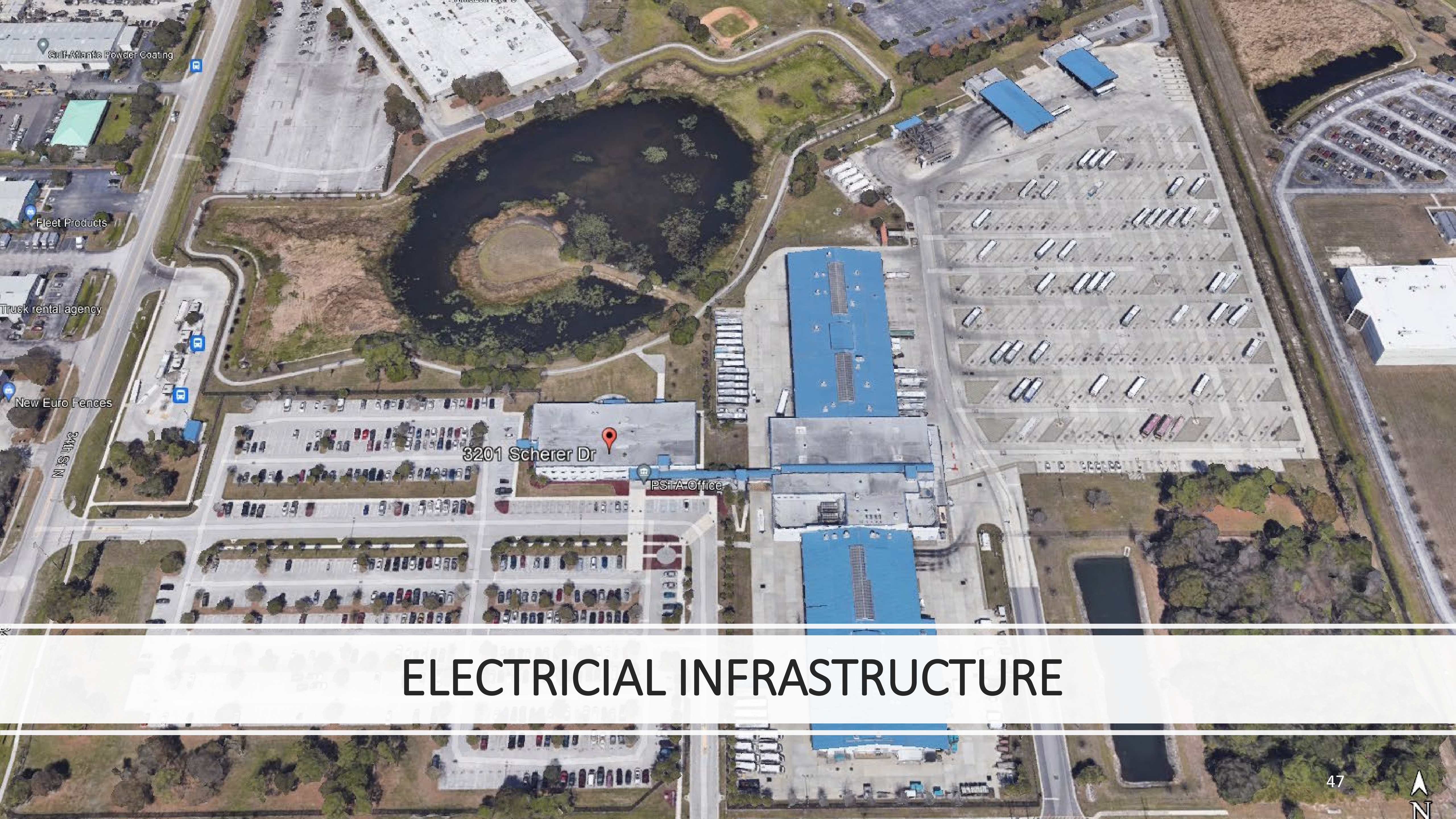


HIGH VOLTAGE EXPERIENCE

- Safety first from the top down and the bottom up.
- Maintenance Executive Staff has 65 years combined experience managing and maintaining hybrid electric and all electric bus fleets (including H2 Fuel Cell).
- Fleet Maintenance Tech's are continually trained on high voltage safety and repair procedures.
- Fleet Maintenance is OEM certified and credentialed to diagnose and repair high voltage vehicles.





ELECTRICIAL INFRASTRUCTURE

INITIAL DISCUSSION — INFRASTRUCTURE

- **Question 1 — How are you going to charge the buses**
  - How many and what type chargers will it take to charge your bus fleet?
  - Depot or On-Route charging?
  - Conductive or Inductive?
  - What are the electrical requirements of the chargers?

INITIAL DISCUSSION — INFRASTRUCTURE

- **Question 2 — Can your facility or handle charging the buses?**
  - Depot Charging - Can your facility handle the additional electrical load of the chargers?
  - On-Route Charging – Is infrastructure able to handle the load?
  - If not, what will be needed to accommodate the extra electrical needs?
  - What alterations to your bus parking lot will be needed?
  - How will you charge the buses when the power goes out?

INITIAL DISCUSSION — INFRASTRUCTURE

- **Question 3 — Can your electrical utility handle your power needs?**
  - Do they have the capacity to support your new incoming power requirements?
  - Is additional energy available in the area?
  - Do you understand your electrical rate structure and how much your true kWh cost be?

CHARGING CHOICES

	TYPICAL INSTALLATION	ADVANTAGES	DISADVANTAGES
Plug-In Charging	• Used to charge buses for a few hours (usually overnight or between blocks) • One or two buses per charger with one or multiple dispensers • Charge power: 50 to 200+ kW • Compliant with SAE J1772 or J3068 standard	• Lower unit cost • Additional chargers can be added for redundancy	• Total cost may be more expensive for a large fleet • Slower charging • Identifying available space • Requires staff to plug/unplug the buses
Overhead Conductive Charging	• One charger serves multiple buses • Charging for 5 to 20+ minutes at higher power • Charge power: 175 to 600 kW • Compliant with SAE J3105 standard	• Total infrastructure costs may be less expensive if fewer chargers are needed for a larger fleet • No manual connections	• May require additional maintenance • Higher capital and construction costs per charger • High power charging may result in higher peak demand • Not all OEM's offer it
Wireless Inductive Charging	• One charger serves multiple buses • Charge power: 50 to 500kW	• No manual connections or moving parts • Could be used by multiple vehicles • Total infrastructure costs may be less expensive if fewer chargers are needed for a larger fleet • Smaller footprint	• Higher capital and construction costs per charger • Charging efficiency varies based on bus alignment • No interoperability among different wireless charger providers • Not all OEMs offer inductive charging

COSTS INVOLVED

Up-front capital costs are one of the biggest obstacles.

- Vehicle costs
- Studying and planning costs
- Charging equipment costs
- Charging infrastructure installation costs
- Electric utility upgrades
- Maintenance facility modifications
- Tooling
- Safety Equipment & PPE
- Training

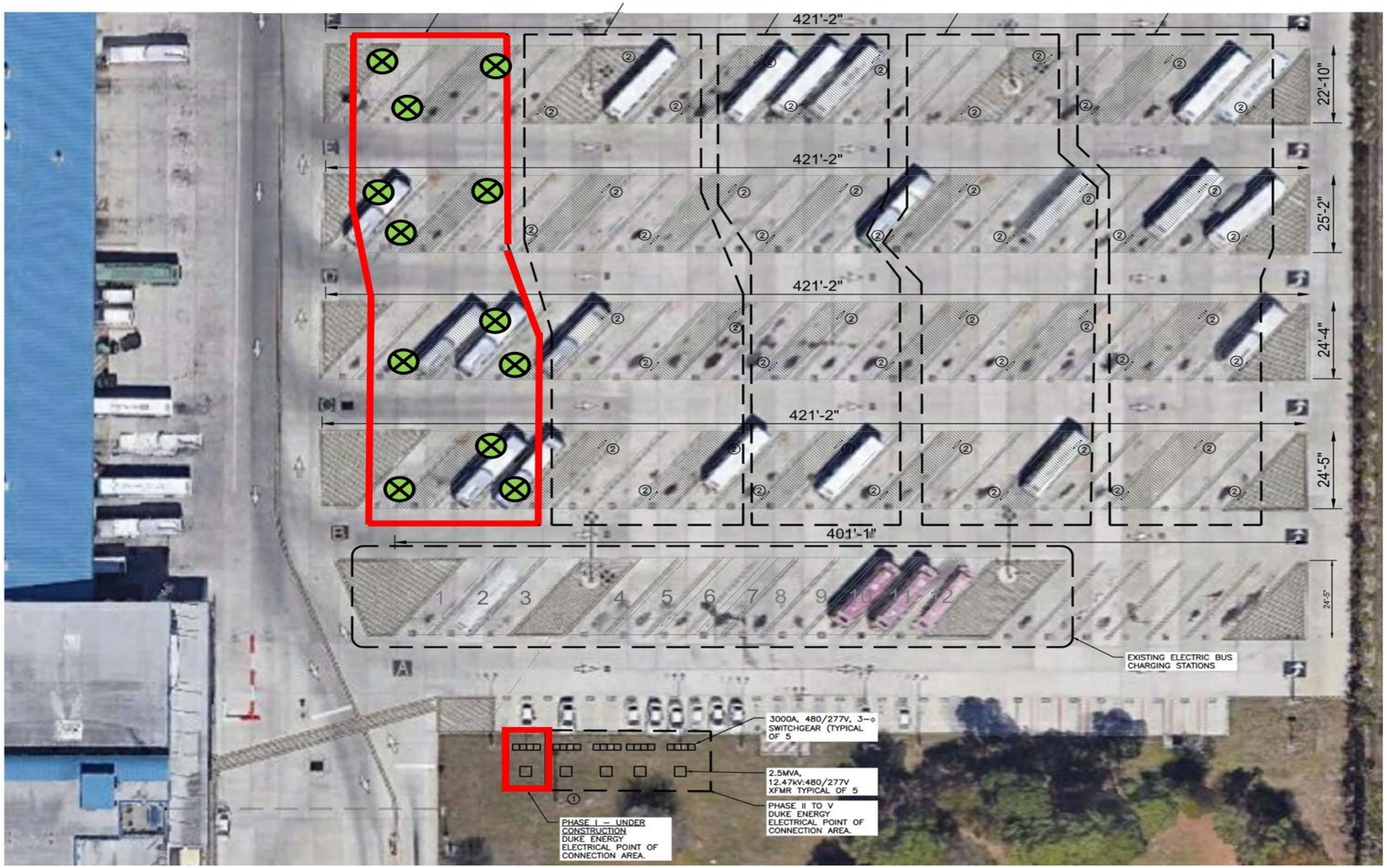
CHARGER COSTS

	High-Level Cost Estimate for 1 Bus Deployment
Plug-in Depot Charger Capital Costs	$15k-200k/charger
Plug-In Depot Charger Design, Build, and Electrical Upgrades	$50k-125k/charger (Facility Site Specific)
Overhead Charger Costs & Installation	$350K--$500K
Inductive Charger Capital Costs & Installation	$200K--$500K
On-Route Charger Design, Build, and Electrical Upgrades	$50K--$600K (Facility Site Specific)

