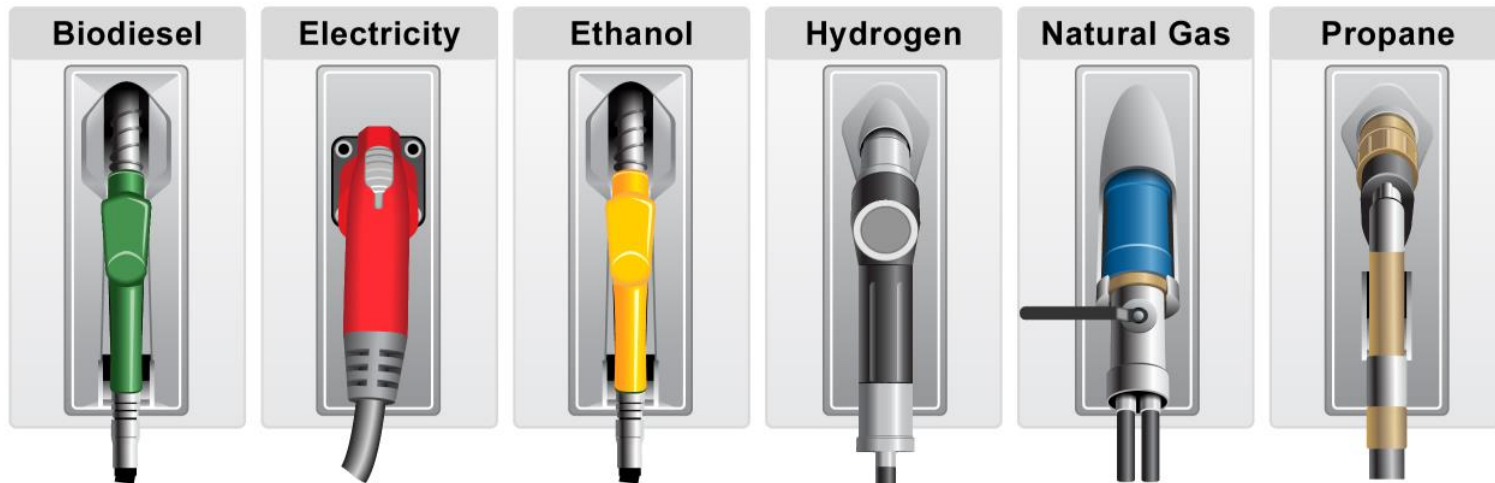


- Vehicles and Driver Choices that Increase Fuel Economy
 - Right-size, Idle Reduction – Bikes, Land Use, Transit
- Advanced Vehicles (e.g., HEVs, PHEVs)
- Alternative (non-petroleum) Fuels & Vehicles

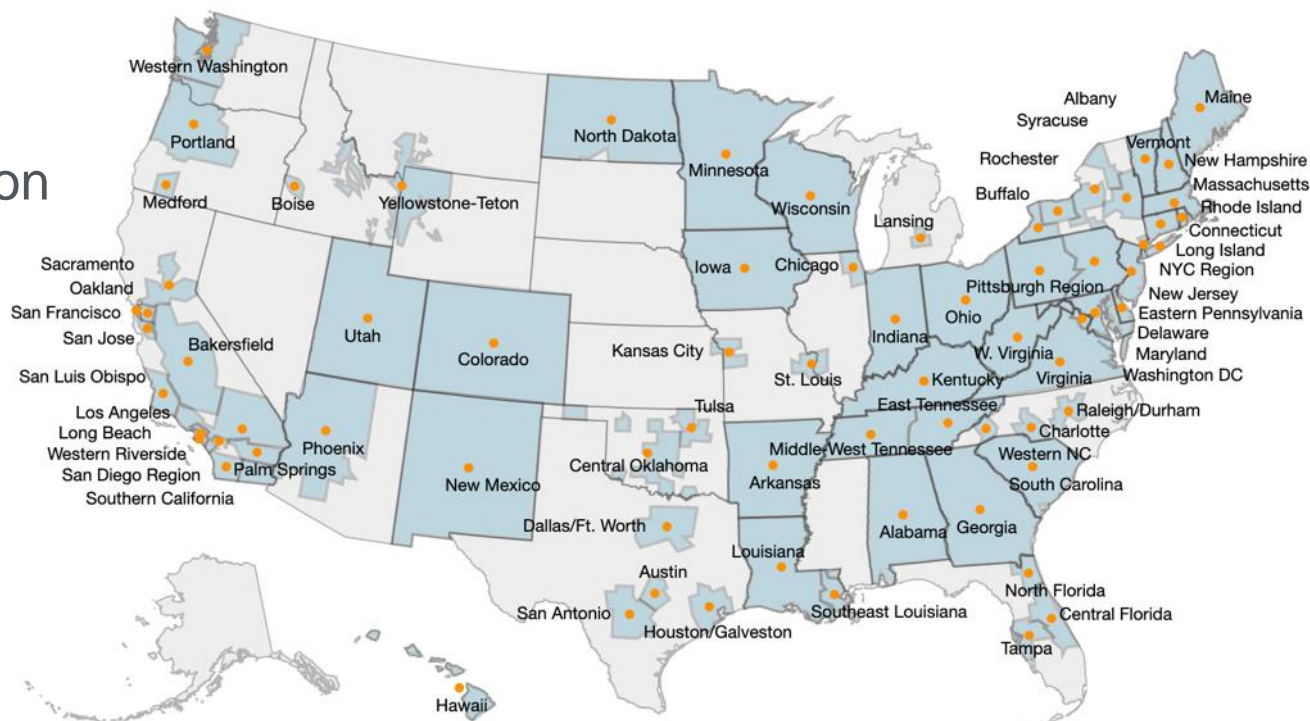


- Lower fuel use
 - Lower cost fuels at scale
 - Fuel our economy
- \$33 million to \$15 million per day
\$2.50 Gasoline to \$1 Renewable Fuel
\$20 million recirculating – daily

