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Agenda

- Introductions
- Disruptive Technologies
- Industry Drivers
- Battery Technologies
- Charger Technologies
- Vehicles
- Additional Resources

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Introductions

John Havrilla, PE

Michael Leydecker, PE

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A Sign of the Times

[Image and Content Source: Tony Seba, Clean Disruption of Energy and Transportation]

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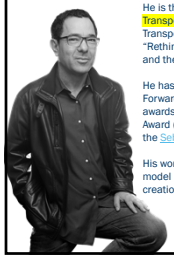
Tony Seba is a world-renowned thought leader, author, speaker, educator, angel investor and Silicon Valley entrepreneur.



He is the author of the #1 Amazon best-selling book "Clean Disruption of Energy and Transportation", "Solar Trillions" and "Winners Take All", and co-author of "Rethinking Transportation 2020-2030", "Rethinking Food and Agriculture 2020-2030" and "Rethinking Humanity: Five Foundational Sector Disruptions, the Lifecycle of Civilizations, and the Coming Age of Freedom".

He has been featured in several movies and documentaries including Bloomberg's Forward Thinking: A Sustainable World, 2040, and SunGanges. He is recipient of many awards including the Savvy Award (2019), Solar Future Today's Visionary Influencer Award (2018), and Clean Energy Action's 2017 Sunshine Award. He is the creator of the Seba Technology Disruption Framework™ (download PDF).

His work focuses on technology disruption, the convergence of technologies, business model innovation, organizational capabilities and product innovation that leads to the creation of new industries and societies and the collapse of existing ones.

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Industry Drivers

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NEW YORK'S CLIMATE LEADERSHIP and COMMUNITY PROTECTION ACT

NEW YORK STATE

New York's landmark new law, the Climate Leadership and Community Protection Act (Climate Act), is demonstrating to the nation how to confront the greatest threat facing life as we know it — a rapidly changing climate. Signed by Governor Andrew M. Cuomo in July 2019, this law will empower every New Yorker to fight climate change and provide the opportunity to improve all our daily lives.

This is our planet. This is our time to fight for it.

By 2040: achieve 100% zero-emission electricity | By 2050: reduce emissions at least 85% below 1990 levels

Achieving the ambitious goals of this law will mean transforming the way we generate and use electricity, the way we heat our homes, and the way we get to school and work. New Yorkers will tackle climate change and create new opportunities for our children and grandchildren. Through thoughtful planning, this effort will breathe life into our economy with well-paying clean energy jobs, new industries and business opportunities, and improved health and quality of life for New York families and communities. New York's course on climate action also means spending less on fossil fuels and keeping our energy dollars in the local economy, and in the pockets of hardworking New Yorkers.

As we experience record temperatures and extreme storms, the Climate Act compels us to take action. New York will undertake a sweeping set of measures to reduce our carbon footprint, make our communities more resilient, and adapt to a changing climate. The State's new climate law sets the stage for this and creates the opportunity for citizens and communities to partner with businesses, schools, and government to create a green economy and build a climate-proof future.

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Recommended Additional Actions

Electrify Everything that Moves

- Adopt ZEV (Zero Emission Vehicle) for medium and heavy duty vehicles and carve out explicit targets for trucks and bus conversion that prioritize diesel emission reduction in air pollution overburdened communities
- Mandate rapid phase in of the conversion of the state's fleet to ZEVs
- Rapidly expand policies to encourage uptake of EV's – like incentives and enhancement/expansion of charging infrastructure

NYS Climate Action Council June 28, 2021 Meeting

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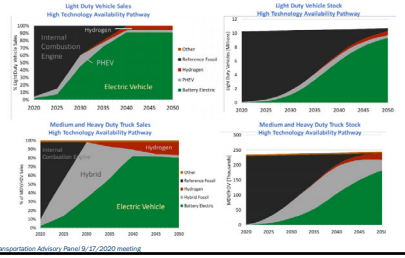
Timing of Vehicle Electrification



Transportation Advisory Panel 9/17/2020 meeting

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Governor Cuomo Announces Initiatives to Electrify Transit Buses, Boosting Access to Clean Transportation and Building Healthier Communities

Governor Andrew M. Cuomo today announced a series of initiatives to increase the number of electric buses in New York as part of the State's efforts to mitigate climate change, create healthier communities, improve air quality, and boost access to clean transportation in underserved communities. Specifically, this effort includes $16.4 million in incentives for the expansion of electric bus usage amongst public transportation authorities, as well as $2.5 million for school bus operators to acquire cleaner forms of transportation with lower emissions. These measures will help take polluting vehicles out of service across the state to reduce greenhouse gas emissions and improve air quality in support of Governor Cuomo's nation-leading clean energy and climate goals in the Climate Leadership and Community Protection Act.

