Better Buildings CHALLENGE
U.S. DEPARTMENT OF ENERGY

K-12 Cohort Call: Transportation Fleet Conversion

October 26, 2017
2-3pm ET
Agenda

- How Does Transportation Fit into the Conversation about Energy Efficient K-12 School Facilities?
  - Crystal McDonald, Moderator, Policy Advisor, Office of Energy Efficiency and Renewable Energy, DOE

- Fuel Cell Buses in the U.S.

- Clean Cities Program: Alternative Fuel School Bus Case Studies
  - Ellen Bourbon, Senior Energy Policy Analyst, Vehicle Technologies Office, Clean Cities Program, AST

- VW Settlement Funds
  - Jonah Steinbuck, Advisor, Office of Energy Efficiency and Renewable Energy, DOE

- Questions & Answers
How Does Transportation Fit into the Conversation about Energy Efficient K-12 School Facilities?

Crystal McDonald, Policy Advisor
Office of Energy Efficiency & Renewable Energy
U.S. Department of Energy
Elements of School District Energy & Environmental Sustainability Plans

- Building energy efficiency
- New construction & design
- Beyond buildings, infrastructure projects
- Healthy learning environments
- Reducing emissions
- Cost savings strategies
Alternative Fuels for School Buses

- Case Studies for School Bus Fleet Conversion
- Clean Cities YouTube Channel
- EPA 2017 School Bus Replacement and Retrofit Rebates
- National Renewable Energy Laboratory – Transportation Research
Fuels Cell Buses in the U.S.

Greg Kleen, Fuel Cell Outreach Team Lead
Fuel Cell Technologies Office
U.S. Department of Energy
Fuel Cell Basics

Takes hydrogen in and puts electricity and water vapor out

Electrical Current to power car

Hydrogen gas

Anode

Membrane (electrolyte)

Cathode

Water vapor and heat

Oxygen from air

H₂O + heat

California

Driving for the future
Why Hydrogen and Fuel Cells?

- **Efficient**
  - Internal combustion engine in a car: 20% - 30%
  - Fuel cell in a car: 60%

- **Uses domestic fuels**
  - Natural gas
  - Renewable sources (wind, solar, biomass, etc.)
  - Nuclear
  - Coal

- **Convenient**
  - Refuels in minutes

- **Quiet**
  - No noise in operation

- **Clean**
  - Zero tailpipe emissions

- **Versatile and easily scalable**
  - Transportation
  - Stationary
Early R&D Focus

**Applied research, development and innovation in emerging hydrogen and fuel cell technologies leading to:**
- Energy security
- Energy resiliency
- Strong domestic economy

Early R&D Areas

**Fuel Cells**
- PGM-free catalysts
- Durable MEAs
- Electrode performance

**Hydrogen**
- Production pathways
- Delivery components
- Advanced materials for storage

PGM = Platinum group metals
MEA = Membrane Electrode Assembly

Early R&D Impact

**60% Lower Fuel Cell Cost**

- $124/kW at high-volume
- $50/kW at low-volume

**Greater Fuel Cell Durability**
- 4X more hours of fuel cell lifetime since 2006

**80% Lower Electrolyzer Cost**
- for H₂ production since 2002
Fuel Cell Cars are Here!

**Fuel Cell Car Sales Growing**

- September 2017: 2,800 fuel cell cars sold or leased in the U.S.

78% of executives absolutely or partly agree that fuel cell cars will be the real breakthrough for electric mobility.