Local Partnerships: Clean Cities Coalitions



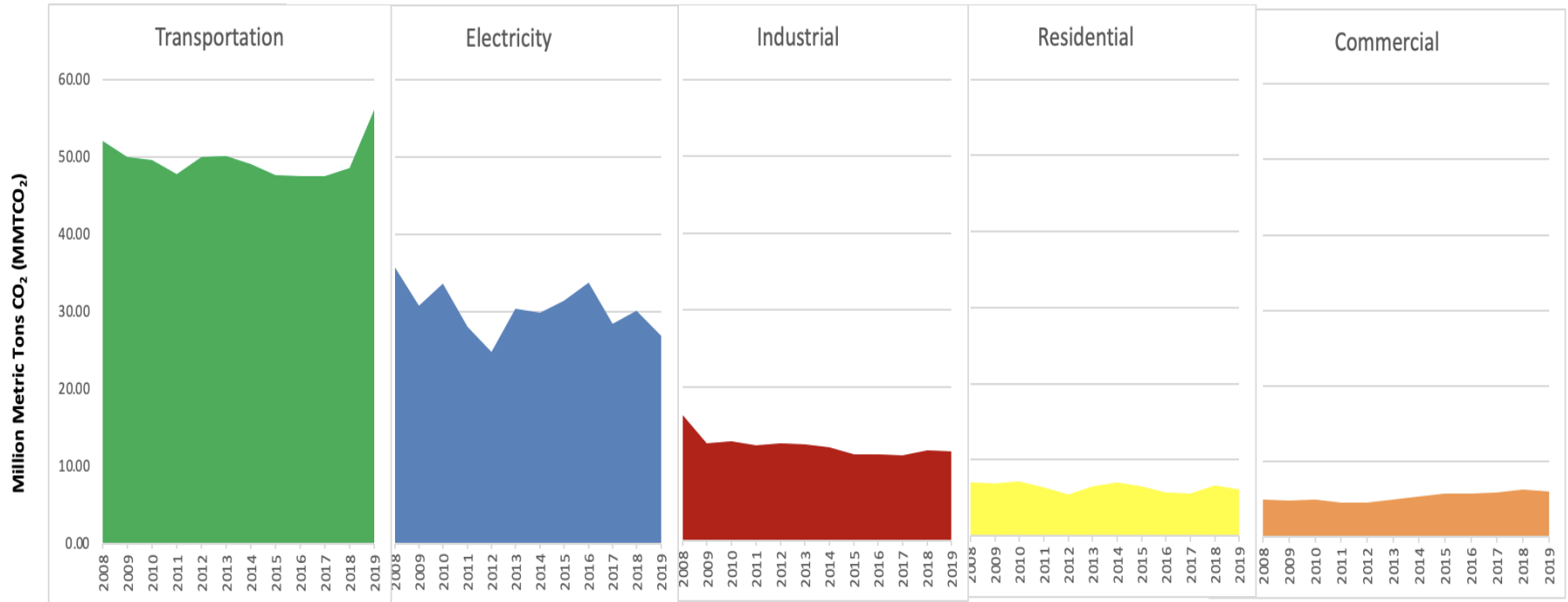
- National network of nearly **75 local coalitions**
- **82% of the total U.S. population** lives inside coalition boundaries
- **500,000 alternative fuel vehicles (AFVs)**
- **Security:**
 - Energy
 - Economic
 - Environmental



Transportation Emissions



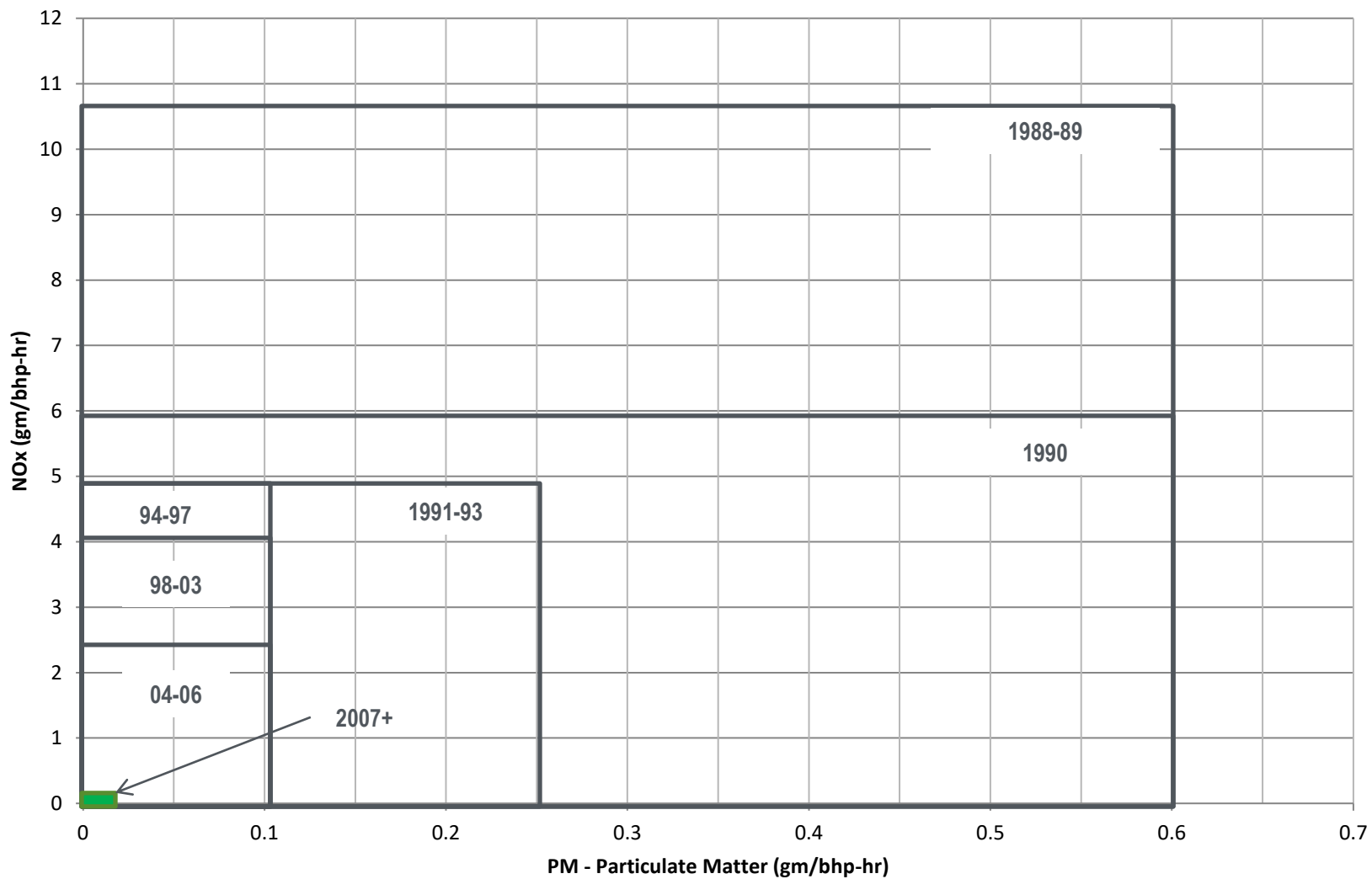
Virginia Carbon Dioxide Emissions by Fossil Fuel Combustion Sector 2007-2019



Emissions Regulation – Heavy-duty



Federal Heavy-Duty Emission Standards History



DOT FUNDING AND FINANCING PROGRAMS WITH EV ELIGIBILITIES*

LEGEND

Construction and installation of EV charging infrastructure including parking facilities and utilities.	Workforce development and training related to EV infrastructure.	EV acquisitions and engine conversions - cars or trucks.	Planning for EV charging infrastructure and related projects.	Construction and installation of EV charging infrastructure to support operational, resiliency, national energy security, environmental, and community goals for freight transportation.	Installation of EV charging infrastructure as part of transit capital projects eligible under chapter 53 of title 49, United States Code.

