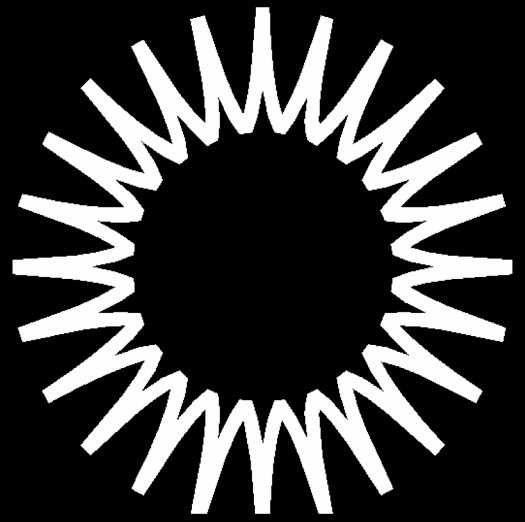

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SFMTA Zero Emission Vehicles Program

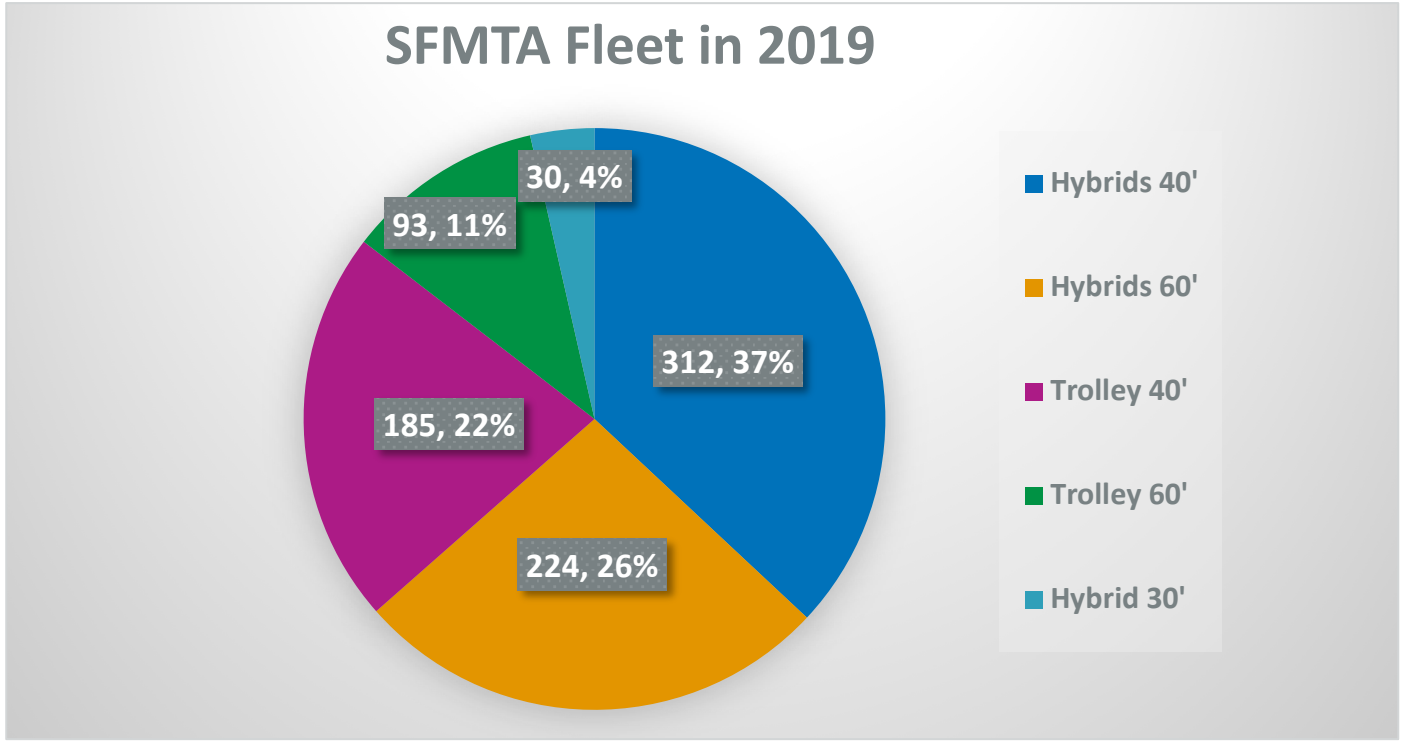
Bhavin Khatri

08/08/2018

Agenda

- ✓ Efforts Towards Zero Emissions
- ✓ SFMTA Board Resolution
- ✓ Pilot Battery Electric Bus Program

Background



Electric Trolleys(Zero Emission) represents 33% of all coaches.

Efforts Toward Zero Emissions

- SFMTA currently operates the nation's largest fleet of zero emissions trolley vehicles, which are driven by clean hydroelectric power.
- SFMTA has replaced over 90% of its older diesel buses with cleaner, more efficient electric hybrid vehicles. Electric hybrid vehicles offer lower fuel usage, reduced emissions, and shorter idling time than diesel vehicles.
    - This change will reduce fuel consumption by 5.4 million gallons and eliminate 82,000 tons of CO2 over the 12 year life of the fleet.