Note: Cumulative number of vehicles sold/leased. Source: hybridcars.com

KPMG, Global Automotive Executive Survey 2017 (Jan. 2017)
Market Growth in Fuel Cell Sales

Fuel Cell Power Shipped (MW) Worldwide

- 2014: 100 MW
- 2015: 300 MW
- 2016: 500 MW

500 MW fuel cell power shipped worldwide
62,000 fuel cell units shipped worldwide
$1.6 Billion fuel cell revenue

Source: DOE and E4Tech
U.S. Electric Bus Coverage and Progress

Source: US Department of Transportation (as of July 2016)

<table>
<thead>
<tr>
<th>Electric /Hybrids: % in Bus Fleet</th>
<th>No. of Electric Buses</th>
<th>Electric Bus Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 1% in 2007 to 18% in 2014</td>
<td>5X increase from 2007 to 2014</td>
<td>20% reduction from 2010 to 2015</td>
</tr>
</tbody>
</table>

Source: US Department of Transportation (as of July 2015)
Fuel Cell Buses Enabling Markets

**Early Markets enable:**
- Fuel cell *cost reduction*
- Robust *supply base*
- Emerging *infrastructure*
- Customer *acceptance*

**FCEV Cost Reduction Enablers**
- Space Applications
- Specialty Vehicles
- Backup Power Systems
- Primary Power
- Portable Power
- APUs for Transportation
- Buses and Fleets

**Market Penetration**

**Early Markets Applications Recently Deployed in the U.S.**
- Fuel Cell Tow Trucks
- Fuel Cell Bus Fleets
- Forklifts
- Backup Power
Fuel Cell Buses are Here!

California
- **Current**: 19 Buses
  - Oakland (13), Thousand Palms (4), Orange County (1), Irvine (1).
- **Planned**: More than 30 Buses
  - Oakland (1), Thousand Palms (12), Oakland and Santa Ana (20).

Michigan
- **Current**: 2 Buses
  - Flint

Massachusetts
- **Current**: 1 Bus
  - Boston

Ohio
- **Current**: 2 Buses
  - Columbus, Canton
- **Planned**: 8 Buses
  - Canton

Hawaii
- **Planned**: 2 Buses
  - Hilo

Source: 2016 NREL Bus Report, updates underway
**AC TRANSIT FLEET**

**Largest in North America**

**AC Transit Fuel Cell Electric Bus**

FTA Funding and Collaboration with DOE- NREL Data collection

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**RECORDS**

**Record Durability:**
Approximately 25,000 hours

**Driven for approximately 1.8M miles**

**More than 17 million passengers**

*As of June 2017*
Cost Projections for Bus Fuel Cell Systems

Low- and High-Volume Fuel Cell System Costs for Buses

- **Low Volume (200 systems/yr)**
  - Fuel Cell Stack Cost: $53,989
  - Balance of Plant Cost: $15,784
  - **Preliminary**

- **High Volume (1,000 systems/yr)**
  - Fuel Cell Stack Cost: $31,338
  - Balance of Plant Cost: $11,856

Source: DOE and SA, updates underway
## Fuel Cell Bus Status vs. Targets

<table>
<thead>
<tr>
<th>Unit</th>
<th>Current Status</th>
<th>2016 Target&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Ultimate Target&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bus lifetime</strong></td>
<td>years/miles</td>
<td>0.8–6/22,700–155,000</td>
<td>12/500,000</td>
</tr>
<tr>
<td><strong>Power plant lifetime</strong></td>
<td>hours</td>
<td>2,300–23,000</td>
<td>18,000</td>
</tr>
<tr>
<td><strong>Bus availability</strong></td>
<td>%</td>
<td>32–93</td>
<td>85</td>
</tr>
<tr>
<td><strong>Fuel fills</strong></td>
<td>per day</td>
<td>1</td>
<td>1 (&lt;10 min)</td>
</tr>
<tr>
<td><strong>Bus cost</strong></td>
<td>$</td>
<td>1.8M–2.5M&lt;sup&gt;h&lt;/sup&gt;</td>
<td>1,000,000</td>
</tr>
<tr>
<td><strong>Roadcall frequency</strong></td>
<td>miles between roadcalls</td>
<td>2,500–7,400/7,900–143,800</td>
<td>3,500/15,000</td>
</tr>
<tr>
<td><strong>Operation time</strong></td>
<td>hours per day/days per week</td>
<td>7–21/5–7</td>
<td>20/7</td>
</tr>
<tr>
<td><strong>Scheduled and unscheduled maintenance cost</strong></td>
<td>$/mile</td>
<td>0.46–2.06</td>
<td>0.75</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>miles</td>
<td>165–298</td>
<td>300</td>
</tr>
<tr>
<td><strong>Fuel economy</strong></td>
<td>miles per diesel gallon equivalent</td>
<td>4.91–7.09</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: 2016 NREL Bus Report, updates underway
Data, Models, and Resources Available