	FY 2022 ¹ AMOUNT						
FORMULA PROGRAMS							
National Highway Performance Program (NHPP)	\$28.4 B ²						
Surface Transportation Block Grant Program (STBG)	\$12.5 B ^{2,3}						
Congestion Mitigation & Air Quality Improvement Program (CMAQ)	\$2.5 B ²						
National Highway Freight Program (NHFP)	\$1.4 B ²						
State Planning and Research (SPR)	\$983.3 M ⁴						
Metropolitan Planning (PL)	\$438.1 M ²						
Carbon Reduction Program	\$1.2 B ^{2,5}						
National Electric Vehicle (NEVI) Formula Program	\$685 M ^{2,5,6}						

Funding Opportunities



DISCRETIONARY PROGRAMS							
Rebuilding American Infrastructure with Sustainability and Equity (RAISE) (formerly known as BUILD)	\$1.5 B						
Infrastructure for Rebuilding America (INFRA) Grant Program	\$1.64 B ^{2,7}						
Advanced Transportation and Technologies and Innovative Mobility Deployment	\$60 M ²						
Discretionary Grant Program for Charging and Fueling Infrastructure	\$300 M ^{2,5}						
Rural Surface Transportation Grant Program	\$300 M ^{2,5}						
Reduction of Truck Emissions at Port Facilities Program	\$80 M ^{2,5,7}						
OTHER ALLOCATED PROGRAMS							
Federal Lands and Tribal Transportation Program (FLTTP)	\$1.3 B ^{2,8}						
Puerto Rico Highway Program (PRHP)	\$173 M ²						
Territorial Highway Program (THP)	\$46 M ²						
INNOVATIVE FINANCE PROGRAMS							
State Infrastructure Banks (SIBs)	Varies						
Transportation Infrastructure Financing and Innovation Act (TIFIA)	\$250 M ²						

ZERO-EMISSION BUSES

ALEXANDRIA TRANSIT COMPANY

DASH



ECO-CITY ALEXANDRIA

CHARGING TOWARD
SUSTAINABLE TRANSPORTATION



3000 Series - Electric

Proterra E2 Catalyst

The all-new, 3000 Series electric Proterra E2 Catalyst bus arrived in the Circulator fleet in May 2018. They were manufactured in the United States and run on 100 percent battery electric propulsion. The vehicles bring clean, quiet, zero-emission transportation to more than 4.8 million annual riders and the Circulator's approximate 200 drivers.



Benefits of 3000 series – Electric

100% battery electric propulsion

Zero emissions

Displaces 88.9K gallons of diesel annually

Eliminates more than 244K lbs of CO2 emissions annually

Provides cost savings of more than \$6 million during a 12-year lifetime

Reduces noise pollution throughout the District



HAMPTON ROADS TRANSIT



HRT Goes Electric

Hydrogen in Vehicles



- Used in fuel cell electric vehicles (FCEVs)
- High energy content by weight
- Stored onboard vehicles in high-pressure tanks
- Challenges are cost-efficiently extracting hydrogen for use as a fuel and developing infrastructure for distribution

Case Study: SunLine Transit

- Ultra-low- and zero-emissions vehicle requirement
- Demonstrating fuel cell electric bus technology
- Produces hydrogen onsite

“We look at hydrogen because it has zero emissions, as well as battery electric, and renewable natural gas paired with low-NOx engines. These technologies continue to drive advancement .”

– Tommy Edwards, Chief Performance Officer at SunLine



Just the numbers

- **Number of buses:** 123 CNG, 16 hydrogen, and 4 battery electric
- **FCEV maintenance cost:** \$0.46/mile
- **FCEV fuel economy:** 6.46 diesel gallons equivalent



Light-Duty

- Light-duty trucks in private and government fleets



Medium-Duty

- Vans and shuttles
- Airports and taxi fleets



Heavy-Duty

- Refuse haulers
- Transit buses
- School buses
- Long-haul trucks
- Street sweepers
- Snowplows
- Short-haul delivery trucks

Basics: What is Natural Gas?

Mixture of Hydrocarbons,
Predominantly Methane (CH₄)

Conventional natural gas

- Extracted from domestic gas and oil wells
- Uses existing pipeline distribution system

Renewable natural gas

- Produced from decomposing organic matter, including sewage, animal byproducts, and agricultural, industrial, and municipal solid waste
 - Fully interchangeable with conventional natural gas
 - Low or -400 Carbon intensity Low Carbon Fuel Standard
-
- .02 Grams Nox per Bhpr





Light-Duty

- Passenger cars and light-duty trucks in private and government fleets
- Personal vehicles



Medium-Duty

- Vans and shuttles
- Airports and taxi fleets
- Cargo trucks



Heavy-Duty

- School buses
- Transit buses
- Snowplows
- Short-haul delivery trucks

Basics: What is Propane?

Three-carbon alkane gas: C_3H_8

**Liquefied petroleum gas (LPG)
or autogas**

- By-product of natural gas processing and crude oil refining
- Gaseous fuel that is compressed to a liquid

Renewable propane

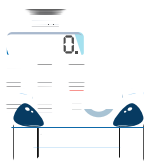
- Produced domestically from biomass-based feedstocks
- 25 carbon intensity low carbon fuel standard



Other Considerations:

Cost and Planning Calculators

afdc.energy.gov/tools



Vehicle Cost Calculator

Compare cost of ownerships and emissions for most vehicle models.



AFLEET Tool

Calculate a fleet's petroleum use, cost of ownership, and emissions.



Laws and Incentives Search

Search for laws and incentives related to alternative fuels and advanced vehicles.

Vehicles: Where to Find Available Models?

Alternative Fuels Data Center

Search the AFDC [SEARCH](#)

[FUELS & VEHICLES](#) [CONSERVE FUEL](#) [LOCATE STATIONS](#) [LAWS & INCENTIVES](#) [Maps & Data](#) [Case Studies](#) [Publications](#) **[Tools](#)** [About](#) [Home](#)

[EERE](#) » [AFDC](#) » [Tools](#) » [Vehicle Search](#) [Printable Version](#)

Alternative Fuel and Advanced Vehicle Search

Find and compare alternative fuel vehicles (AFVs), engines, and hybrid/conversion systems. Some of the light-duty AFVs may count toward vehicle-acquisition requirements for [federal fleets](#) and [state and alternative fuel provider fleets](#) regulated by the Energy Policy Act (EPAAct).

Download a complete list:
[Light-Duty Vehicles](#)
[All Vehicles](#)

Vehicles by Type

 Sedan/Wagon	 Pickup	 SUV	 Van
 Step Van	 Vocational/Cab Chassis	 Street Sweeper	 Refuse
 Tractor	 Passenger Van/Shuttle Bus	 Transit Bus	 School Bus

Vehicles by Manufacturer

Light-Duty
 [SEARCH](#)

Medium- and Heavy-Duty
 [SEARCH](#)

Engines and Hybrid/Conversion Systems

For medium- and heavy-duty vehicles:

[ENGINE & POWER SOURCES](#) [CONVERSION & HYBRID SYSTEMS](#)

[ABOUT THE DATA](#)

Center for Transportation and the Environment

Zero Emission Bus Transition Planning



June 28, 2022

Center for Transportation and the Environment



WHO WE ARE

501(c)(3) nonprofit engineering and planning firm



OUR MISSION

Improve the health of our climate and communities by bringing people together to develop and commercialize clean, efficient, and sustainable transportation technologies



Education & Outreach

We help organizations of all shapes and sizes stay ahead of the technology curve.



Prototype Development & Demonstration

We support technology providers through technology research, development, and demonstration.



Smart Deployment

We support early adopters by providing the best technical solutions for initial deployments.



Fleet Transition

We help fleet operators implement strategic plans for full electrification.