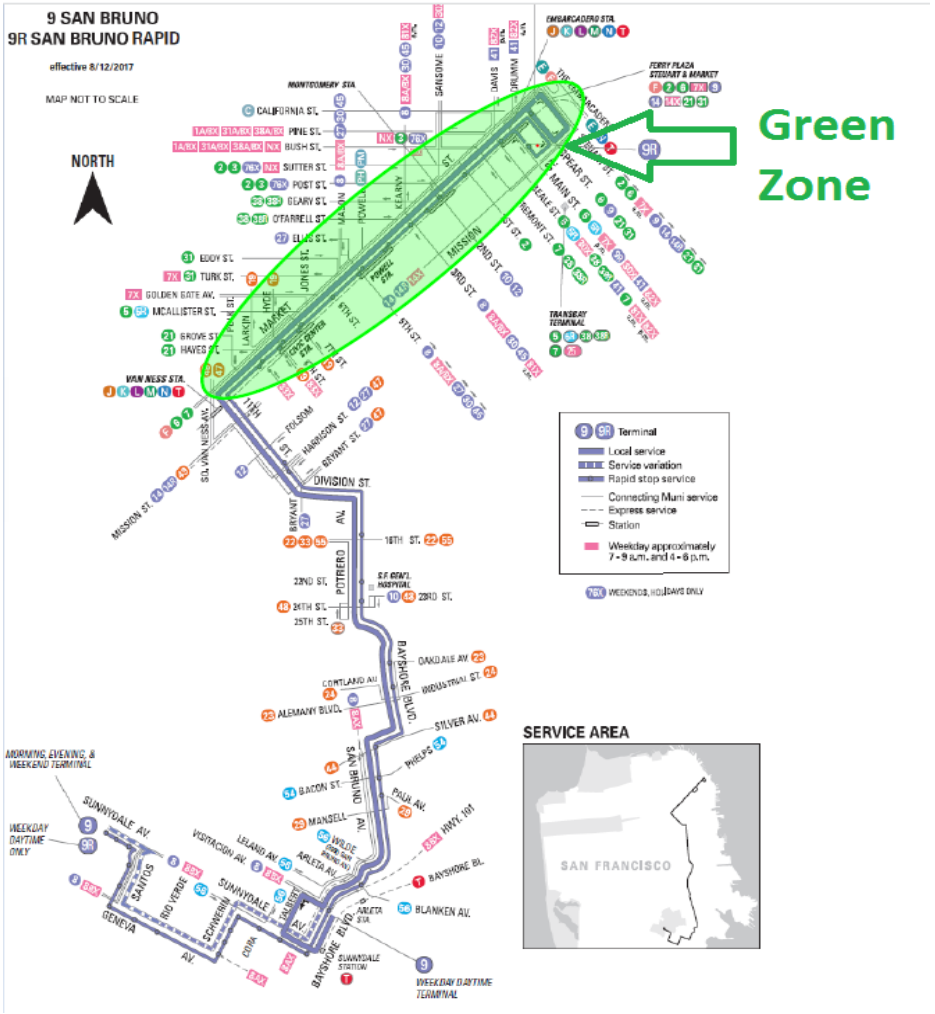
Efforts Toward Zero Emissions

- In 2016, SFMTA began incorporating an engine auto stop-start and depot mode feature into 54 electric hybrid fleet vehicles, which allows a vehicle to stop its engine entirely and drive under battery electric power for short distances.

MODE	FEATURES	BENEFITS
START/STOP DRIVE 	• Engine shuts off at stops • Engine starts upon acceleration	• Reduces engine operation time: up to 40% • Save fuel - incremental up to 10%
DEPOT DRIVE 	• Engine is off • All electric operation inside depot garage • Operator selected	• Emission-free • No fuel • Quiet

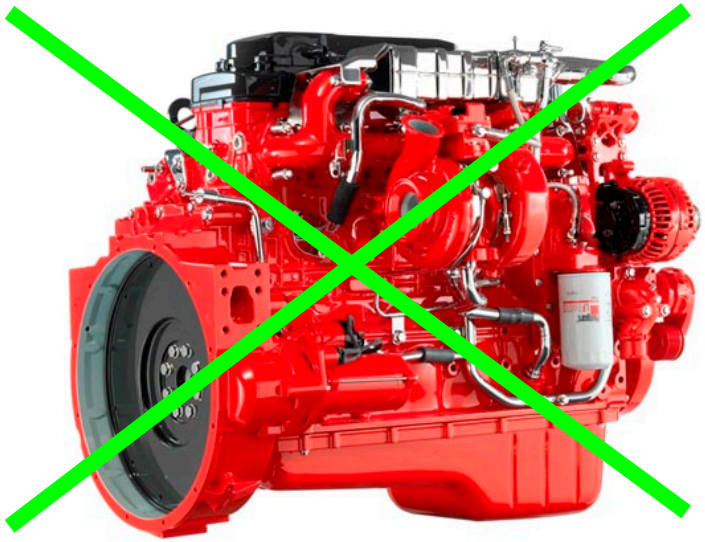
Efforts Toward Zero Emissions

- SFMTA has recently purchased electric hybrid vehicles with higher capacity on-board battery system allowing for the vehicles to travel significant distances on battery power alone.
- The increase battery capacity will allow SFMTA to run a test program to operate “Green Zones” along several electric hybrid routes.
- The “Green Zone” signifies an area in which the vehicle will not produce any emission as the bus will operate entirely on battery power with the engine off.

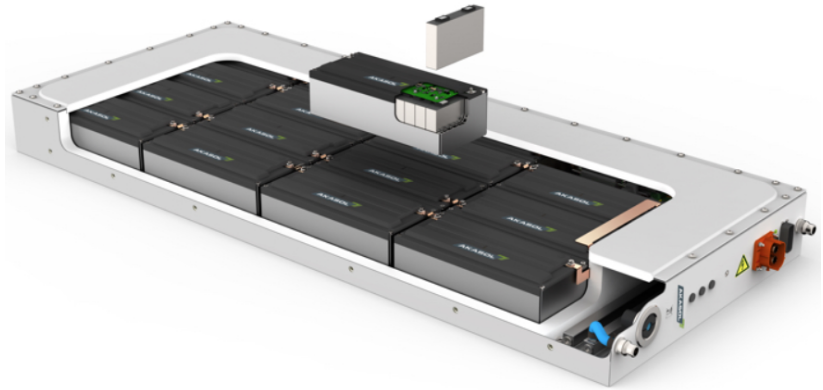


Efforts Toward Zero Emissions

- SFMTA is working to develop pilot programs to convert electric hybrid into plug-in battery electric buses by removing the engine and installing a larger battery pack by the end of 2018. This will pave the way toward a significant overhaul of our existing fleet.
- Once the pilot is proven, this will pave the way towards a significant overhaul of our existing hybrid fleet further allowing us to expedite zero emission goals.