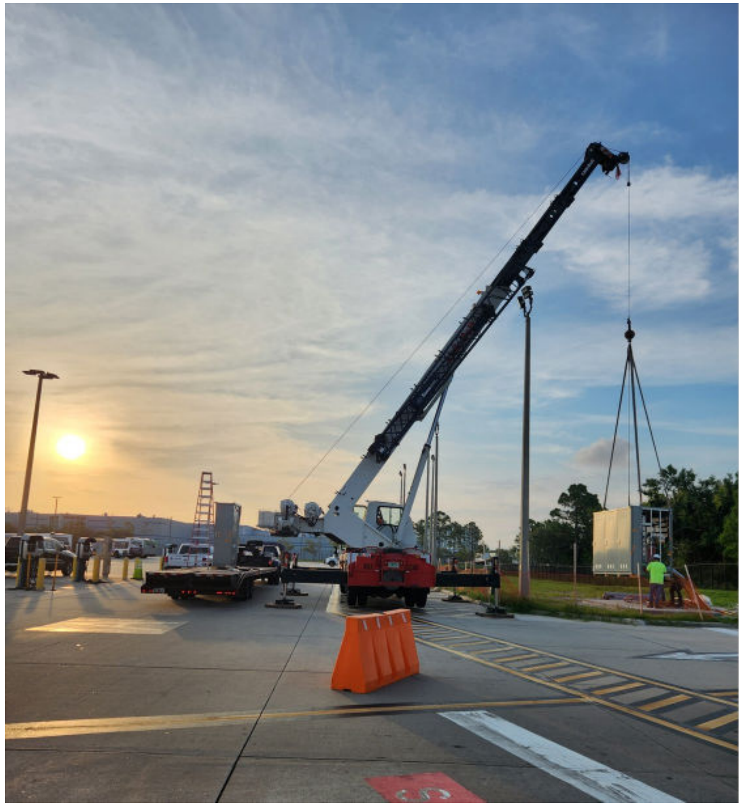
ELECTRICAL INFRASTRUCTURE

PHASE I CONSTRUCTION

PHASE I —CHARGERS 1-12



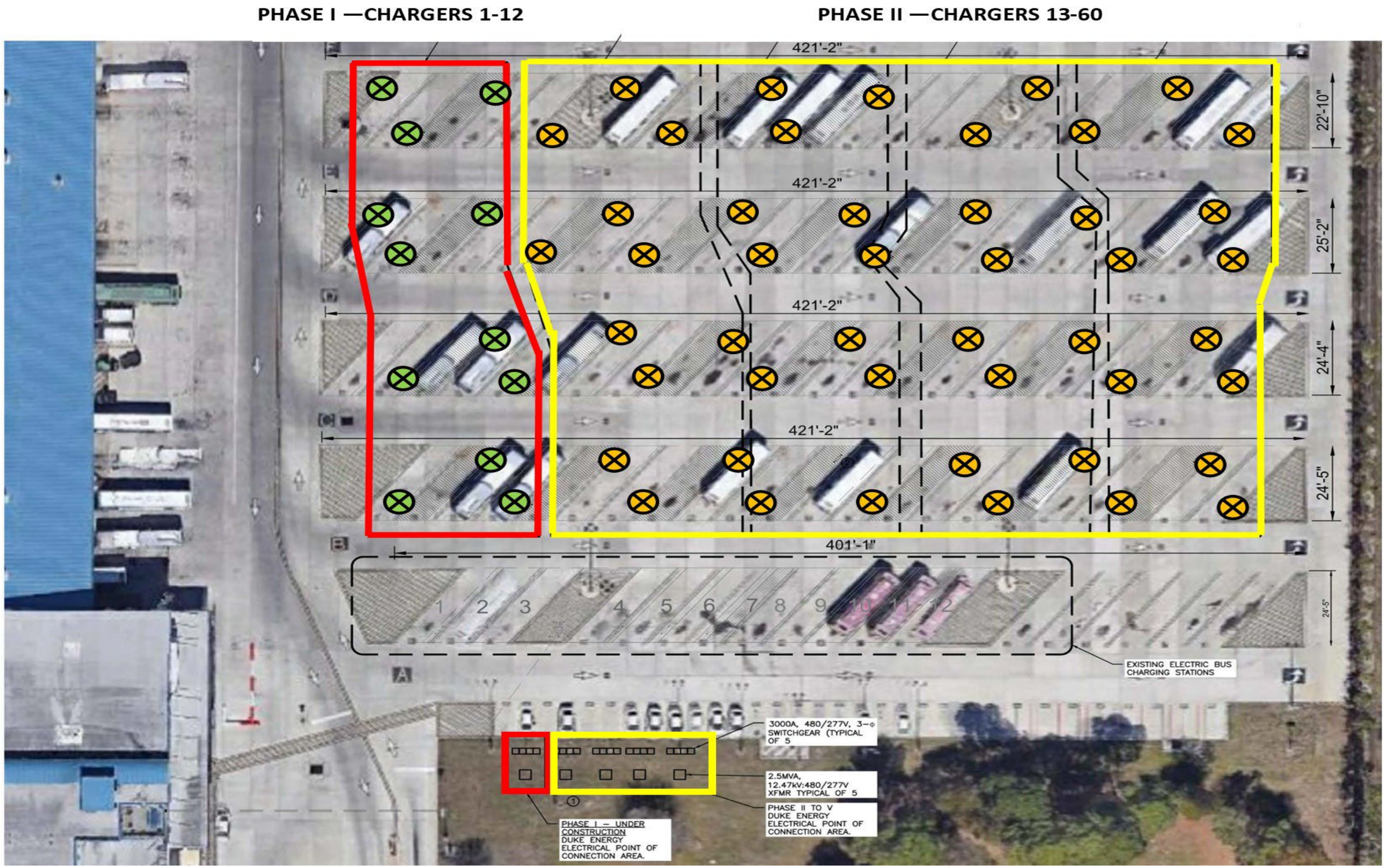
PHASE I CONSTRUCTION



PHASE I CONSTRUCTION

Chargers are 200kW capacity = full recharge in 4 hours.

PHASE II CONSTRUCTION

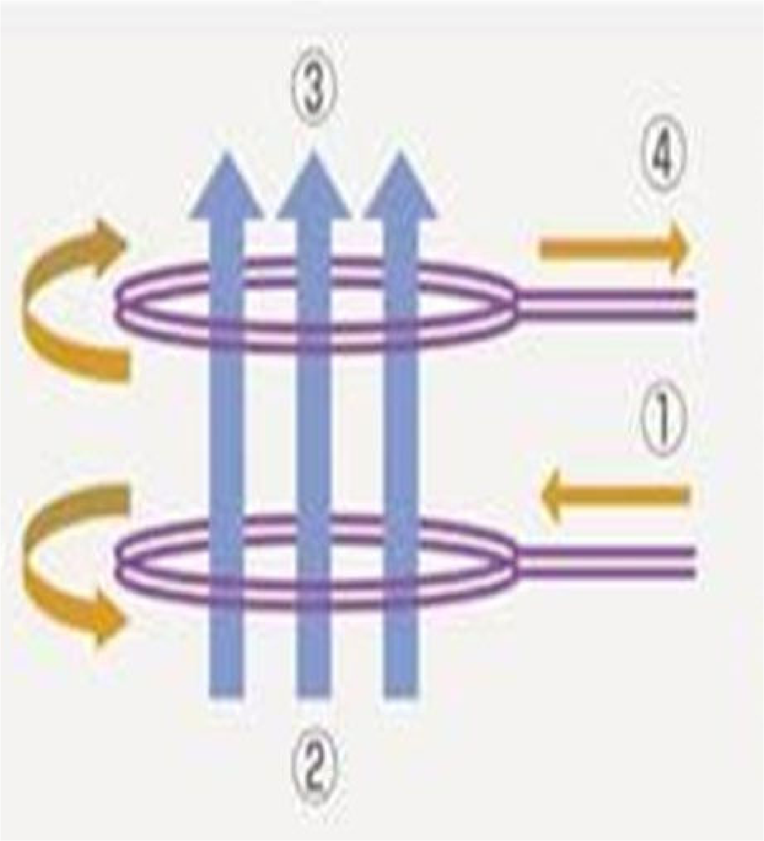


PHASE II CONSTRUCTION

- **Turn-key installation of 48 additional chargers over next 1.5 years.**
- **Installation of (4) 2.5 MVA coastal rated transformers and matched 3000A outdoor rated switchgears.**
- **Each transformer & switchgear supports 12 chargers at full capacity.**
- **Completed in time to support arrival of battery electric buses per delivery schedule.**
- **FTA Funded**