Key Considerations for Transition Planning

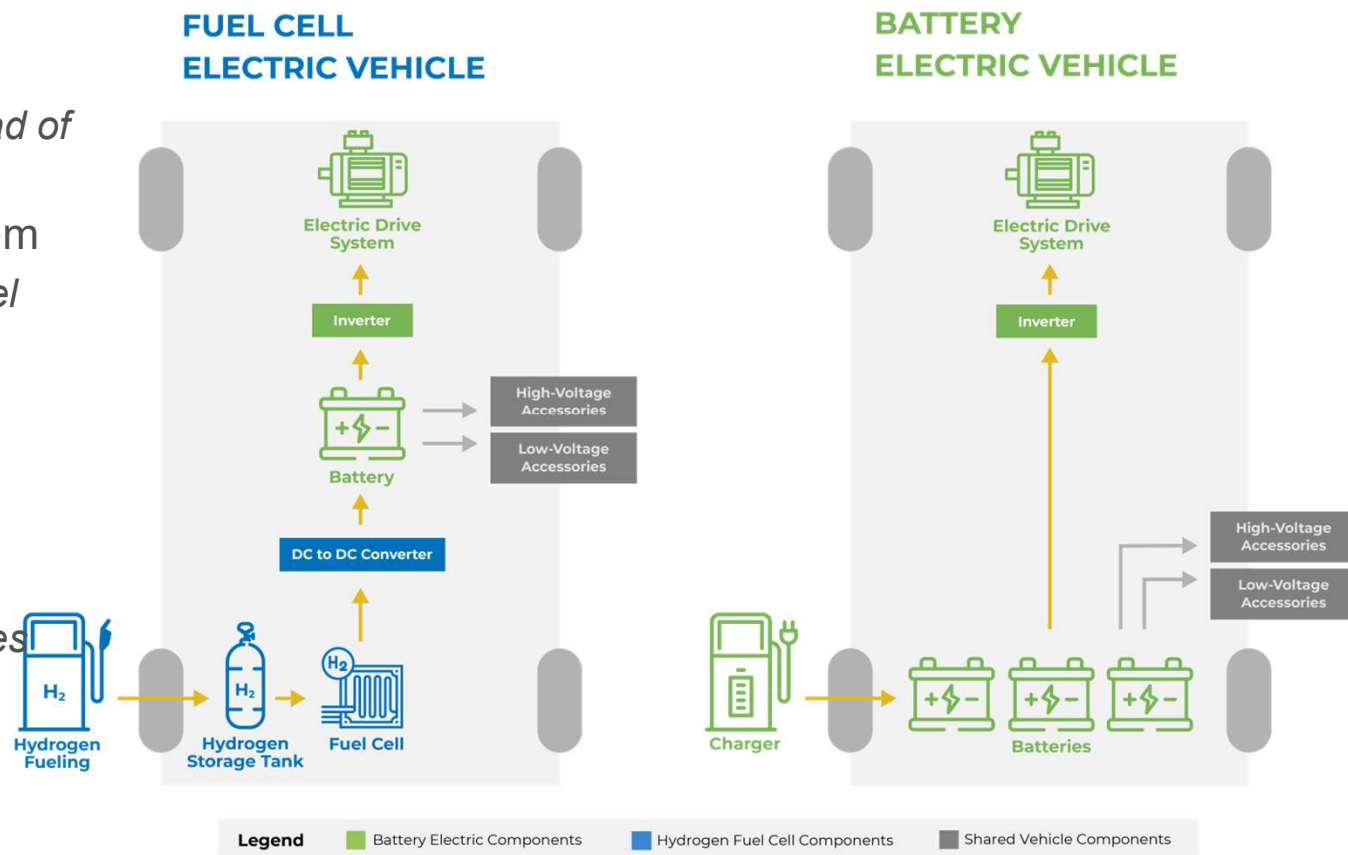
- Fleet Assessment
- Funding Needs Assessment
- Policy Assessment
- Facilities Assessment
- Partnership Assessment
- Workforce Analysis

Objectives for Transition Plan

- Determine feasibility of replacing existing buses with zero emissions buses
- Determine what alternatives would work best for specific transit service
- Understand incremental costs for buses and fueling infrastructure
- Develop a Transition Master Plan

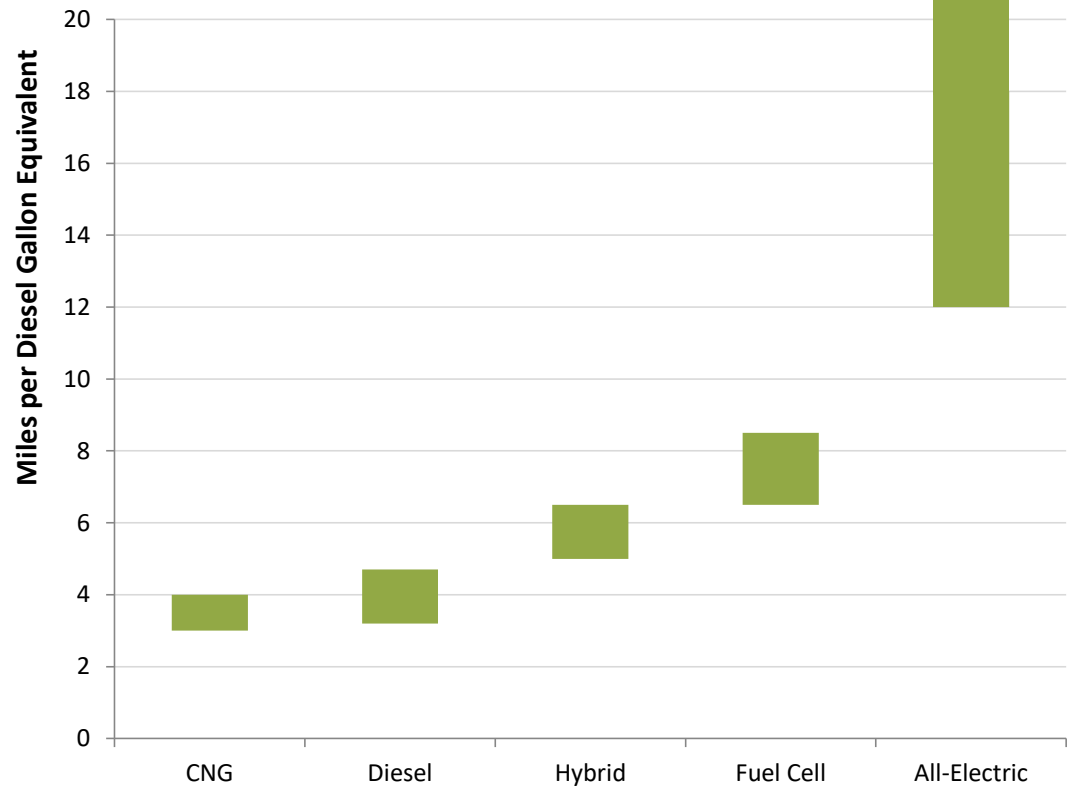
Zero Emission Buses — What's Different?