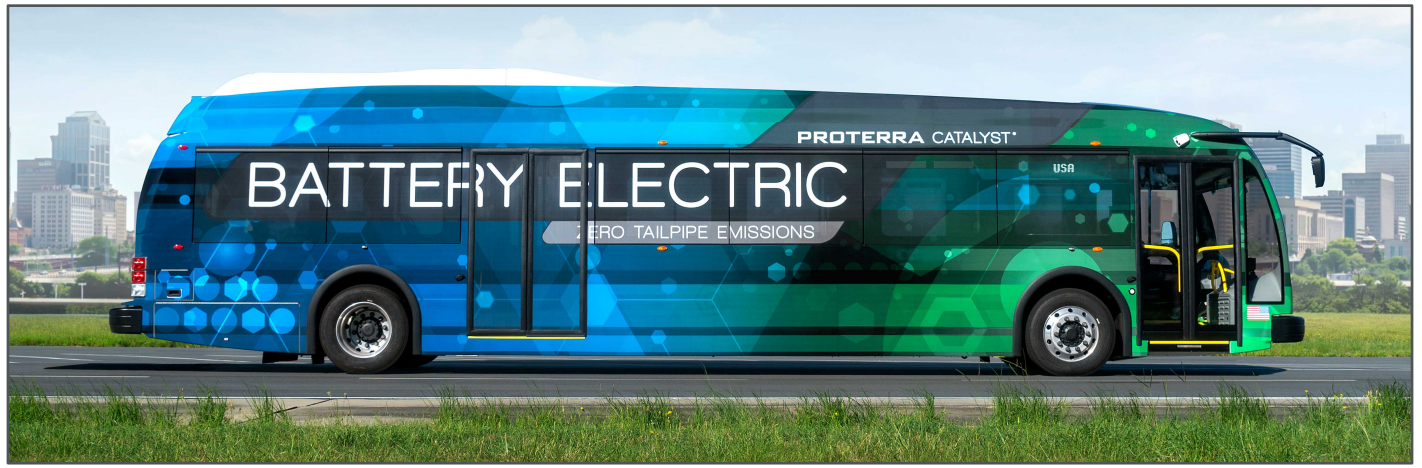
Engine



Battery Packs

Zero Emission Committee

- In 2017, SFMTA formed the Zero Emission Fleet Technology Committee and established a pilot program within SFMTA for testing battery electric buses.
- 9 buses will be purchased and put into revenue service in 2019 to determine the efficacy of battery electric buses in San Francisco's unique operating environment.



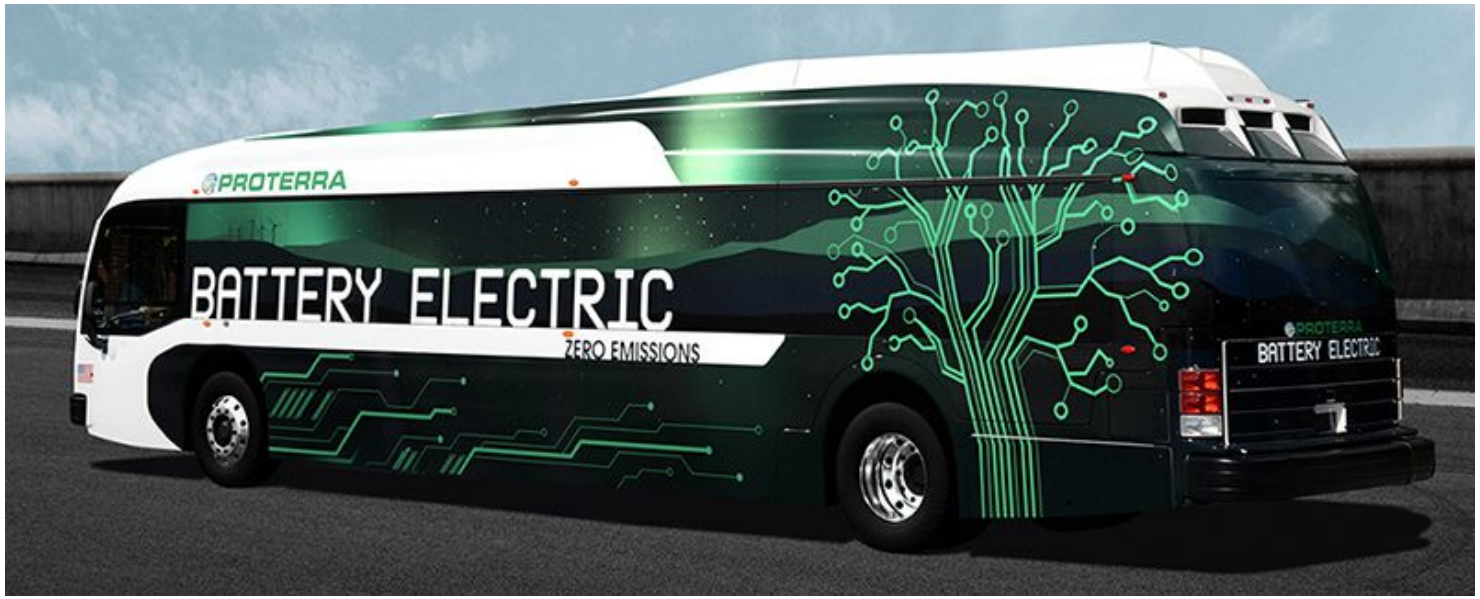
CARB Resolution

- The California Air Resources Board (CARB) has proposed a long term strategy for clean transit and mobility options called the Innovative Clean Transit measure.
- The long term vision of the Innovative Clean Transit measure is to achieve a zero emissions transit system by 2040. This would be achieved by requiring the purchase of a gradually increasing percentage of zero emissions buses as part of all bus procurements, with 100% of bus purchases being zero emissions by 2029.

CALIFORNIA
AIR RESOURCES BOARD

Zero Emission Vehicles Resolution

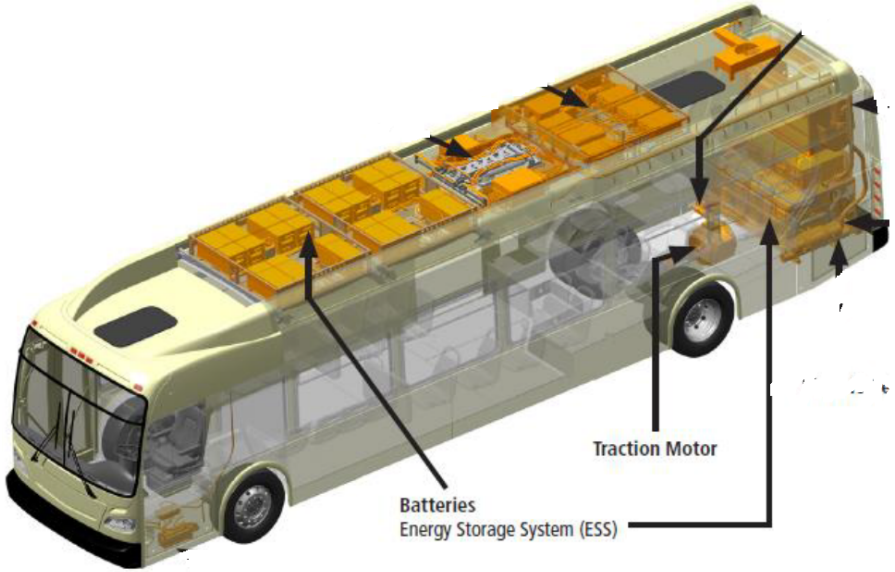
- SFMTA has been one of the foremost national leaders in pursuing sustainable, reduced, and zero emissions revenue transit vehicles.
- SFMTA Board of Directors adopted a resolution to begin procuring zero emission battery buses to replace our electric hybrid vehicles starting 2025, with a goal of achieving a 100% electric vehicle fleet by 2035.