INDUCTIVE WIRELESS CHARGING

INDUCTIVE WIRELESS CHARGING



Electric Transmission by Way of Electromagnetic Induction

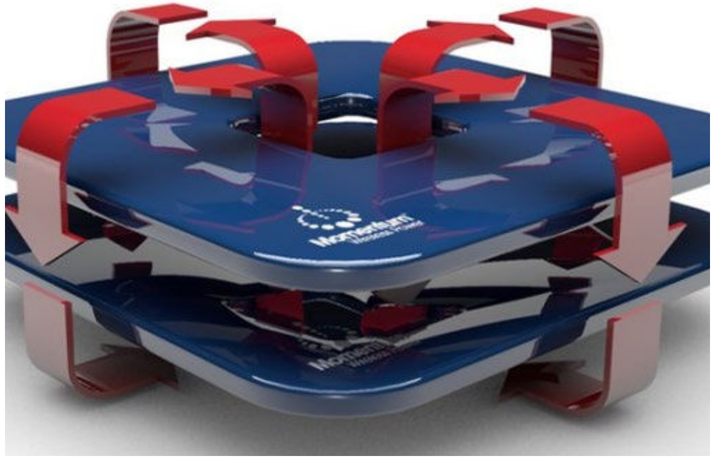
1. **Electricity is applied to the coil.**
2. **Magnetic field occurs from the coil.**
3. **Magnetic field passes through the coil on the object.**
4. **An electrical current occurs on the coil on the object.**

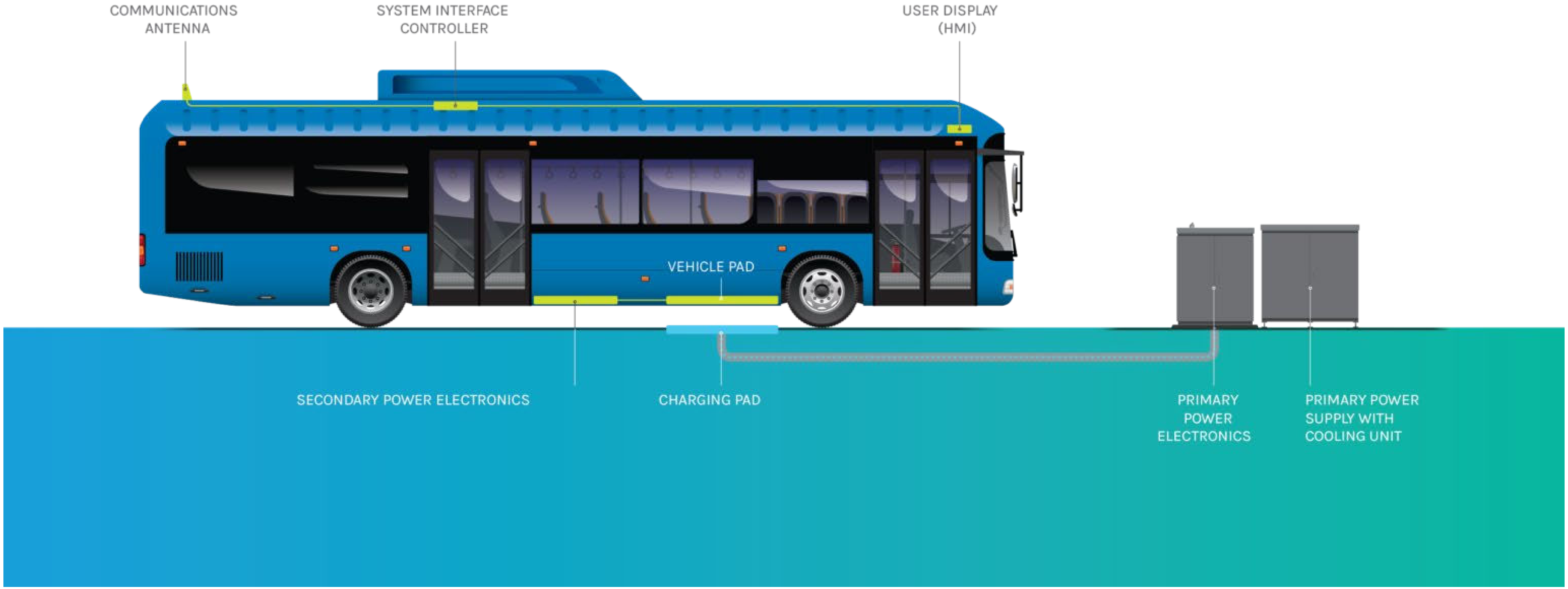
INDUCTIVE WIRELESS CHARGING

LARGE SCALE MOBILE APPLICATION

250kW Inductive Wireless Technology

- Inductive charging systems charge the battery of an electric vehicle wirelessly through a charging pad embedded in the roadway.




COMMUNICATIONS ANTENNA
SYSTEM INTERFACE CONTROLLER
USER DISPLAY (HMI)
VEHICLE PAD
SECONDARY POWER ELECTRONICS
CHARGING PAD
PRIMARY POWER ELECTRONICS
PRIMARY POWER SUPPLY WITH COOLING UNIT

EXCLUSIVE Paintless Dent Repair LLC ...
Ryder Truck Rental
Fleet Products
Quality Speed And Performance
AVANTI AUTO SALES
New Euro Fences
Atlas Hydraulics
GMD Gates & Fences United States
CLEANER AIR

CLOSING REMARKS

- 62 Gillig BEB's on Order
- 60 Plug-In Chargers to be Installed—Phase I Completed, Phase II Starting
- 30% of PSTA Bus Fleet will be Battery-Electric by 2025
- Goal of 100% by 2050
- Pinellas County & PSTA Routes are Well Suited for BEB's.
- PSTA is Highly Experienced Operating & Maintaining High Voltage Vehicles & Systems.
- Duke Energy is Fully Capable of Supporting PSTA's EV Infrastructure Needs.

Thank You For Your Time

Energy and Charging Considerations for Light Duty Public Mobility Fleets

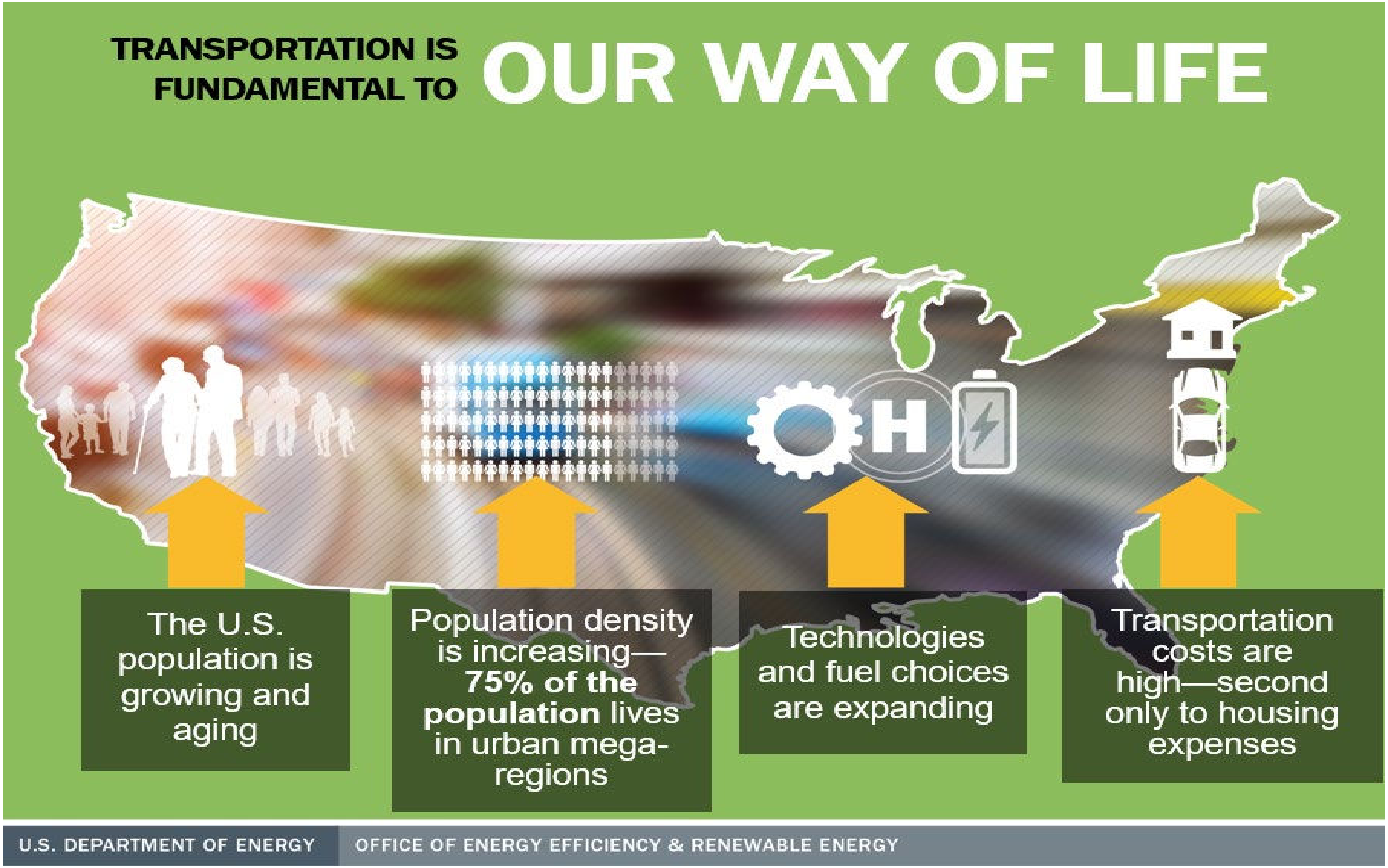
Stanley E. Young, P.E., PhD

Team Lead – Mobility Innovation and Equity National Renewable Energy Laboratory

NREL
Transforming ENERGY

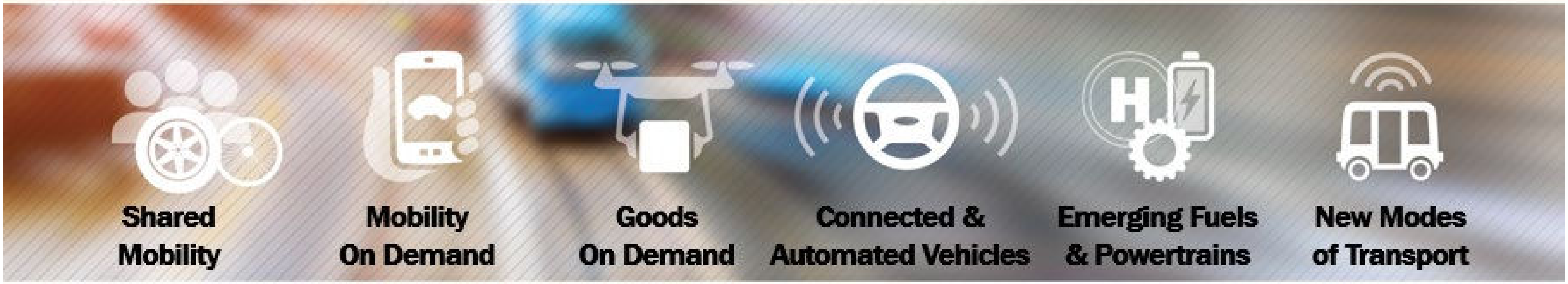
NREL Mobility Futures

Stanley E. Young, P.E. Ph.D.
Team Lead – Mobility Innovation and Equity, NREL
Chief Data Officer - Eastern Transportation Coalition