- Propulsion System
 - Traction Motor instead of engine
- Energy Storage System
 - Battery instead of fuel tank
- HVAC
 - No “free” heat
 - Electric heater
- Time to “Re-fuel”
 - FCEB: 10 minutes
 - BEB: ~3 hours



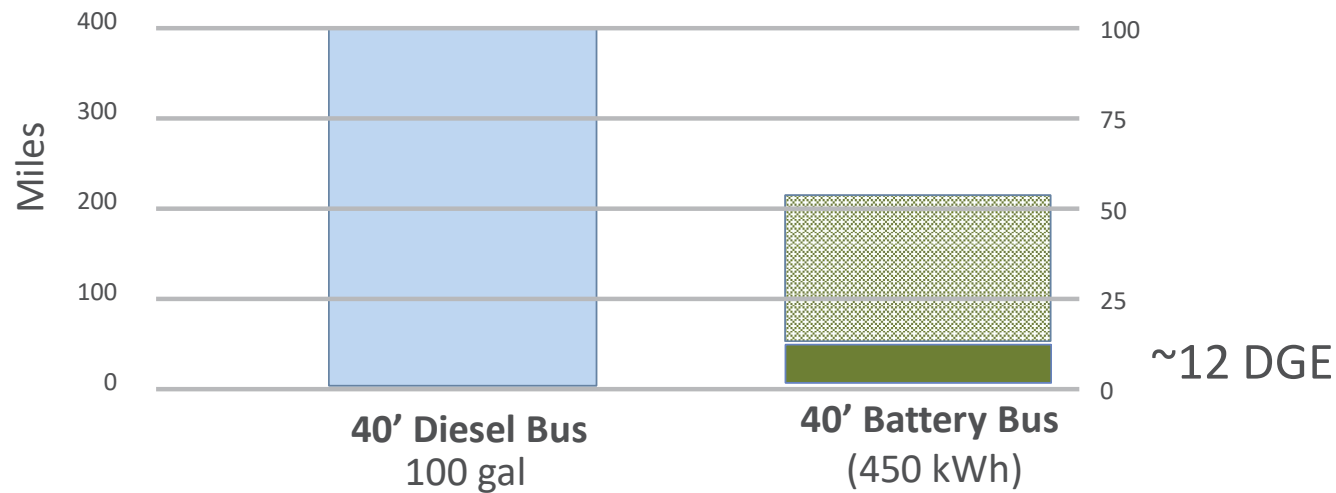
Efficiency Comparison

- Battery-electric buses are ~4x more efficient than diesel
- BEB efficiency (and range) changes with local conditions and driving habits more than diesel and CNG buses.



BEB vs Diesel Range

Different methods of storing energy require different deployment plans.



**Electric drive is
four times as
efficient as a
diesel engine!!!**

U.S. Department of Energy: 38 kWh is equivalent to 1 gallon of diesel

Source: Center for Transportation & the Environment



Factors Affecting ZEB Range



- Route characteristics: speed, stops, grade



- Ridership



- Climate: Heating and cooling

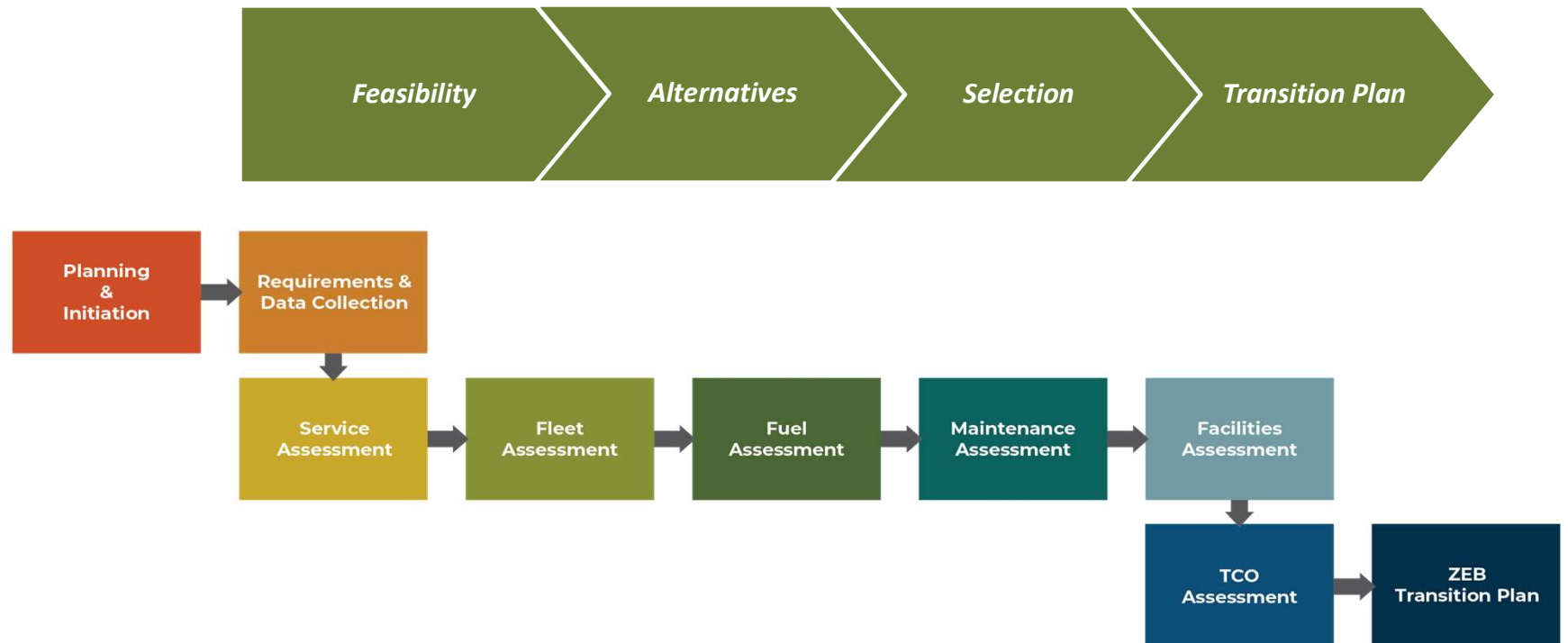


- Battery degradation

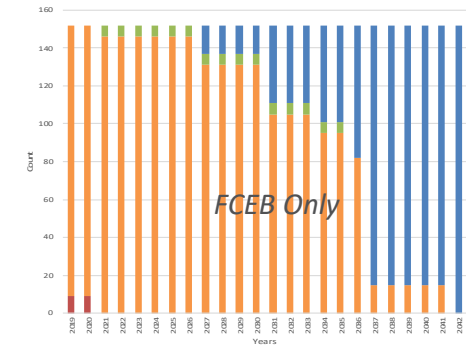
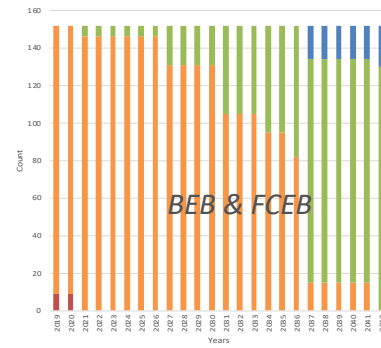
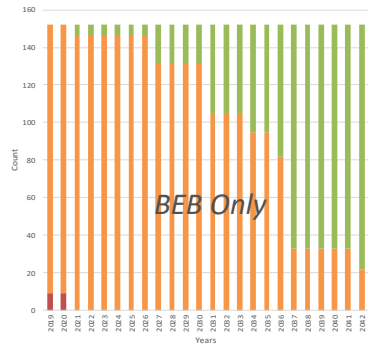