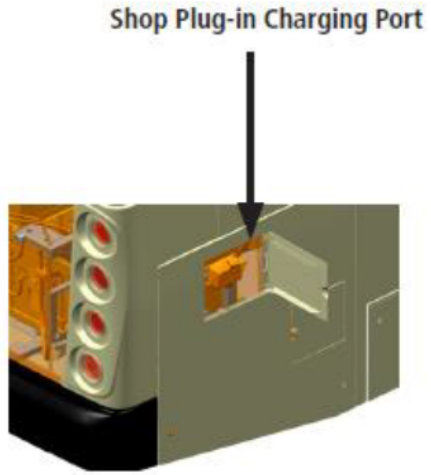


Battery Electric Bus Pilot Program

What is a battery electric vehicle?

- Uses a very large onboard battery system to store energy
- Battery powers a traction motor to move the vehicle
- Can be charged via plug-in depot charging or an overhead charging assembly





Battery Electric Bus Pilot Program

Battery Electric Buses

- Comparable to conventional diesel/CNG/hybrid electric transit buses
- Offer 200+ mile range between charges
- Have all amenities of a normal transit bus
- Are offered by an increasing number of bus OEMs in the US

Battery Electric Bus Pilot Program

2 main methods of charging electric vehicles

1. Plug-in depot charging
   - Plug charger into a port on the vehicle
   - Vehicle charges slowly, usually overnight
   - Most common charging system on electric vehicles
2. Overhead catenary charging
   - Charger suspended above the vehicle charges it rapidly
   - Charging is much faster, with charges lasting for several minutes
   - Usually paired with vehicles with smaller battery capacities, necessitating more frequent charging

Battery Electric Bus Pilot Program

PLUG-IN CHARGERS

Express 250 Station

Battery Electric Bus Pilot Program

Overhead Chargers

Battery Electric Bus Pilot Program

- ❑ Purchase 9 battery electric buses
  - 3 buses from each of the 3 major electric bus manufacturers in the US
  - Buses need to be 40’ long, have at least 160 miles of range, and charge completely via plug-in charging in within 4 hours
- ❑ Drive the vehicles on SFMTA’s bus routes for a period of at least 1 year
  - Vehicles will be used in regular revenue service.
- ❑ Provide a report analyzing the electric buses and comparing them to our existing hybrid-electric and trolley coaches

Battery Electric Bus Pilot Program

- Long Range Plug-In Battery Electric Buses
- Provision for Overhead Fast Charge
- Highly Efficient Buses