TRANSPORTATION IS FUNDAMENTAL TO OUR WAY OF LIFE
The U.S. population is growing and aging
Population density is increasing—75% of the population lives in urban mega-regions
Technologies and fuel choices are expanding
Transportation costs are high—second only to housing expenses
U.S. DEPARTMENT OF ENERGY
OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY

NEW TECHNOLOGIES & BUSINESS MODELS ARE

DRIVING DISRUPTION



Mobility Energy Productivity Metric

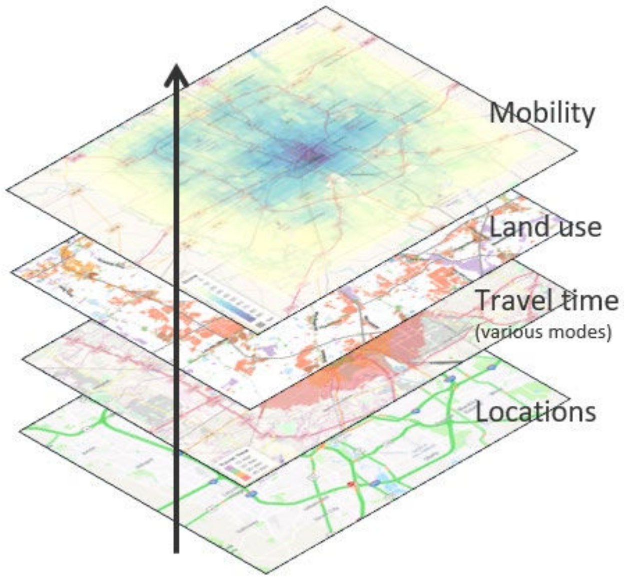
- Key Questions
  - What is mobility?
  - How do you quantify mobility?

    No 'open' and practical method to quantify mobility

    Existing transportation performance metrics measure utilization or efficiency of road network
- Can we increase energy use if we connect people better?
- Productivity = Mobility Benefits / Costs
- Can we optimize energy use if we connect people better?

EEMS will identify and support technologies and innovations that encourage a ***Maximum-Mobility, Minimum-Energy Future.***

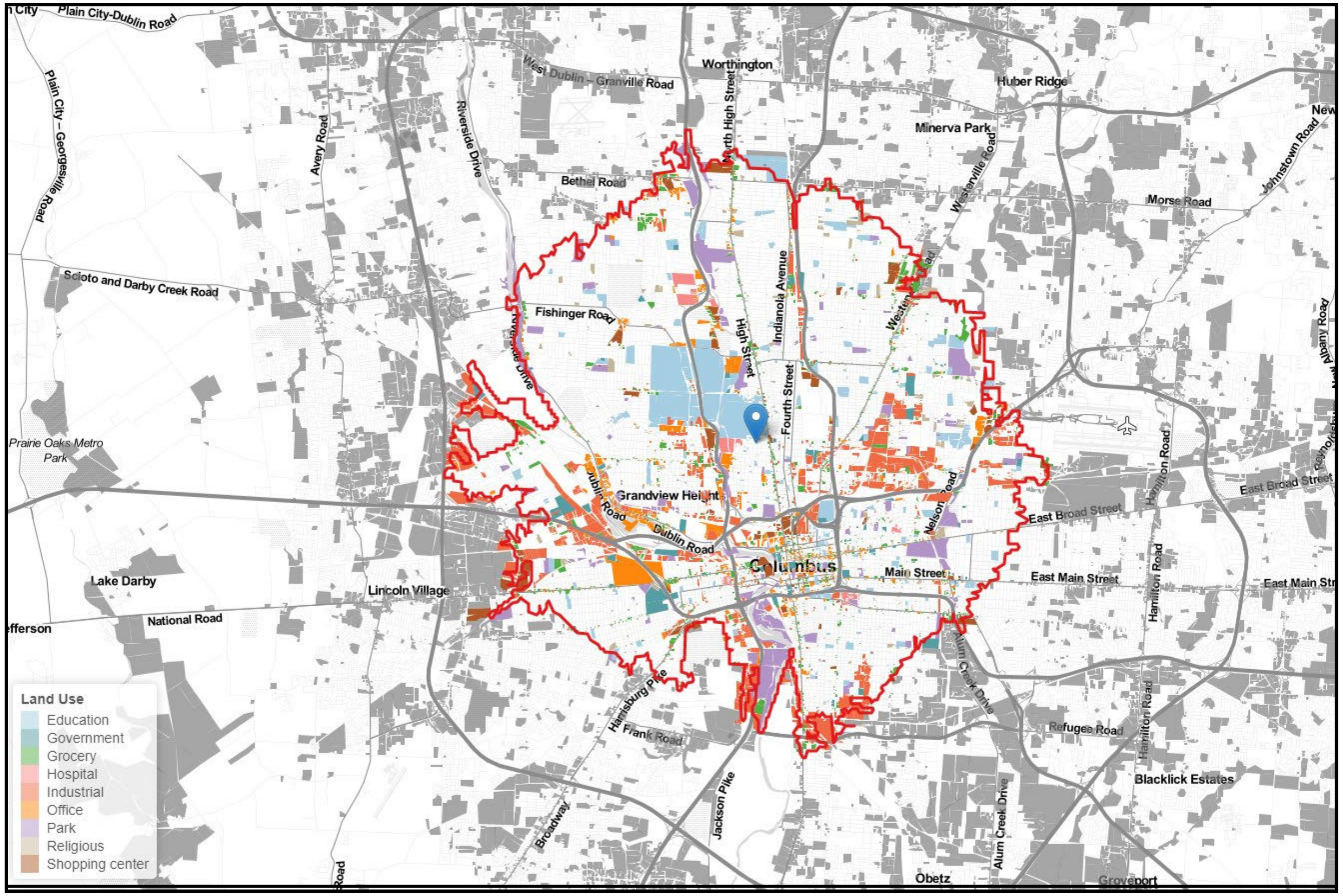
- Existing metrics such as 'walk score', 'bike score', 'transit score' – points toward need for overall, flexible 'Mobility Score'
- Need to cover all modes, each mode, combination of modes – even new or conceptual modes
- Covers Travel Time, Cost, and Energy



Mobility is the quality of a transportation system to connect people to goods, services, and employment that define a high quality of life.

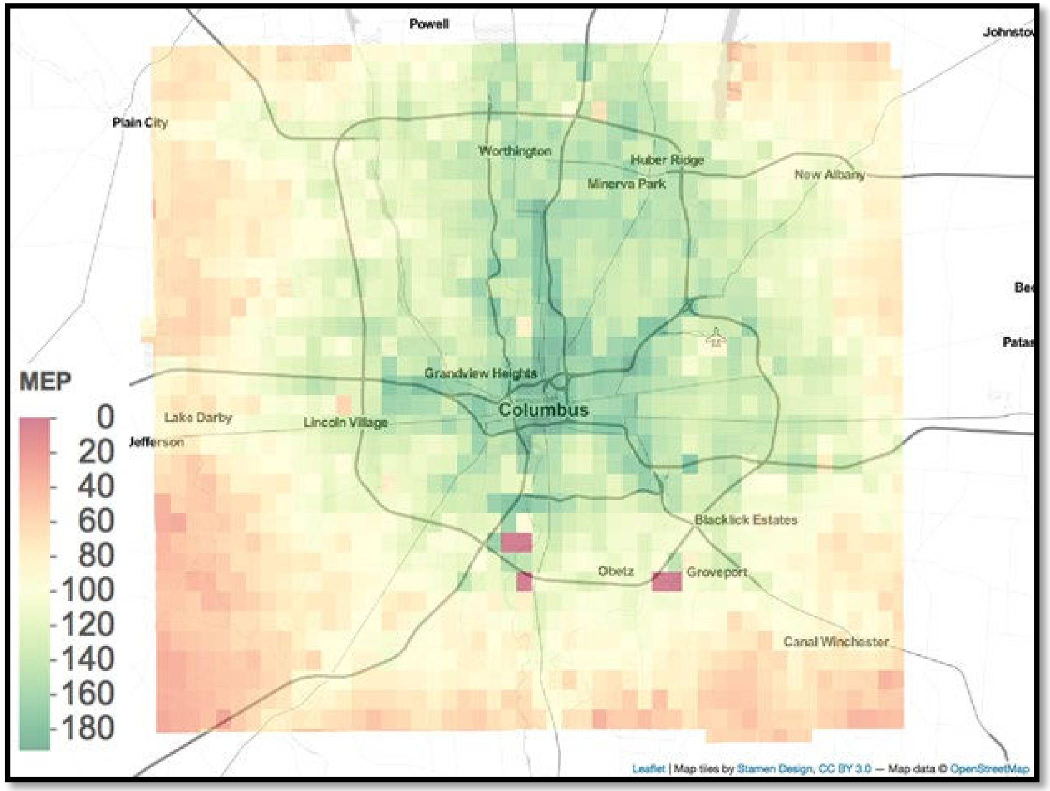
Cumulative Opportunities

- Count the opportunities that can be accessed within travel time of 10, 20, 30, 40 minutes for every cell
- Diminished by time, cost and energy of accessing opportunities
- Evaluate by various sub-populations