"Electrifying transit and school buses at scale is an important step in our fight against climate change and is essential in helping us reach our ambitious goals to create a greener New York State," Governor Cuomo said. "Through these initiatives, bus operators will now have the support and resources they need to modernize their fleets, reduce emissions and ensure underserved communities have cleaner public transit options as we work to further reduce our carbon footprint."

New York's Nation-Leading Climate Targets

- 85% Reduction in GHG Emissions by 2050
- 100% Zero-emission Electricity by 2040
- 70% Renewable Energy by 2030
- 9,000 MW of Offshore Wind by 2035
- 3,000 MW of Energy Storage by 2030
- 6,000 MW of Solar by 2025
- 22 Million Tons of Carbon Reduction through Energy Efficiency and Electrification

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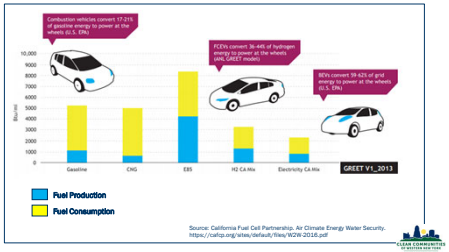
Overall Efficiency



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Overall Efficiency

Source: NREL Report – Foothill Transit Study

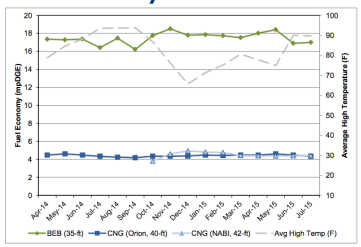

Figure 13. Monthly average fuel economy for the BEBs and CNG buses (evaluation period)

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Assessment of Learning Question #1

What are the major drivers to vehicle electrification?

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Battery Technology

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BEB Overview: Battery Fundamentals

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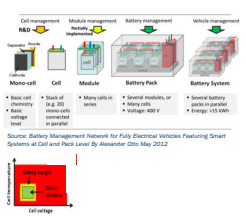

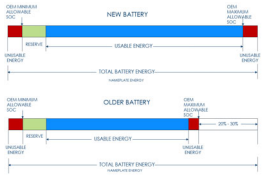

Source: Battery Management Network for Fully Electrical Vehicles Featuring Smart Systems at Cell and Pack Level By Alexander Otto May 2012

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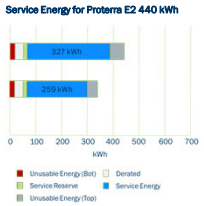
Proterra 440 kWh Example

KNOW WHAT YOU ARE GETTING.



Nominal Range			
CAPACITY	EFFICIENCY	MPGe	RANGE
327 kWh [New]	2.2 kWh/Mile	15.3 MPGe	149 miles
259 kWh [Old]	2.2 kWh/Mile	15.3 MPGe	118 miles
327 kWh [New]	1.7 kWh/Mile	19.8 MPGe	192 miles
259 kWh [Old]	1.7 kWh/Mile	19.8 MPGe	152 Miles

2.2 kWh/Mile (15.3 MPGe) - efficiency through modeling of performance on routes in the state of Connecticut.

1.7 kWh/Mile (19.8 MPGe) - efficiency from Altoona testing on a test track in Altoona PA by the FTA. No heat or A/C, flat track, no passengers.