HYBRID
4.58
MPG

DIESEL
3.86
MPG

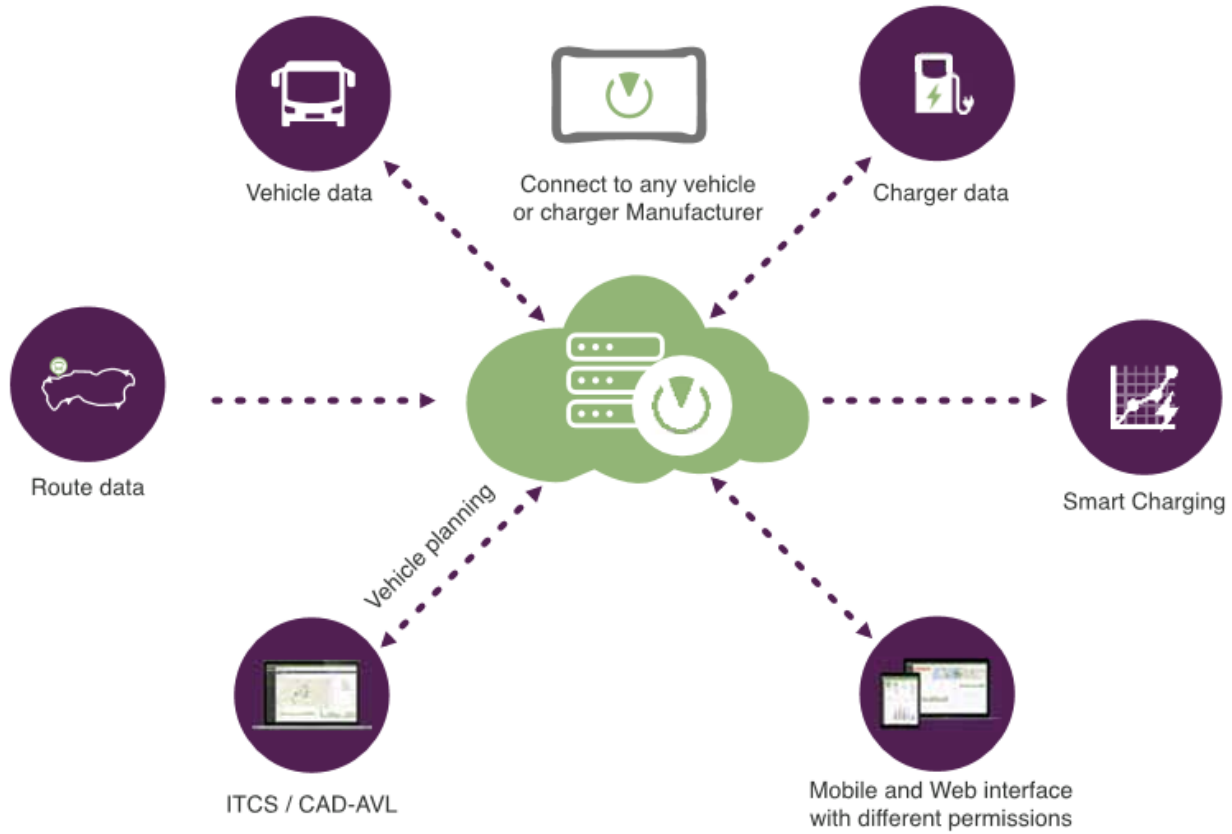
CNG
3.27
MPG

BATTERY ELECTRIC BUS
21.4
MPGe

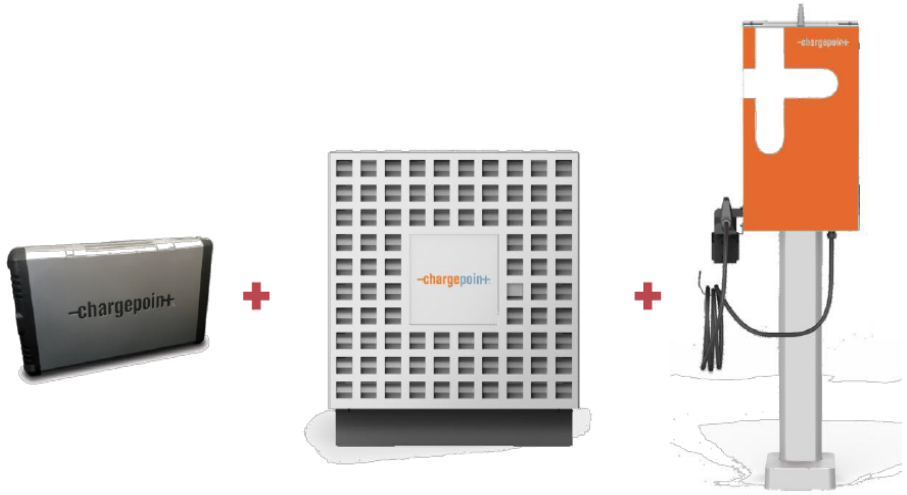
Battery Electric Bus Pilot Program

Advanced Monitoring System

- Driver Behavior: Driver statistics, Regeneration profile and Reports
- Maintenance: Remote diagnostics, battery statistics.



Battery Electric Bus Pilot Program



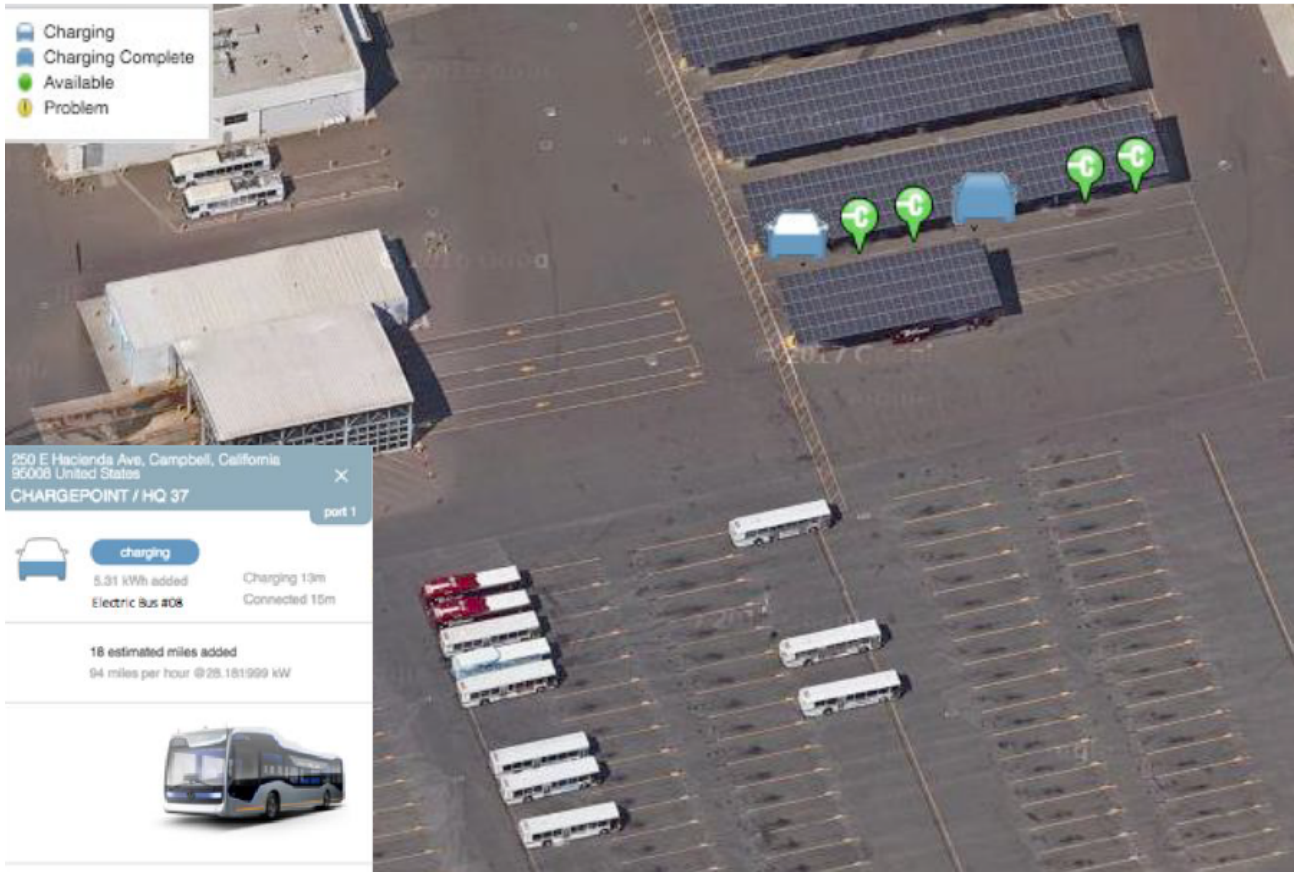
Power Module Power Block Depot Station

Advanced Charging Solution

- State of the Art Modular System
- One of the first Transit Agency in the United States to adopt this
- Allows chargers to be mounted above coaches for space saving in tightly packed yards.

Battery Electric Bus Pilot Program

Remote Monitoring of Charging Status



VTA's EV bus and Advanced Energy Management system

Gary Miskell
Santa Clara Valley Transportation Authority

Ruth Cox
Prospect Silicon Valley

Valley Transportation Authority

&

PROSPECT Silicon Valley

Electric Buses

VTA is rolling out brand new, all-electric Proterra buses

VTA ZEB program is helping to meet the California goal of reaching 1.5 million zero emission vehicles (ZEVs) on California's roadways by 2025.

"About 279,000 barrels a day of fuel won't be needed this year due to EV's"

Jeremy Hodges Bloomberg Technology

Vehicle to Grid Integration

The Santa Clara Valley Transportation Authority (VTA) teamed up with Prospect Silicon Valley, and Bay Area tech companies to pilot a cutting-edge system that will manage charging and energy consumption on electric buses while reducing the impact on the state's electricity grid.