- Operator

ZEB Transition Approach and Methodology



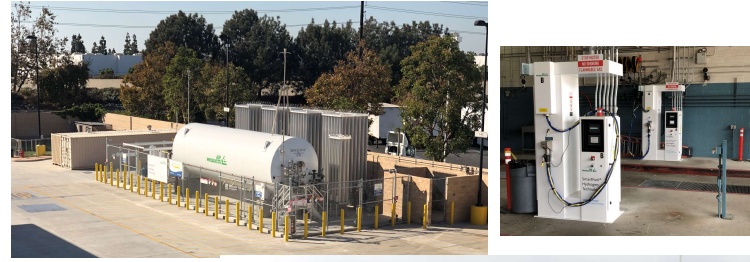
Fleet/Infrastructure Alternatives



Depot



Hydrogen Fueling Station

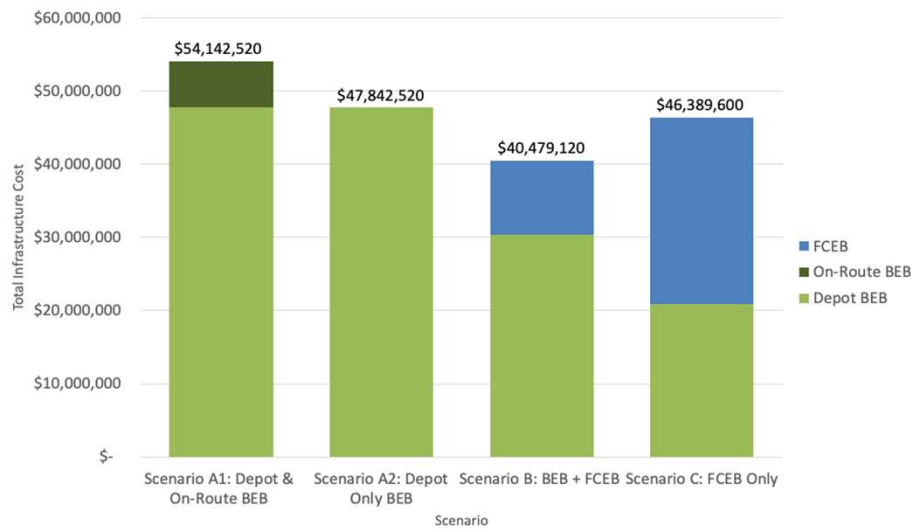
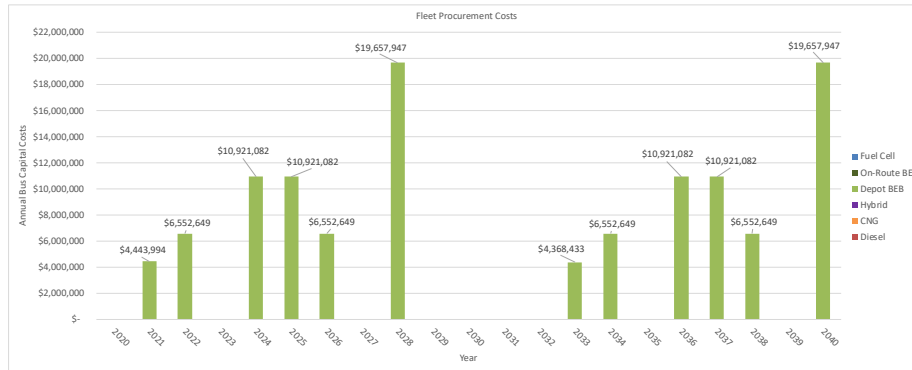