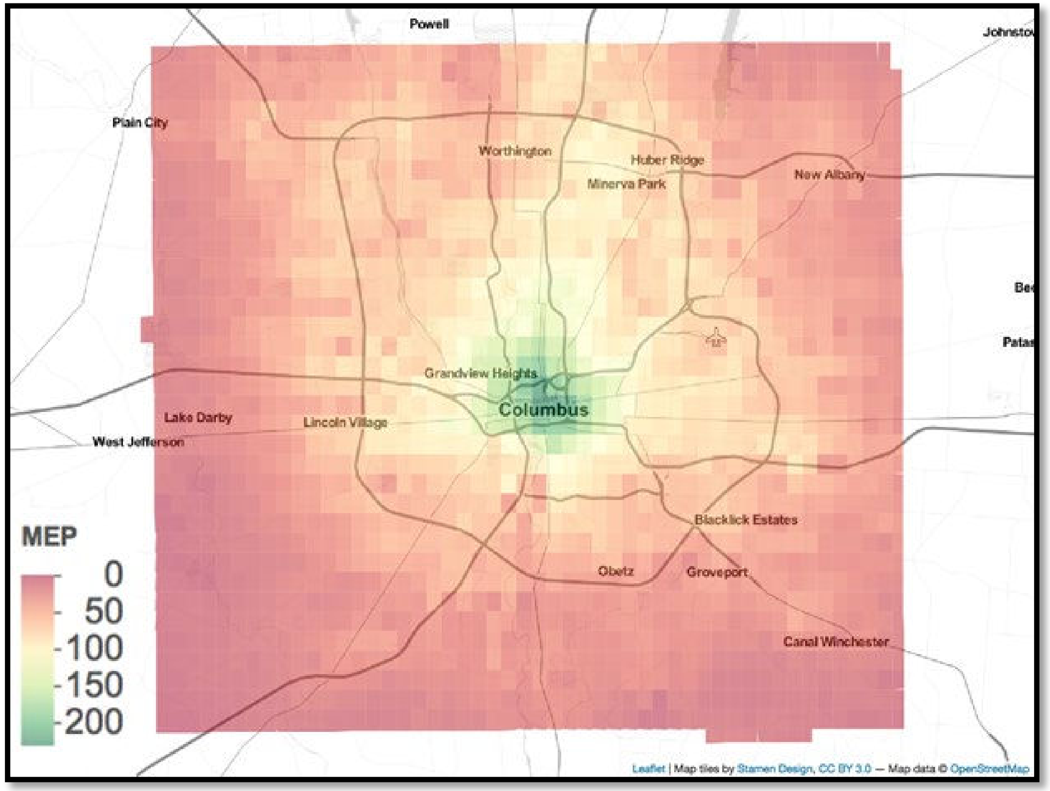


A example of opportunities accessible by biking

MEP Maps by Mode - Columbus

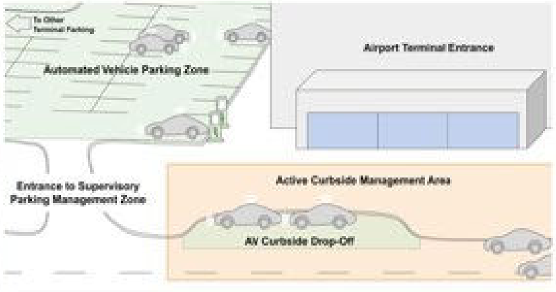


Driving



Transit, Biking, and Walking Combined

Mobility : The quality of a network or system to connect people to goods, services and employment that define a high quality of life.



DFW Auto-Valet Demo 2023

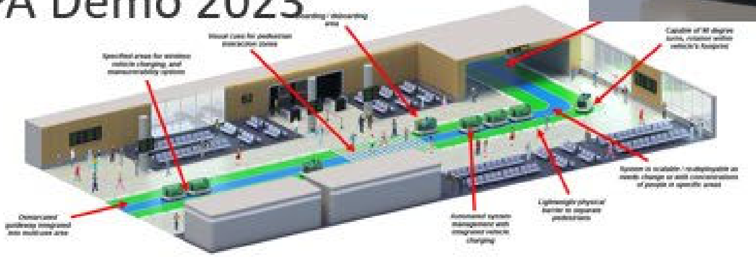
Landside Autonomy Futures

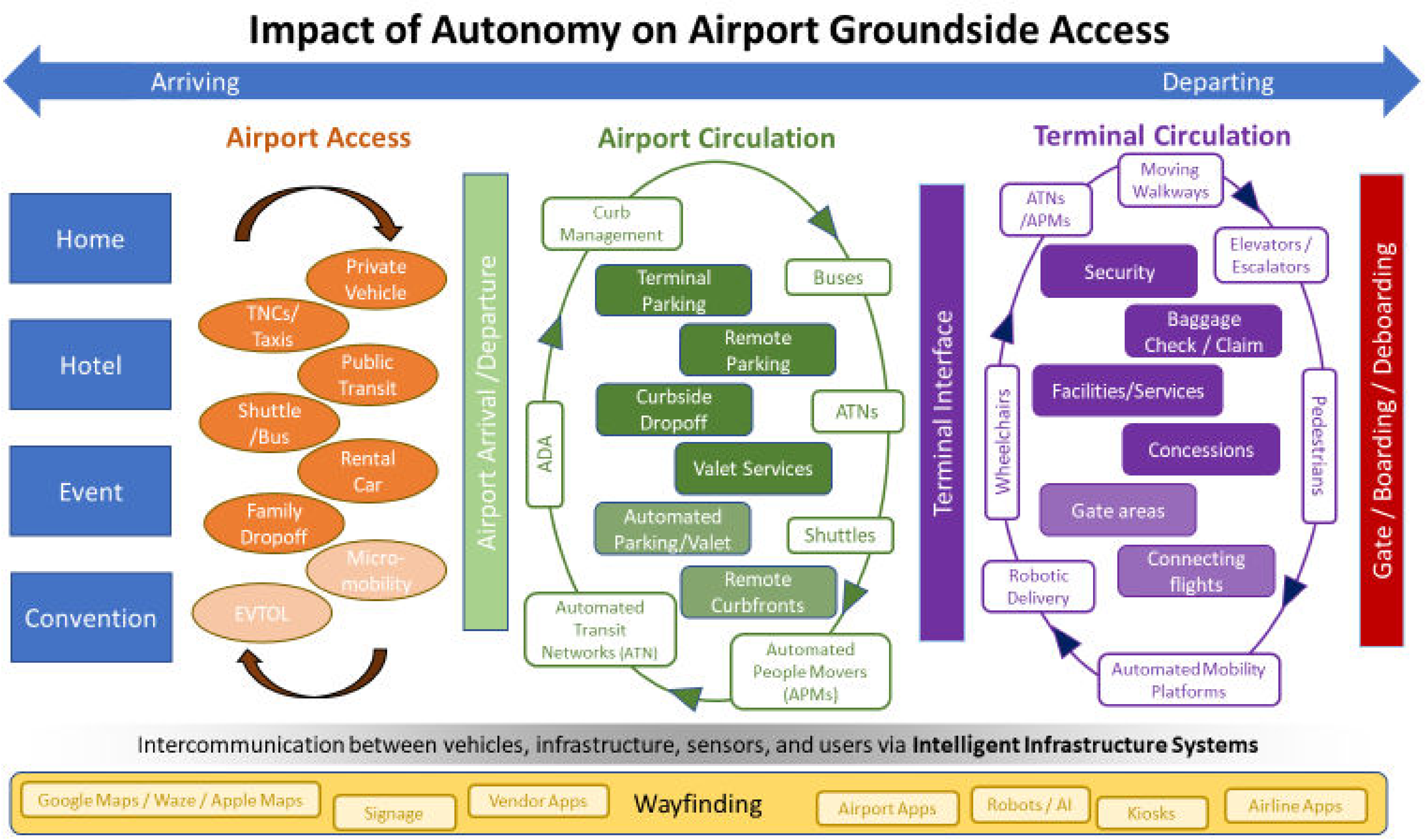
High Capacity PUDO Zones (AMD Study)