The pilot funded by the California Energy Commission will serve as a major case study for transit agencies throughout the country

Connected & Making Real Time Decisions

PARTNERS

PROSPECT Silicon Valley

Valley Transportation Authority

CALIFORNIA ENERGY COMMISSION

NREL NATIONAL RENEWABLE ENERGY LABORATORY

KISENSUM

CALSTART

PROTERRA

CISCO

ENERGY SOLUTIONS

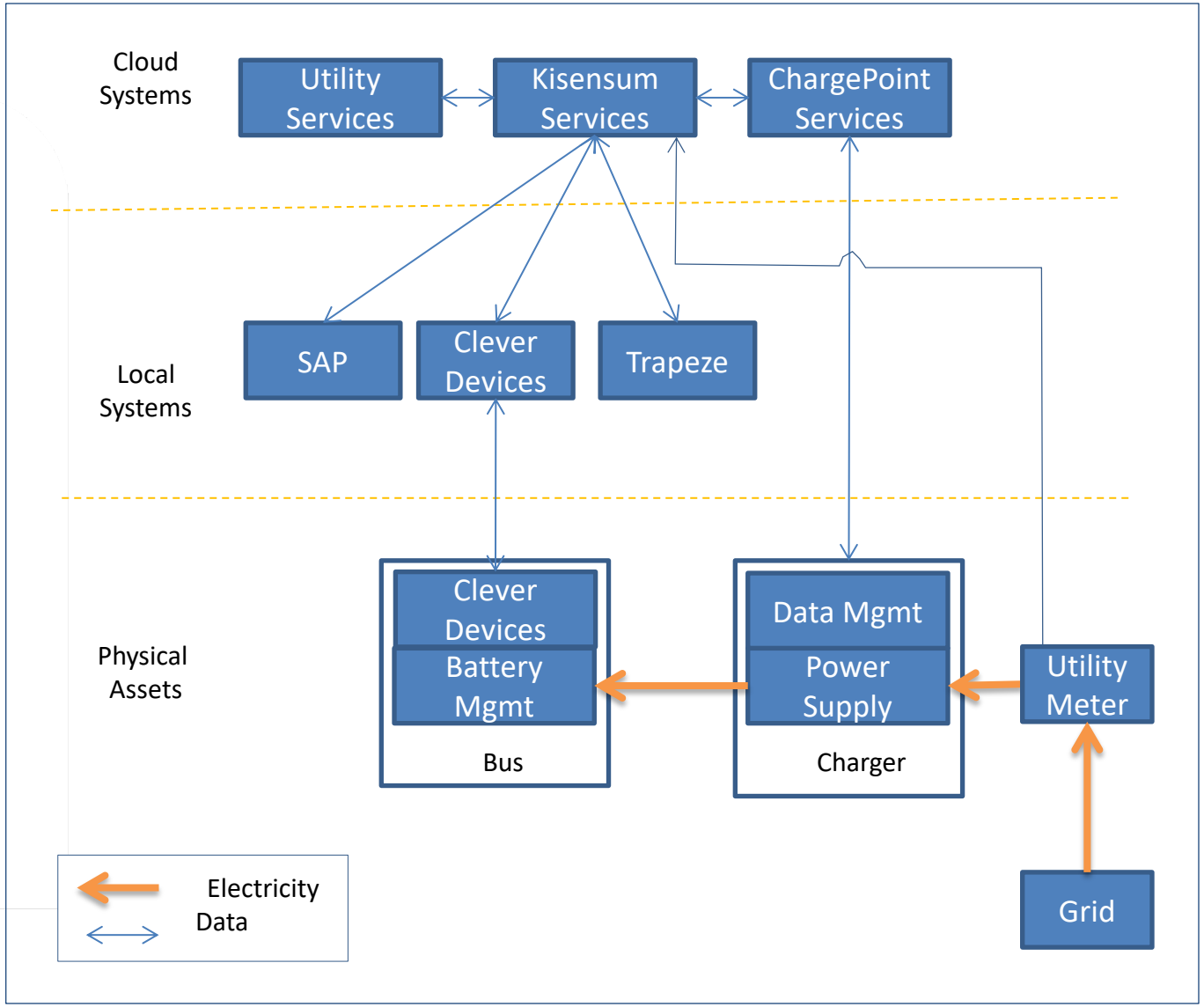
nova WORKFORCE DEVELOPMENT

ZNEAlliance

Solutions that move you

Primary Goals of the VGI Solution

1. Ensure that the buses are charged and ready to go before pullout time
2. Provide visibility into charging process
3. Send alerts when there are issues in the charging process or during daily operation that needs to be addressed
4. Support the bus to block assignment process
5. Minimize PG&E bill
6. Simulate Grid interactions with system