Traditional diesel bus mileage 4.0 - 5.0 MPG

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Battery Considerations

- Most BEB batteries are Lithium-Ion Batteries
- Bigger isn't always better
  - The larger the battery the longer the range of the vehicle
  - The larger the battery the heavier the vehicle, the heavier the vehicle the smaller the load
- On route Charging vs Depot Charging
  - Smaller battery – on route charging
  - Larger battery – depot charging

Catalyst E2 440 kWh	Curb	Seated	Seated & Standing
Overall	31,360	37,230	43,530
Front	14,000	15,860	17,950
Rear	17,360	21,370	25,580
Driver		1	1
Seated		38	38
Standing			40
Total		39	79

Intermodal Surface Transportation Efficiency Act (ISTEA)
Year Enacted: 1992 End Date:1994 In 2012 extended indefinitely
Transit buses temporarily exempted from 20,000 pounds single axle weight limit on Interstate Highways. States are not allowed to enforce a single axle weight limit of less than 24,000 pounds

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Vehicles: Batteries

- Energy storage systems, such as batteries, are essential for electric drive vehicles
- All original equipment manufacturer (OEM) PHEVs and EVs made today use **lithium-ion** batteries; other battery options include:
  - **Nickel-metal hydride (HEVs)**
  - **Lead-acid**
  - **Lithium-polymer**
  - **Ultracapacitors**
- Battery recycling is an option, but the market is currently small
- Battery swapping is becoming available for long-distance trips

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ALTERNATIVE POWER | BATTERY ELECTRIC

'Game changing' Toyota solid-state battery lighter, much more powerful than current lithium-ion

Tom Quimby, CCJ senior editor
Jan 11, 2021 | Updated Jan 21, 2021

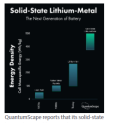
Toyota confirmed this week that it's developing a solid-state battery to be used in vehicle electrification. Compared to conventional lithium-ion, solid-state lithium-metal batteries are much lighter, more powerful, take up less space, charge faster, last longer and present much lower risks for flammability.

While Toyota, the parent company of truck manufacturer Hino, won't reveal much on the matter, they did offer the following statement:

Next-generation batteries, such as solid state and metal-air batteries, are safer and demonstrate higher performance than lithium-ion batteries. We are currently working on the research and development, including the production technology of solid-state batteries, and we have achieved ultra-small BEV driving. We are accelerating development aiming for commercialization by the first half of the 2020s.

Commercial Carrier Journal January 2021

Toyota joins Volkswagen-backed QuantumScape in making recent and noteworthy news on solid-state battery development. QuantumScape, a California based startup, reported in December that its solid-state design offers 80% more range than current lithium-ion cells, a 15-minute charge time and has a longer lifespan. The batteries also weigh less (they're virtually anode-free), offer nearly double the energy density of conventional lithium-ion, take up less space and feature a solid, non-combustible separator.



QuantumScape reports that its solid-state battery has roughly twice the energy density of conventional lithium-ion.
Source: QuantumScape

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Assessment of Learning Question #2

What maintains a battery in a safe operating range?

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Charger Considerations

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Small vs. Large Battery Electric Vehicles

BEV OVERVIEW

Understanding Size

Proterra Electric Transit Bus

Tesla Model S

Large Vehicles/Fleets
220 kWh – 660 kWh

What
- DC Fast Chargers (Level 2 or Level 3)
- Fast or slow

Who
- Transit agencies (BEV's)
- Class 8 EV's
- Large fleets

Where
- Garages/Depot/Storage areas
- On-route charging

Small Vehicles
42 kWh – 75 kWh

What
- Level 1 (on board) or Level 2 (off board) Chargers
- AC or DC
- Rapid, Fast or Slow

Who
- Individual cars
- Small vehicle fleets

Where
- Public parking areas/Municipal lots
- Rest areas/Office parks

Vehicle to Grid Technology: How and where does this apply?

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Pantograph Charging Options

Automatic

Inverted Pantograph

Drop down Pantograph
Utilized heavily for on-route charging in the US.

Automatic

Roof-Mounted Pantograph

Bus Mounted Pantograph
Utilized heavily for on-route charging in the Europe.
First Pantograph Indoor charging System In Europe.