On Route



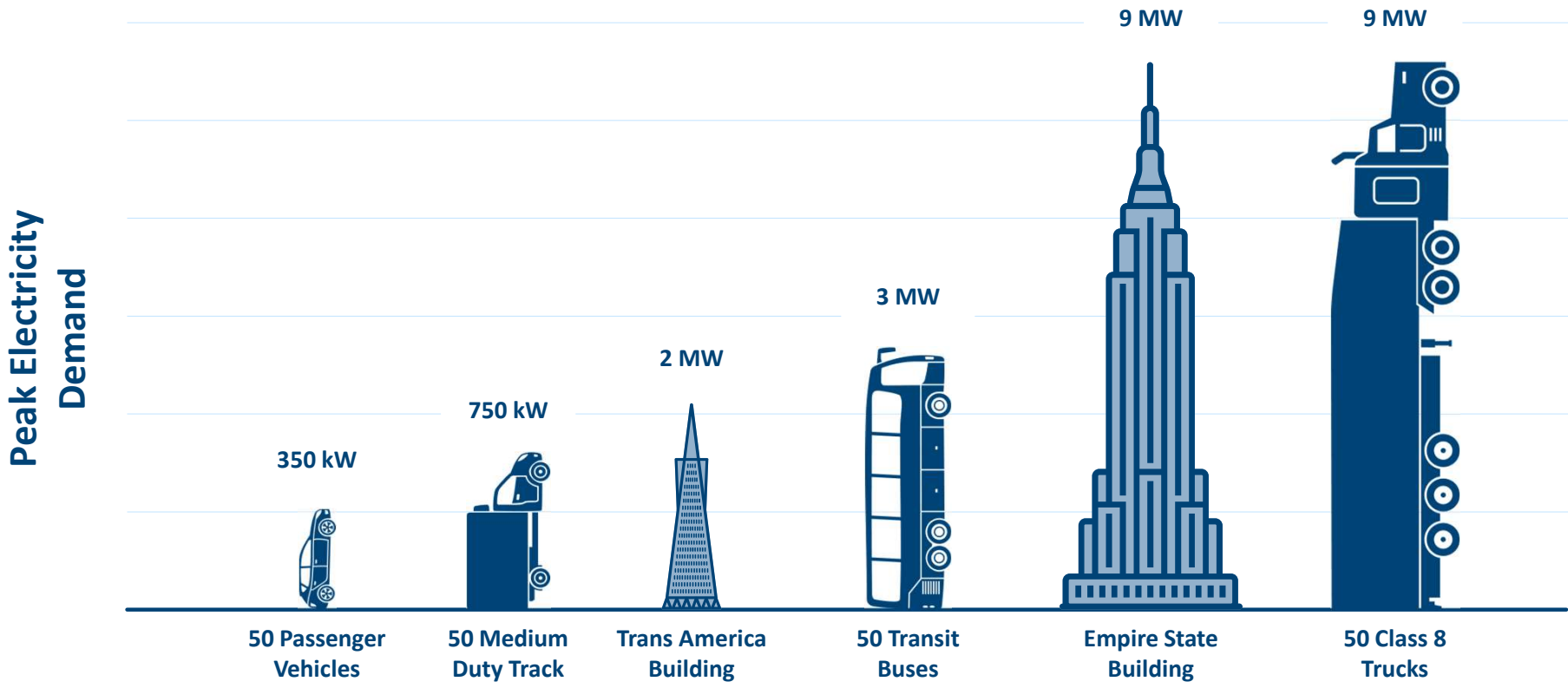
June 28, 2022

Bus and Infrastructure Incremental Costs



June 28, 2022

Fleet Electrification Peak Demand Ranges





BEBs at Blacksburg Transit



Lessons Learned

Tim Witten – ITS/Special Projects Manager



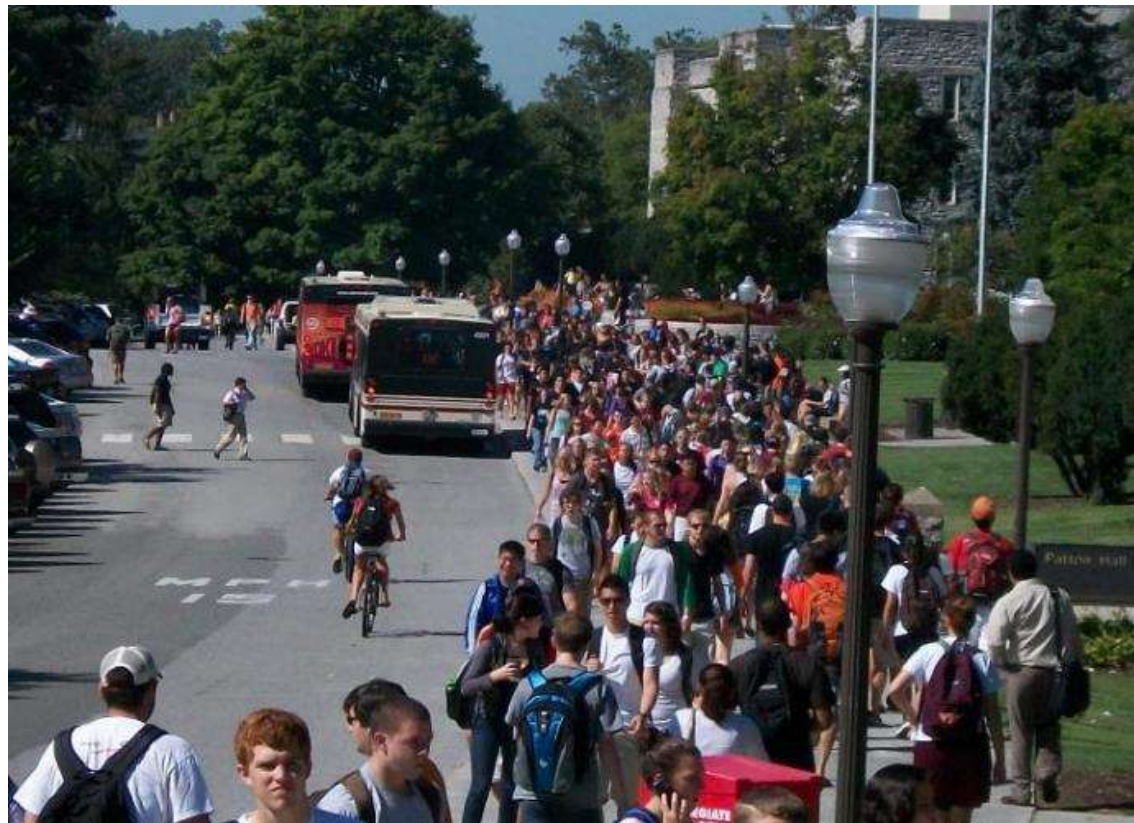
Agenda

- Blacksburg Transit
- Pathway to BEBs
- Lessons Learned
 - Vocabulary
 - Operations





Blacksburg Transit





Blacksburg Transit - 1983

- 8 buses
- 3 routes
- 95,000 passenger trips
- Operated out of a trailer
- 32 staff





Blacksburg Transit - 2022



- 53 buses
- 16 routes in Blacksburg, 2 in Christiansburg
- 4,659,053 passenger trips (FY2019)
- Operates out of a 95,000 SF facility.
- 165 staff



Pathway to BEBs

- 2009 Alternative Fuels Study
 - Bio-Diesel
 - CNG
 - LPG
 - Hybrid Buses
- ARRA funding
 - 14 – 2010 New Flyer Hybrid Electric Diesel Buses
 - 2 – 60ft buses
 - 12 – 40ft buses





Pathway to BEBs

- VW Environmental Mitigation Trust (FY2019 grant)
 - 5 - 2020 New Flyer Battery Electric Buses (BEBs)
 - 3 - 35ft buses
 - 2 - 60ft buses
 - Charging Infrastructure
 - 2 - Depot Chargers
 - 5 - Depot Dispensers
 - Switchgear and Electrical Upgrades





Pathway to BEBs

- FY2021 Low No Grant
 - 5 - New Flyer BEBs
 - 3 – 40ft buses
 - 2 – 60ft buses
 - 1 – Opportunity Charger
 - 2 – Depot Chargers
 - 5 – Dispensers
- FY2021 DRPT/DEQ
 - 12 - BEBs
 - 12 – 40ft buses
 - 2 – Depot Chargers
 - 5 – Dispensers

41% Battery Electric by FY2025



BEB Vocabulary 101



Transformer





Duct Bank





Switchgear





Depot Charging

Charger



Dispenser





Opportunity Charging

Pantograph

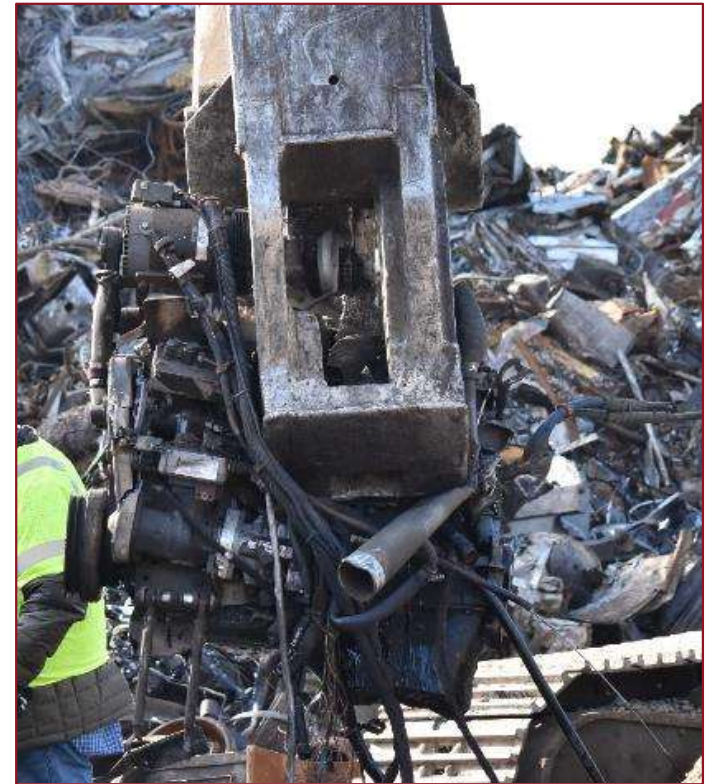


Inductive





Scrappage





BEB Operations 101



Electricity Rates

- Tariff
- Off Peak vs On Peak
- Demand Charges
- NTD
- EIA (www.eia.gov)

Current APCO Charges		
Tariff 347 - Public Authority 12/21/21		
Service Delivery Identifier: 00007330261512203		
On-Peak Generation (4080 kWh Used)	\$	257.18
Off-Peak Generation (7680 kWh Used)		103.25
Transmission Services		242.23
Distribution Services		793.84
PIPP-Universal Service Fee		.48
Public Authority Surcredit		-49.98
Electricity Supply Service		
Fuel Factor @ 0.0230000 Per kWh		270.48
Current Balance Due	\$	1,617.48
Total Balance Due	\$	1,617.48
Pay \$1,641.74 after 01/11/2022		