Active Curb Management

EV Landside Transition

AMPS STTR – PA Demo 2023

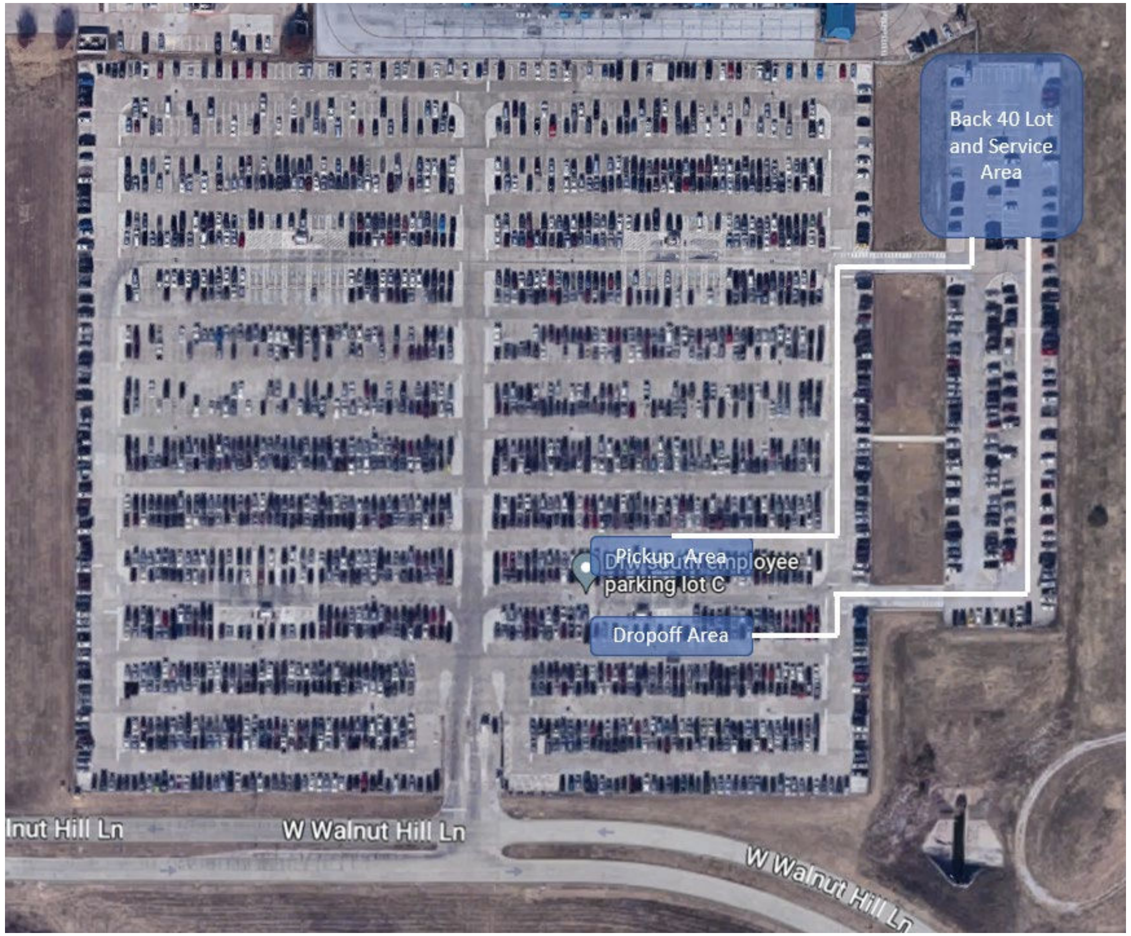


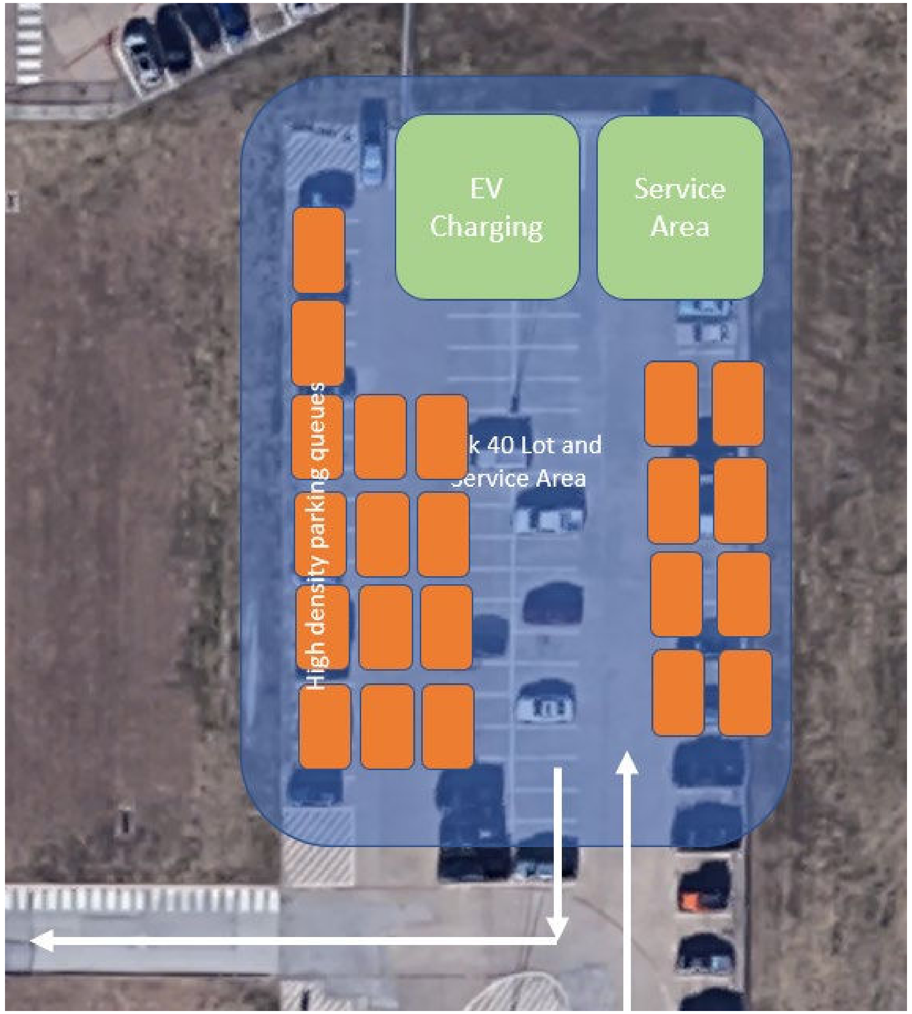


Impact of Autonomy on Airport Groundside Access
Arriving
Departing
Airport Access
Home
Hotel
Event
Convention
Private Vehicle
TNCs/ Taxis
Public Transit
Shuttle /Bus
Rental Car
Family Dropoff
Micro-mobility
EVTOL
Airport Arrival /Departure
Airport Circulation
Curb Management
Terminal Parking
Buses
Remote Parking
Curbside Dropoff
ATNs
ADA
Valet Services
Automated Parking/Valet
Shuttles
Remote Curbfronts
Automated Transit Networks (ATN)
Automated People Movers (APMs)
Terminal Interface
Terminal Circulation
ATNs /APMs
Moving Walkways
Elevators / Escalators
Security
Baggage Check / Claim
Facilities/Services
Concessions
Wheelchairs
Pedestrians
Gate areas
Connecting flights
Robotic Delivery
Automated Mobility Platforms
Gate / Boarding / Deboarding
Intercommunication between vehicles, infrastructure, sensors, and users via Intelligent Infrastructure Systems
Google Maps / Waze / Apple Maps
Signage
Vendor Apps
Wayfinding
Airport Apps
Robots / AI
Kiosks
Airline Apps

For Employee Parking / Equity

- Shorter, more convenient commutes
- Higher parking density
- Consolidated shuttle service (possible automated)
- EV charging and other services





Electrification and Automation

Airport / Urban

- Electrification Needs:
  - Employees / Travelers
  - Rental Car Fleets
  - Bus and shuttle fleets
  - Air side services
  - Building loads – air loads
- Opportunities for renewable energy
  - Parking lots, buildings, high cost
- No tolerance for outages
  - Micro-grids, large local storge
- Robust grid infrastructure
- Fledging automation applications

Rural America

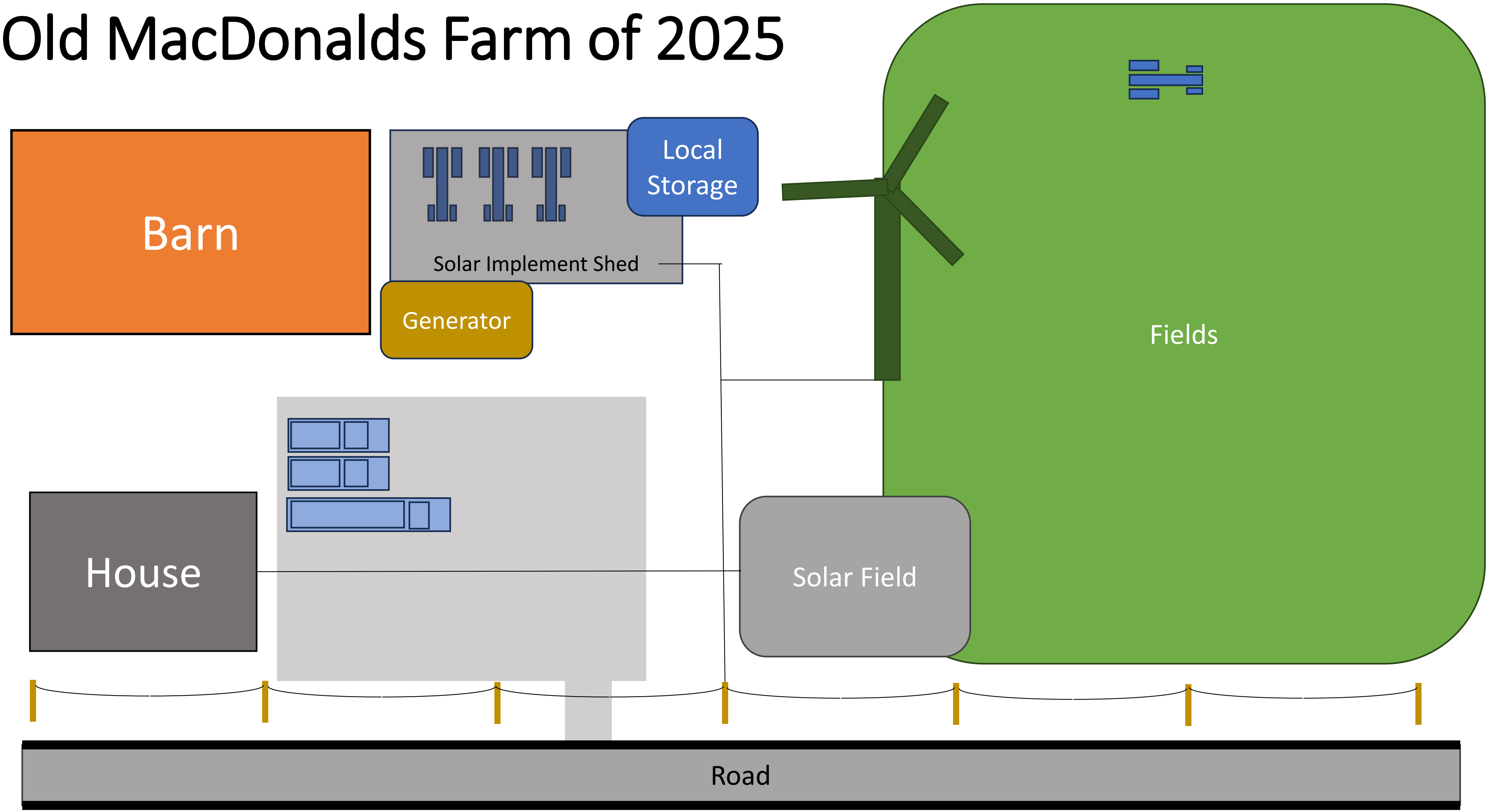
- Electrifications Needs
  - Heavy side of light-duty
    - Pickups, SUV
  - Medium/heavy duty –
    - Machinery
    - Trucks
  - Freight corridors
- Land for renewables, low cost
- Some tolerance for outages
  - Time to start ‘generators’
- Minimum grid infrastructure
- Accustomed to automation
- Very cost sensitive