Advantages
- Able to deliver high-capacity charge
- Able to provide on-route charging
- On-route applications may reduce battery size requirements

Disadvantages
- High maintenance – particularly in winter climates, icing, alignment issues, etc.
- Added cost to the bus (roof mounted)
- If deployed on-route will require:
  - Additional infrastructure in constrained areas (Switchgear, transformers, pantograph structure)
  - On-route would be all on-peak charging, potentially significantly increasing charging costs.
- If deployed in Bus facility will increase structural and height requirements with associated costs.

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Inductive Charging Options

Advantages
- Able to deliver high-capacity charge
- Able to provide on-route charging
- On-route applications may reduce battery size requirements
- No moving parts, less maintenance
- Little impact to bus storage processes
- Little impacts to system from weather

Disadvantages
- Added cost to the bus (receptors mounted under bus)
- If deployed on-route will require:
  - Additional infrastructure in constrained areas (switchgear, transformers)
  - On-route would be all on-peak charging, potentially significantly increasing charging costs.
  - If deployed in bus facility will require trenching for embedded equipment.

Deployed in Europe and the US. Multiple manufacturers.

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Plug In Charging Options

Advantages
- Simple, low-cost option for bus charging
- Low maintenance
- Can be used for either high capacity or slow charging
- Can be used on-route but is mostly used in depot charging
- Chargers are typically the same as for other delivery options

Disadvantages
- Is manually operated
- Placement in tight bus garages becomes challenging – may require reels mounted in the ceiling, adding to capital cost (reels and structure costs) and maintenance
- Pullouts can damage equipment
- Drop down reel options are currently limited with cord length limitations

Deployed in Europe and the US. Multiple manufacturers.

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Infrastructure: Connectors and Plugs

	Charging Standard
Level 1	SAE J1772 NEMA 5-15 NEMA 5-20
Level 2	SAE J1772
DC Fast	CHAdeMO SAE J1772 Combo Tesla Supercharger
Wireless	SAE J2954 *(pending)*

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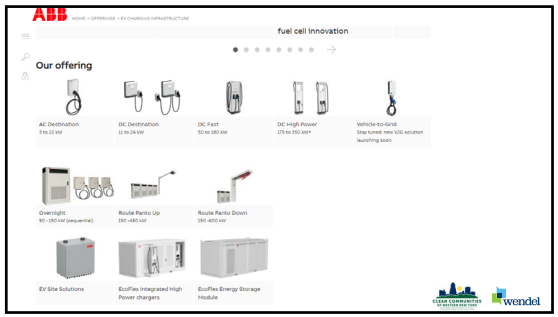

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Depot Charging Options

PROTERRA

PRODUCT	PROTERRA POWER CONTROL SYSTEM 85KW	PROTERRA POWER CONTROL SYSTEM 125KW	PROTERRA POWER CONTROL SYSTEM 500KW
MAX POWER LEVEL AVAILABLE (kW)	60	125	500
PCS LOCATION	DEPOT	DEPOT	DEPOT / OVROUTE
DISPENSER TYPE	PLUG IN / OVERHEAD	PLUG IN / OVERHEAD	OVERHEAD
CONNECTION STANDARD	J1772 CCS PLUG IN J3105 INVERTED PANTOGRAPH J3105 BUS-UP PANTOGRAPH	J1772 CCS PLUG IN J3105 INVERTED PANTOGRAPH J3105 BUS-UP PANTOGRAPH	J3105 INVERTED PANTOGRAPH J3105 BUS-UP PANTOGRAPH
VEHICLES	CHARGING TIME OR MILEAGE PER CHARGE*		
FC	1.1 HOURS	0.6 HOURS	19 MILES PER 10 MINUTES
FC+	1.5 HOURS	0.7 HOURS	30 MILES PER 10 MINUTES
XR	2.9 HOURS	2.4 HOURS	9 MILES PER 10 MINUTES
XR+	4.4 HOURS	2.4 HOURS	13 MILES PER 10 MINUTES
E2	5.8 HOURS	2.8 HOURS	17 MILES PER 10 MINUTES
E2+	7.3 HOURS	3.1 HOURS	20 MILES PER 10 MINUTES
E2 MAX	6.8 HOURS	4.2 HOURS	24 MILES PER 10 MINUTES