Operational Analysis and Simulation Strategy

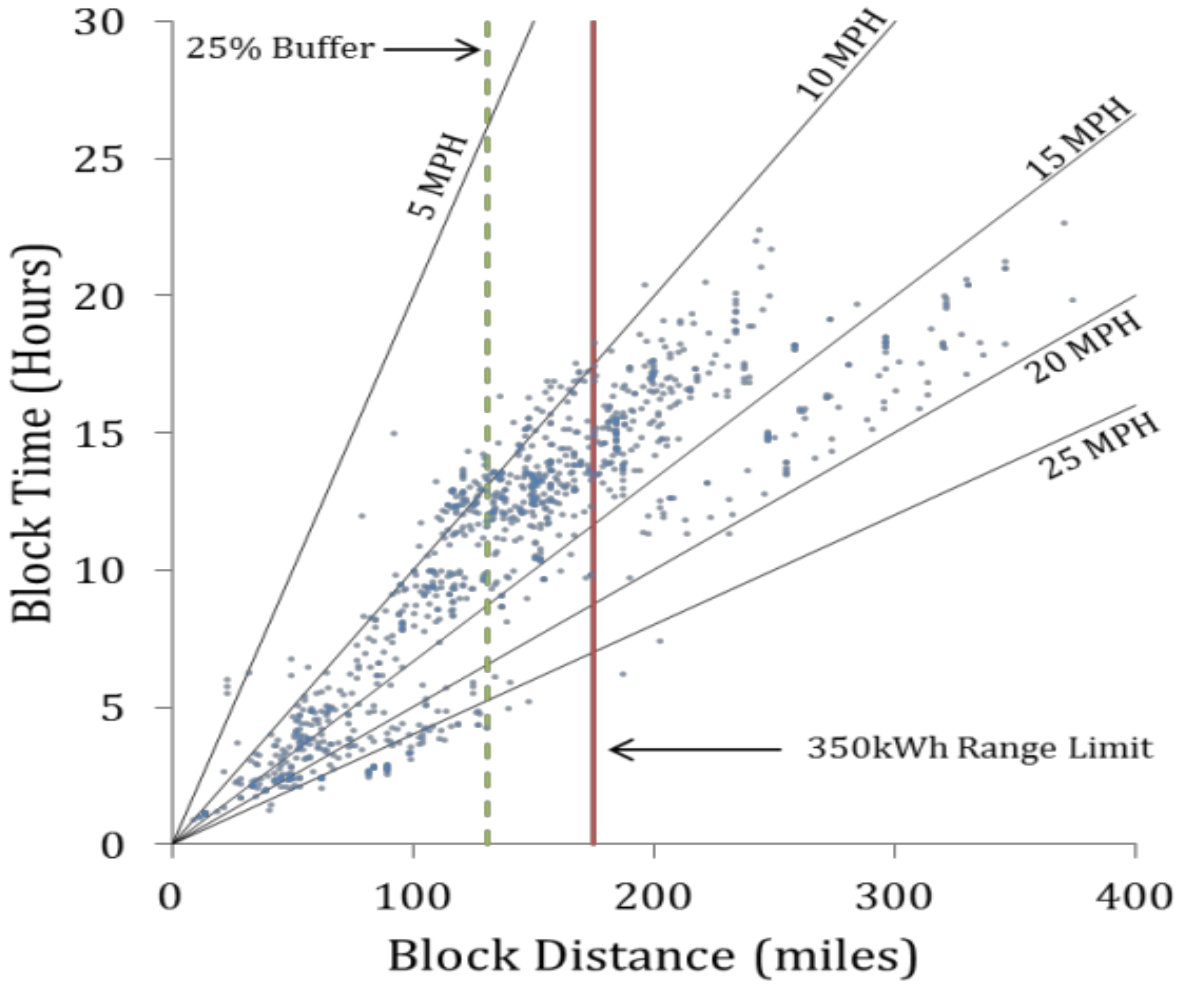
Project Leverages the National Renewable Energy Lab's expertise in analysis and modeling of Electric vehicles

Analysis Development

- Develop the analytic
- Develop operational & cost models

Models will be used to predict and recommend operational parameters during the pilot phase followed by post implementation analysis to validate the effectiveness.

- **Analyze operating conditions**
- **Recommendations**.
- **Fleet wide Analysis**



Comparison of distance versus travel time for each block

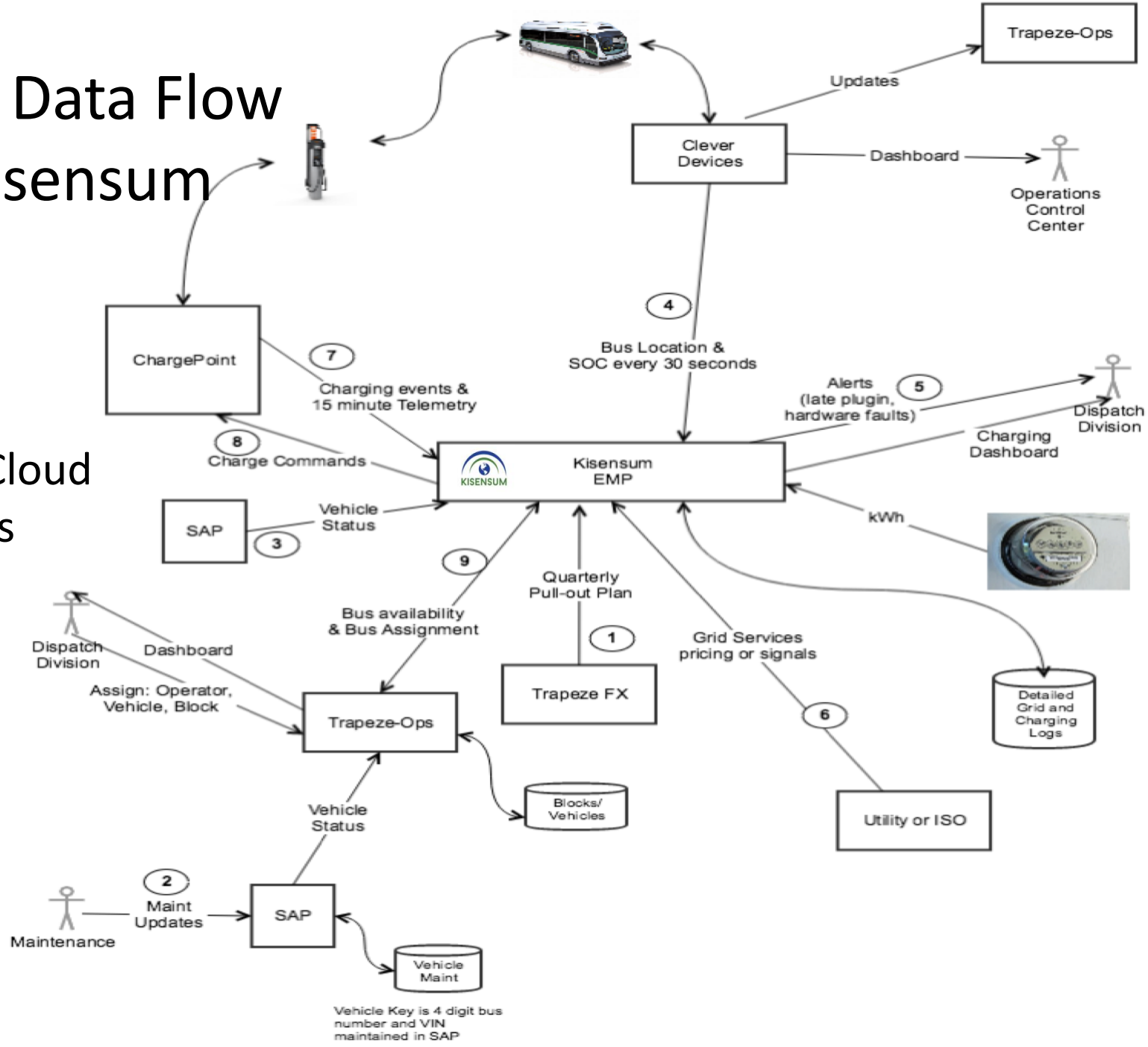
So What is the Big Deal? – Data Flow
NEW Core Application = Kisensum

Inputs

- Trapeze-FX
- Trapeze-Ops
- SAP
- ChargePoint Cloud
- Clever Devices
- Grid Signals
- Electric Meter