Factors Affecting BEB Range

- Ambient Temperature
- Route Design
- Load Profile
- Topography
- Route Timing
- Operator Training
- Battery Type/Age/Size
- Opportunity Charging





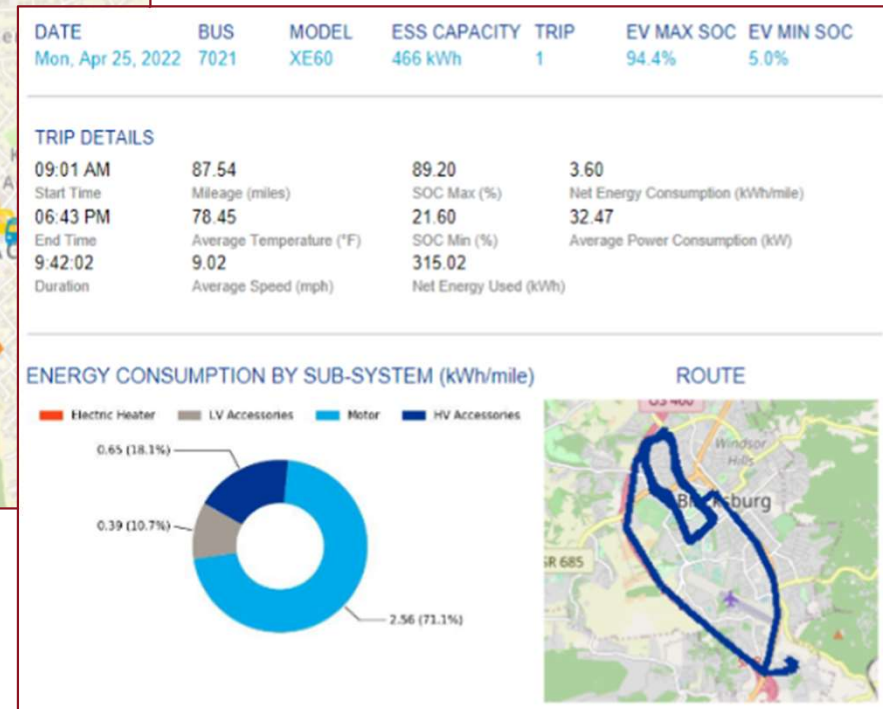
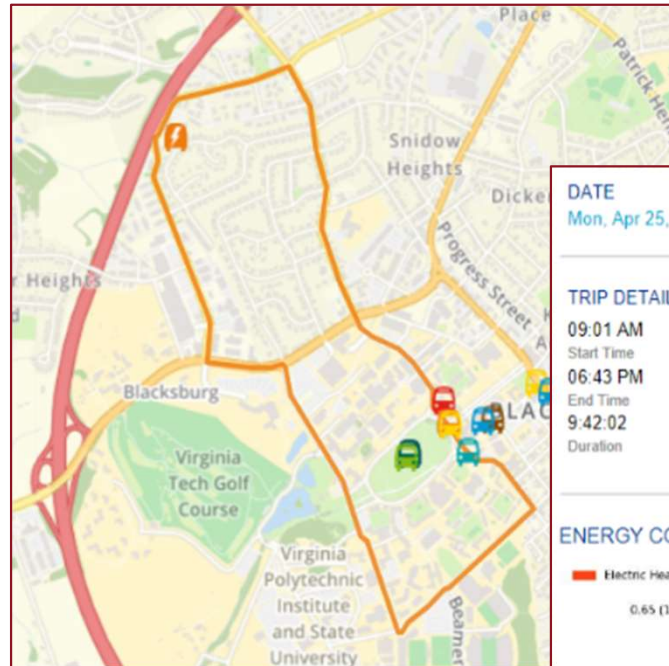
Ambient Temperature





Regenerative Braking

- Route Design
- Load Profile
- Topography
- Route Timing
- Operator Training





Battery Specifications

- Type
- Size
- Age





Contact Info

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Blacksburg, VA 24060

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540.443.1571

Resources: https://drive.google.com/drive/folders/1gIRDVoSHv5vKUijs2wWJa_010vjdNRwz?usp=sharing



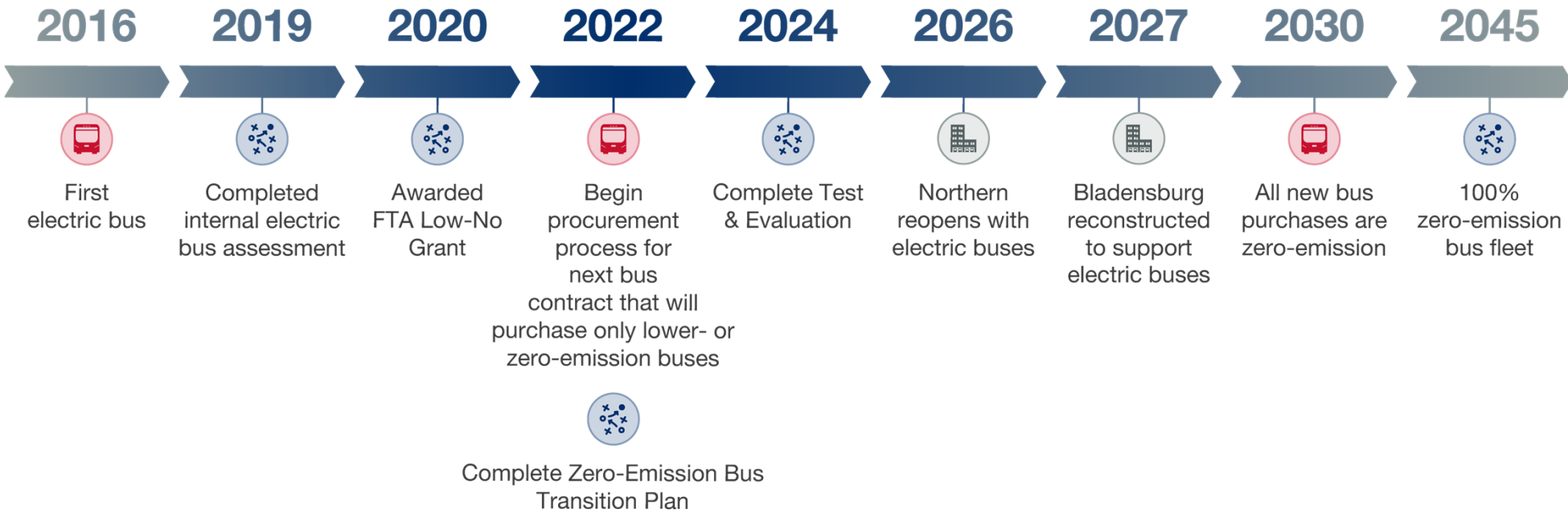
Transition to the Zero-Emission Bus

Virginia Transit Association
2022 Conference

Maya Alunkal
Washington Metropolitan Area Transit Authority
June 2, 2022



Driving toward a 100% Zero-Emission Bus Fleet



 Bus
  Facilities
  Strategy



Key Components of a Zero-Emission Bus Transition Plan

1

Route Modeling



2

Facility Assessment



3

Equity



4

Resiliency



5

Business and
Workforce Planning