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CPE 250

62.5 kW or 125 kW
Shared between 2 – CPE 250's

chargepoint

Available late spring 2020

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Vehicle-to-Grid Technology

How V2G Works

Not all cars can accept V2G
Nissan Leaf and Nissan e-NV200

1 PLUG IN YOUR CAR to any charger

2 CHARGE BATTERY safely and efficiently in V2G Mode

3 MAKE MONEY by providing power capacity and sending energy back and forth to regulate the Grid

OR SAVE COSTS by using stored energy from EV batteries to reduce building energy peak consumption

4 YOU'RE READY TO DRIVE with the charge you set for the day with advance trip planning using a mobile fleet management app

wendel

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Assessment of Learning Question #3

What types of vehicles use Level 1 charging?

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Vehicles

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Basics: Electric Drive Vehicles

Hybrid Electric Vehicle (HEV)
- Powered by an engine and electric motor
- Does not use electric vehicle supply equipment (EVSE) to charge the battery

Plug-In Hybrid Electric Vehicle (PHEV)
- Powered by an electric motor and engine
- Uses EVSE to charge the battery

All-Electric Vehicle (EV)
- Powered by an electric motor
- Uses EVSE to charge the battery

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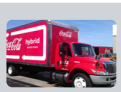
Vehicles: Vehicle Availability



Light-Duty
- HEVs, PHEVs, and EVs widely available
- New models rolling out nationwide

Medium-Duty
- Variety of HEVs, PHEVs, and EVs available
- New models becoming available
- Certified conversions an option

Heavy-Duty
- Several HEV makes and models available
- Light hauling, delivery, and off-road service

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Vehicles: Maintenance and Safety

- **HEVs and PHEVs have similar maintenance requirements** as conventional vehicles
- **EVs typically require less maintenance** than conventional vehicles:
  - Battery, motor require little to no maintenance
  - Fewer fluids to change
  - Brake wear is reduced due to regenerative braking
  - Fewer moving parts
- Electric drive vehicles **must meet the same safety standards** as conventional vehicles

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Assessment of Learning Question #4

True or False: Electric vehicles are more expensive to maintain.

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Additional Resources

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More Information

Wendel Companies
www.wendelcompanies.com

Alternative Fuels Data Center (AFDC)
afdc.energy.gov

Electric Drive Transportation Association (EDTA)
electricdrive.org

Plug In America
pluginamerica.org

FuelEconomy.gov

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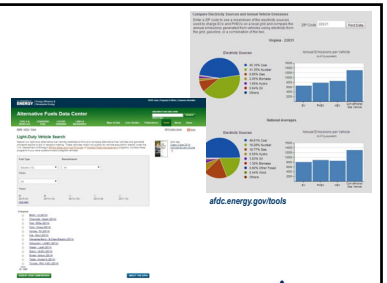
Tools

Vehicle Cost Calculator
Compare cost of ownership and emissions for most vehicle models.

AFLEET Tool
Calculate a fleet's petroleum use, cost of ownership, and air pollutant and GHG emissions.

PEV Readiness Scorecard
Assess your community's readiness for the arrival of plug-in electric vehicles.



afdc.energy.gov/tools

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PEV Handbooks

Helpful Resource:
Clean Cities PEV Handbooks are great resources for fleet managers, station owners, and individuals who are ready to start using PEVs and infrastructure.

afdc.energy.gov/publications

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Questions To Ask

- What federal, state, and local incentives are available?
- What are my driving range needs?
- What type of PEV is best for me?
- How and where will my PEV be charged each day?
- What level of charging will I need?
- Are there charging stations in my area? Are they public or private? Can I visit?
- What support can my local Clean Cities coalition provide?

Helpful Resource:
The ***AFDC Laws and Incentives Search*** provides information about available state and federal incentives for PEVs and EVSE.