Electrification Futures – Rural Tech Opportunities

- **Automation –**
  - Easier/safer long-distance travel capabilities
  - Low speed vehicle control perhaps with inductive charging (agricultural)
  - Infrastructure enabled/assisted – (less gear on the vehicle)
- **Local renewables –**
  - Local energy production and storage – behind the meter storage
  - Micro-grids for higher resiliency
  - Resilience for adverse weather
- **Storage –**
  - 'Harvest' local renewables
  - 'Sip' power from the grid for use in heavy duty applications
- **Knowledge / Training –**
  - Rural 'know-how'
  - Tech training / re-training

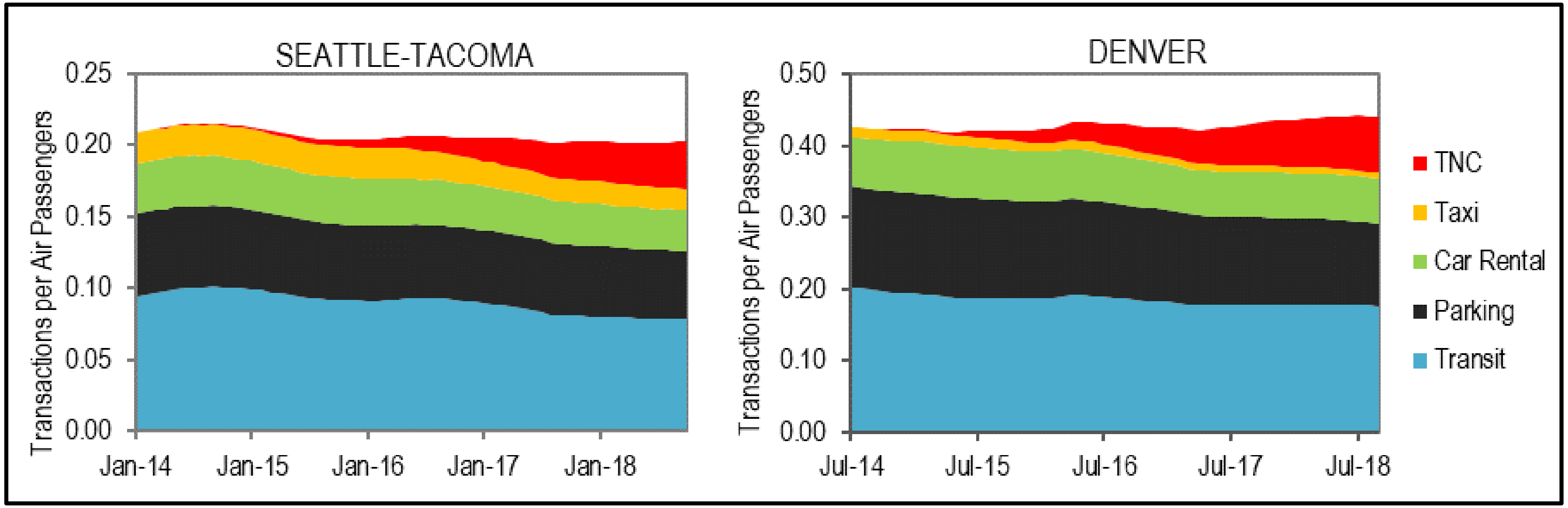
Charging – the 'Ball and Chain' of Electrification

Old MacDonalds Farm of 2025

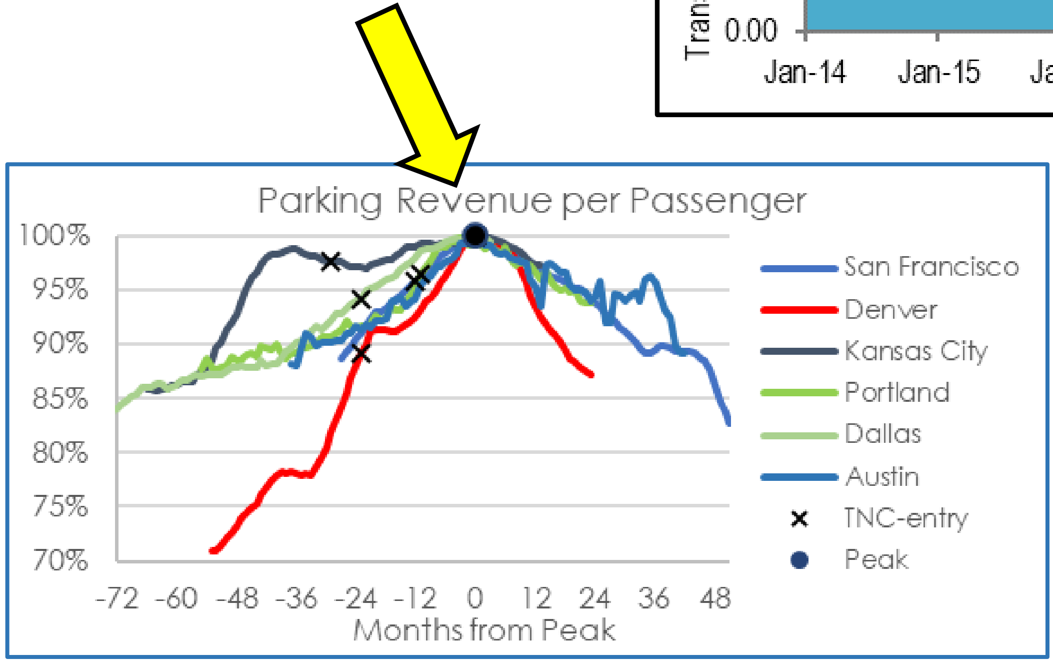


Airports – Precursor for Emerging Mobility Adoption

TNC share growing over time



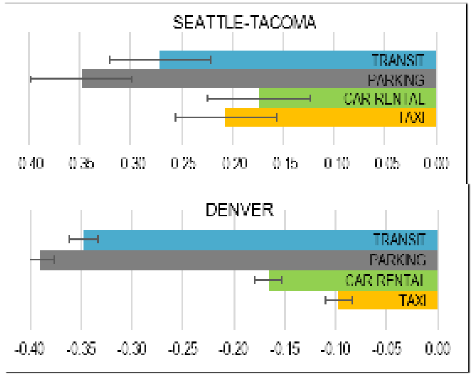
After TNC introduced, parking revenue declines



DECREASE IN GROUND TRANSPORTATION TRANSACTIONS PER UNIT OF TNC INCREASE

mode (sea-tac)	Estimate	Pr(>|t|)	95% CI
tnc (transit)	-0.2714	< 2e-16 ***	(-0.3226 -0.2201)
tnc (parking)	-0.3483	< 2e-16 ***	(-0.3994 -0.2970)
tnc (car rental)	-0.1739	9E-11 ***	(-0.2251 -0.1226)
tnc (taxi)	-0.2065	3E-14 ***	(-0.2578 -0.1553)

mode (den)	Estimate	Pr(>|t|)	95% CI
tnc (transit)	-0.3475	< 2e-16 ***	(-0.3610 -0.3340)
tnc (parking)	-0.3896	< 2e-16 ***	(-0.4031 -0.3761)
tnc (car rental)	-0.1658	< 2e-16 ***	(-0.1793 -0.1523)
tnc (taxi)	-0.0971	< 2e-16 ***	(-0.1106 -0.0836)



Henao, A., Sperling, J., Garikapati, V., Hou Y. & Young, S. (2018). "Airport Analyses Informing New Mobility Shifts: Opportunities to Adapt Energy-Efficient Mobility Services and Infrastructure" Golden, CO: National Renewable Energy Laboratory. NREL/CP-5400-71036.
https://www.nrel.gov/docs/fy18osti/71036.pdf

AV - ODT Deployment Milestones

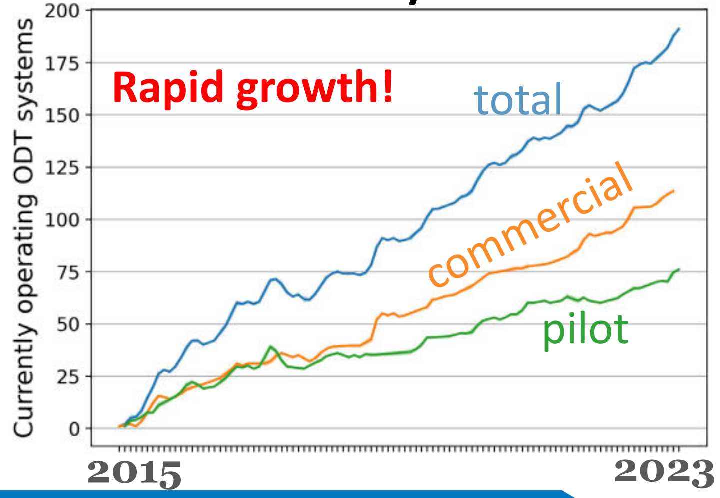
On-Demand Transit

2009
Uber Technologies is founded

2014
Bridj & Chariot micro-transit companies founded

2016
FTA began recognizing micro-transit as public transportation

On-demand systems in USA



?