Data Validation of Real World Applications through the NREL’s NFCTEC

- Data products provide insights on technology improvements, issues and gaps

NFCTEC: The National Fuel Cell Technology Evaluation Center

Example: Sources of H₂ Infrastructure Maintenance

To Participate

techval@nrel.gov

Models “Toolbox” Online

- Financial, technical and economic models covering H₂ infrastructure, jobs, and more.
- Visit: energy.gov/eere/fuelcells/hydrogen -analysis-toolbox

Total Events: 3,140

Most maintenance related to compressors and dispensers
Ways to Spread the Word

Celebrate Hydrogen & Fuel Cell Day
October 8 or 10/8
(Held on its very own atomic-weight-day)

Give an “Increase your H2IQ” presentation in your community!

Learn more:
energy.gov/eere/fuelcells

Download for free at:
energy.gov/eere/fuelcells/downloads/increase-your-h2iq-training-resource
Thank You

Greg Kleen
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Fuel Cell Technologies Office
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hydrogenandfuelcells.energy.gov
Clean Cities Program
Alternative Fuel School Bus Case Studies

Ellen Bourbon, Senior Energy Policy Analyst
Vehicle Technologies Office
Clean Cities Program, AST
Clean Cities Program
Alternative Fuel School Bus Case Studies

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October 26, 2017
About the Clean Cities Program

Clean Cities Mission

To advance the energy, economic, and environmental security of the United States by supporting local decisions to adopt practices that reduce the use of petroleum in the transportation sector.

Alternative & Renewable Fuels
- Biodiesel
- Electric Vehicles
- Ethanol
- Hydrogen
- Natural Gas
- Propane

Idle Reduction
- Heavy-Duty Trucks
- School & Transit Buses
- Light-Duty Vehicles

New Area of Emphasis
Energy Efficient Mobility Systems

Fuel Economy
More fuel efficient vehicles, adopting smarter driving and vehicle purchasing habits

Hybrids
- Light- and heavy-duty
- Electric hybrids
- Plug-In hybrids
- Hydraulic hybrids
Nearly 100 coalitions with thousands of stakeholders
Representing ~80% of US population
Alternative Fuels Data Center Case Studies
(https://www.afdc.energy.gov/case)
Alternative Fuels Data Center Case Studies: Propane School Buses

School Districts Move to the Head of the Class with Propane

School districts across the country are under pressure to reduce their cost of operations and ensure their budgets are spent wisely. School bus fleets operate more than 675,000 buses in the United States, and many school districts have found the answer to their budget woes in the form of propane, or liquefied petroleum gas (LPG). Propane is a reliable, domestic fuel, and it’s used in approximately 12% of school buses nationwide.

Propane’s School Bus History

While propane has been used in buses for decades, recent technological advancements have made it more reliable than ever. Prior to 1980, all propane vehicles used vapor injection technology. In 1981, Blue Bird rolled out a propane school bus using direct liquid injection for the first time, and this was followed by Thomas Built Buses and Navistar. Liquid injection technology enables propane buses a more reliable system.

Since 2007, vehicle emission standards have tightened for all vehicles. Propane vehicles meet those emission standards without aftertreatment systems required for diesel vehicles. Because of this, and other reasons, many districts have found propane meets their criteria as an affordable, clean alternative.

Economic and Environmental Impacts

Propane is a domestic fuel created as a byproduct from crude oil refining and natural gas processing. Propane engines have simpler emissions controls, which allow them to meet U.S. Environmental Protection Agency standards. In addition, some school districts are reporting cost savings from reduced preventive maintenance such as oil changes (an effect also attributed to the fuel’s cleaner-burning nature). Most significantly, propane also typically costs less than diesel fuel, particularly for buses that work with their local propane marketers and equipment providers to install private...
New Hampshire Cleans up with Biodiesel Buses

Find out how the Manchester Transit Authority improves air quality with biodiesel buses.