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References and Resources

- AFDC Vehicle Cost Calculator (http://www.afdc.energy.gov/calc/)
- AFDC EV Emissions page (http://www.afdc.energy.gov/vehicles/electric_emissions.php)
- AFDC Alternative Fuel and Advanced Vehicle Search (http://www.afdc.energy.gov/vehicles/search)
- AFDC Station Locator Database (http://www.afdc.energy.gov/locator/stations/)
- FuelEconomy.gov's Alternative Fuel Vehicles (AFV) page (http://www.fueleconomy.gov/feg/alternatives.shtml)
- Clean Cities Plug-In Electric Vehicle Handbook for Fleet Managers (http://www.afdc.energy.gov/pdfs/pev_handbook.pdf)
- Clean Cities Plug-In Electric Vehicle Handbook for Workplace Charging Hosts (http://www.afdc.energy.gov/uploads/publication/pev_workplace_charging_hosts.pdf)
- Clean Cities Plug-In Electric Vehicle Handbook for Public Charging Station Hosts (http://www.afdc.energy.gov/pdfs/51227.pdf)
- Clean Cities 2015 Vehicle Buyer's Guide (http://www1.eere.energy.gov/cleancities/publications.html)
- Argonne National Laboratory's (ANL) *Well-to-Wheels Energy Use and Greenhouse Gas Emissions Analysis of Plug-in Hybrid Electric Vehicles* report (http://www.transportation.anl.gov/pdfs/TA/559.pdf)
- Electric Drive Transportation Associations (EDTA) Electric Drive Sales Dashboard (http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952)
- National Fire Protection Association EV Safety Training (http://www.evsafetytraining.org)
- National Alternative Fuels Training Consortium First Responder Safety Training (http://www.naftc.wvu.edu/course_workshop_information/first_responders)
- Plug In America's Vehicle Tracker (http://www.pluginamerica.org/vehicles)
- Tony Seba (https://tonyseba.com/)

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Assessment of Learning Question #5

Where can I go to get more information on BEV's?

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Do you have any questions?

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Assessment of Learning Questions

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Alternative Energy

- Fuel Cells
  - Expensive - $11,441.00/kW
  - Reliability issues
  - Space issues
- Solar Arrays
  - Most cost-effective solution
  - Third party BOOM – no up-front costs to transit agency.
  - Space available if roof can support
- Battery Storage
  - Good for peak shaving/load shifting
  - Space is an issue
  - Third party BOOM available in some states
- Generation
  - Not feasible to back up 100% of the fleet – transit agency will be grid dependent.
  - Space is the biggest constraint.
  - Diesel or natural gas fired units.
  - Third party BOOM available in some areas

Fuel Cell – 1.4 MW fuel cell – Requires the space of a tennis court

NextEra solar plan for Hamden. 2.22 MW

Tesla 20 MW battery storage facility in California. 1.5 acres of land.

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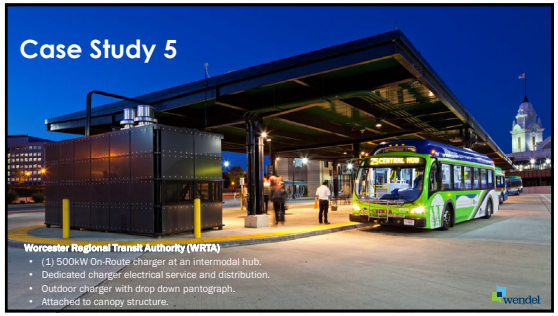

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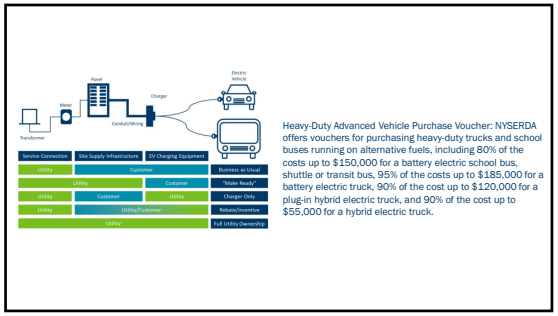

Heavy-Duty Advanced Vehicle Purchase Voucher: NYSERDA offers vouchers for purchasing heavy-duty trucks and school buses running on alternative fuels, including 80% of the costs up to $150,000 for a battery electric school bus, shuttle or transit bus, 95% of the costs up to $185,000 for a battery electric truck, 90% of the cost up to $120,000 for a plug-in hybrid electric truck, and 90% of the cost up to $55,000 for a hybrid electric truck.

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