AV

2004-2005
1st and 2nd DARPA Grand Challenges

2005-2007
DARPA Grand Challenge startup spinoffs

2014
Tesla Announces the first version of autopilot

2016
Waymo is first CAV company to test on public streets in Phoenix

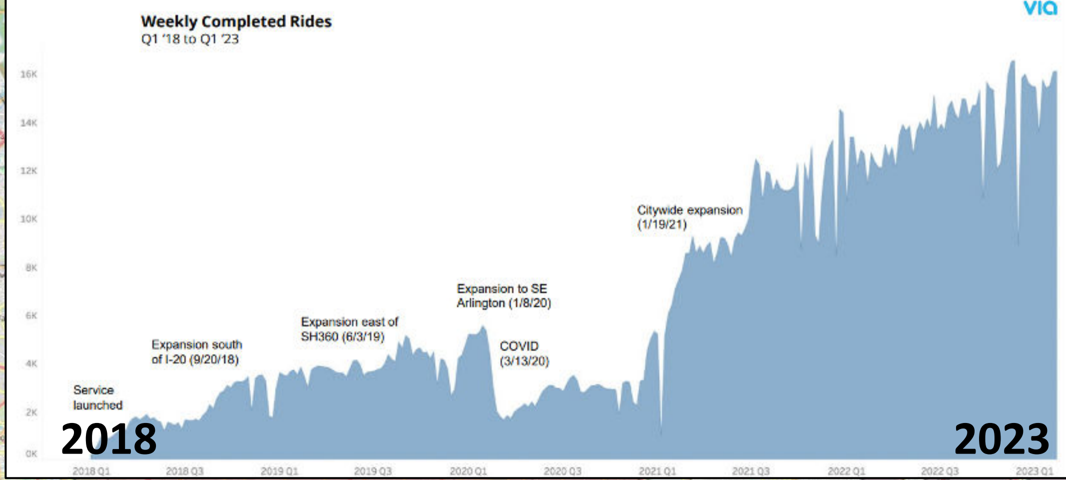
2016
USDOT release Federal Automated Vehicles Policy

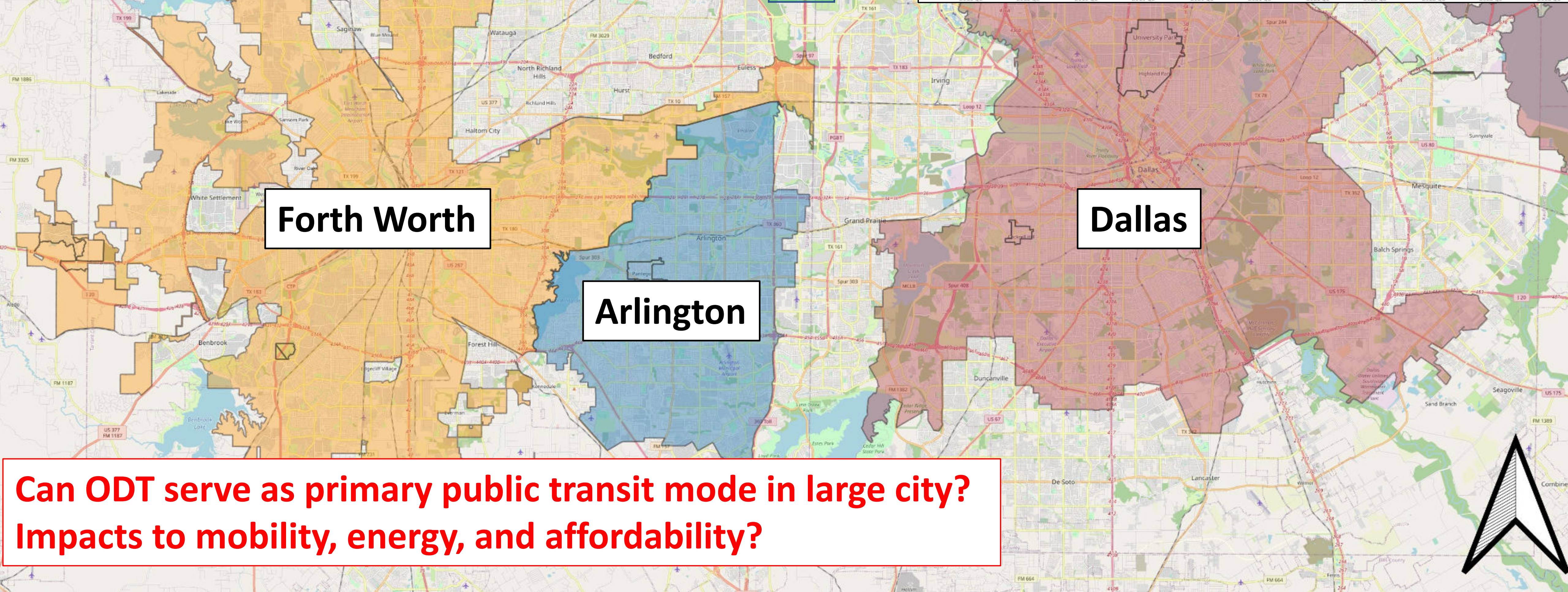
2023
Waymo expand to 300+ sq. miles, 700 vehicles across SF, Austin, Phoenix

2023
Cruise reaches Austin, Dallas, Houston, Phoenix, Miami, SF, Nashville, Atlanta, 400+ vehicles

2023
CPUC approve Waymo, Cruise expansion in SF, begin charging fares

- 68 6-passenger vans, 12 WAVs
- Fare: $3-5/person
- Hours: 6am-9pm
- 2 million rides since launch (Q1 2018)
- Ave wait time = 10-15 minutes
- 88% or riders make < $50k/year





Can ODT serve as primary public transit mode in large city?
Impacts to mobility, energy, and affordability?

Impacts of city-scale ODT on Mobility Energy Productivity?

Def: A measure of access to goods and services weighted by travel time, cost, and energy use

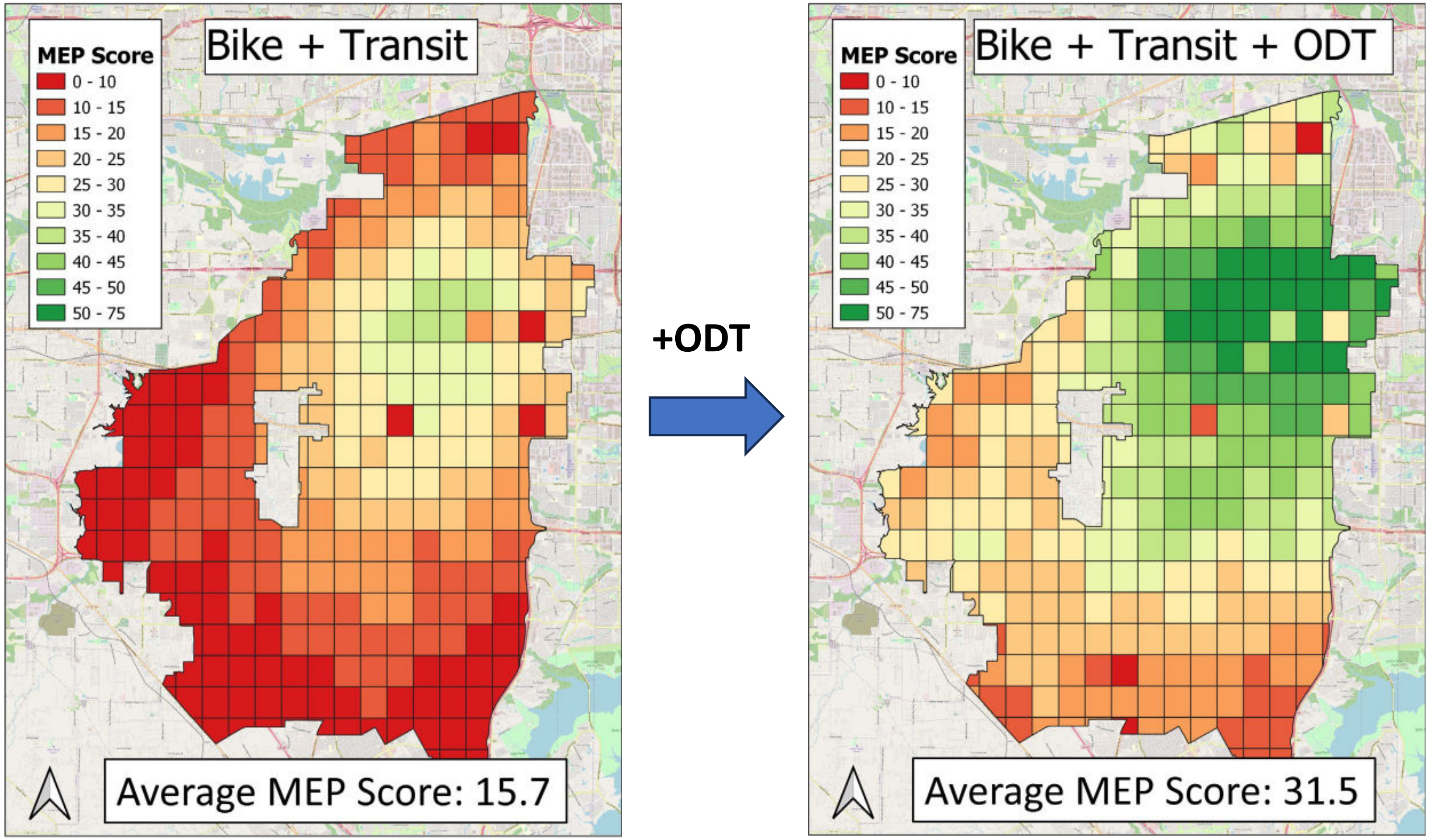
MEP Score = α(cost) + β(travel time) + γ(energy use)

Inputs for ODT service:

Wait time = 15 minutes

Travel speed = 0.75 * private auto

Cost = $0.96/mi (based on fares & ave trip distance)



Findings
(not considering private auto):

- Adding ODT doubled MEP score in Arlington
- Benefits were spread throughout the service region
- Greatest benefits in downtown

Thank You!

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stanley.young@nrel.gov

NREL Transforming ENERGY