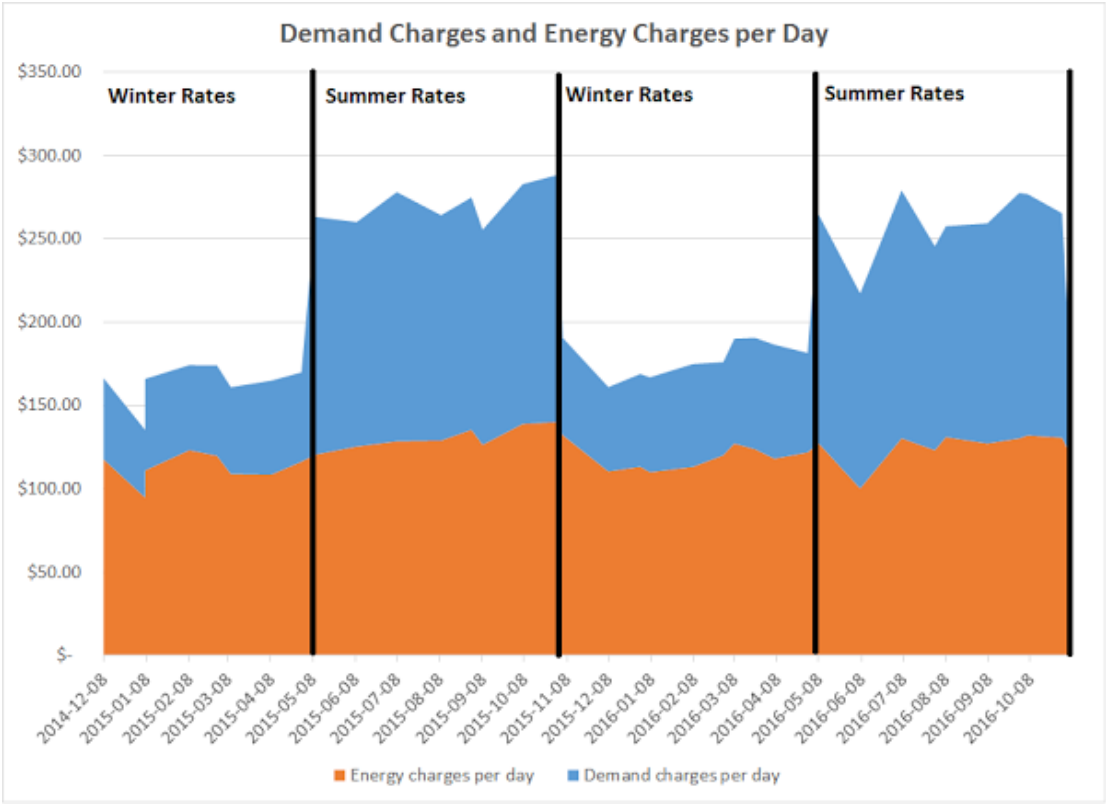
Outputs

- Trapeze-Ops
- ChargePoint Cloud
- Clever Devices
- Operators



What Are The Major Innovations?

- Creating charge plans that support more buses than charge stations
- Energy Management Platform that interoperates with VTA and Grid systems
- Dashboard and alerting system supporting vehicle Charging & operations
- Realtime cost minimization process through demand leveling and Time of use aware charging
- Performing Grid Service simulations while not jeopardizing the bus charging operations

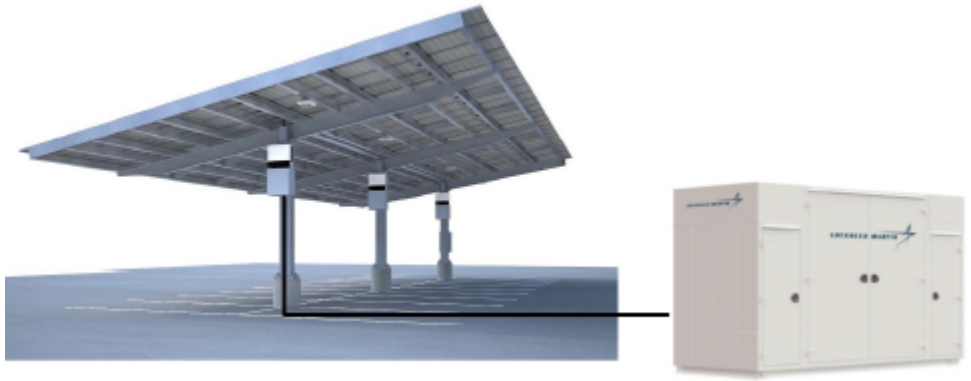


What We've Learned Thus Far

- Advances in Passenger Fleets are now being applied to truck and bus fleets
- Ranges for truck and bus fleets need to be extended to meet the distance requirements of most routes
- Gaps can be filled with "In-Field Charging" and larger battery packs (1,000 KWH)
- Shuttles are best suited for first and last mile or short demand trips – lower power consumption and longer distances between charges

What's Next??

Connecting battery storage to solar installations will enable demand charge avoidance, reduce losses from AC to DC inversion, and provide emergency islanding resources



Expanded Solar

Smart Microgrid + Energy Storage

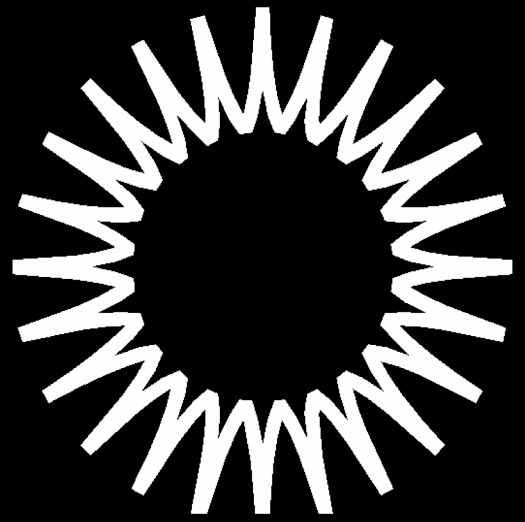
Moving to Autonomous and Connected EVs

- Developing an ADA compliant Autonomous Shuttle for a pilot project at the Veteran's Administration campus in Palo Alto
- Will supply hands free "In-Field" charging at the VA Center
- Potential to collaborate with CalTrans on CV technology for smart intersections
  - Traffic management and prioritization
  - Collision avoidance
  - Pedestrian safety

Thank You!!

Gary Miskell
Chief Information Officer
Gary.Miskell@vta.org
(408) 321-7014

Ruth Cox
CEO, ProspectSV
Ruth.Cox@prospectsv.org
(408) 273-9224



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