For information about this project, contact Granite State Clean Cities Coalition.

Provided by Maryland Public Television

https://www.afdc.energy.gov/case/2850
Feb. 18, 2017

**Natural Gas Fuels School Buses and Refuse Trucks in Tulsa, Oklahoma**

Watch how Tulsa, Oklahoma, powers its school buses and refuse trucks with compressed natural gas.

For information about this project, contact Tulsa Clean Cities.

See more videos provided by Clean Cities TV and FuelEconomy.gov.

https://www.afdc.energy.gov/case/2672
Clean Cities Recovery Act Project:
Kentucky Hybrid-Electric School Buses

Contact: Melissa Howell, KY Clean Cities Coordinator
mhowell@kentuckycleanfuels.org, 502-593-3846
Vehicle-to-Grid Electric School Bus Pilot Project

- One of the first demonstrations of electric school bus technology on the East Coast of the U.S.

- 3 grants awarded for purchase of electric school buses and chargers by Amherst, Cambridge and Concord Public Schools

- Pilot will test ability of electric school buses to provide supplemental energy to buildings during times of peak energy use.

Contact:
Steve Russell
MA Clean Cities Coordinator
Stephen.Russell@state.ma.us
617-626-7325
Thank You!

For more information:

Clean Cities website
https://cleancities.energy.gov/

Alternative Fuels Data Center
https://www.afdc.energy.gov/

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VW Settlement Funds

Jonah Steinbuck, Advisor
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
VW Settlement – Outline

- Funds
- Timeline
- Eligible Actions
- Application to School Buses
- KY and CA Case Studies
- Resources
VW Settlement – Funds

- $2.9 Billion Environmental Mitigation Trust (states, territories)
  - $8M - $423M per state (based on number of affected vehicles)
  - 20 states: > $50 million
  - Administered by Wilmington Trust

- $2+ Billion Zero Emission Vehicle investment (national and CA)

- $10.8 Billion Vehicle Buyback and Modification (consumers)
VW Settlement – Timeline

**October 2016**
Settlement Effective Date

**Trust Effective Date (TED) October 2, 2017**
Establishment of Environmental Trust

**December 1, 2017 TED + 60 Days**
Deadline to Apply for Beneficiary Status

**TED + Up to 120 Days January 30, 2018**
Deadline for Trustees to Designate Beneficiaries

**30 Days Prior to Submitting First Funding Request**
Deadline for Beneficiaries to Submit Mitigation Plans.

Source: vwclearinghouse.org
Environmental Mitigation Trust – Eligible Actions

• Eligible mitigation actions must result in decreased NOx emissions.

• Eligible Action Areas:
  (1) Class 8 Local Freight Trucks and Port Drayage Trucks ( Eligible Large Trucks)
  (2) Class 4-8 School Bus, Shuttle Bus, or Transit Bus
  (3) Freight Switchers
  (4) Ferries and Tugs
  (5) Ocean Going Vessels (OGV) Shorepower
  (6) Class 4-7 Local Freight Trucks (Medium Trucks)
  (7) Airport Ground Support Equipment
  (8) Forklifts and Port Cargo Handling Equipment
  (9) Light Duty Zero Emission Vehicle Supply Equipment
  (10) Diesel Emission Reduction Act (DERA) Option
Environmental Mitigation Trust – Buses

Option (2) Class 4-8 School Bus, Shuttle Bus, or Transit Bus

<table>
<thead>
<tr>
<th>Repower with new diesel or alternate fueled engine</th>
<th>Government Owned</th>
<th>Non-Government Owned</th>
</tr>
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<tbody>
<tr>
<td>Up to 100%</td>
<td>Up to 40%</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Replace with new diesel or alternate fueled vehicle</th>
<th>Government Owned</th>
<th>Non-Government Owned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 100%</td>
<td>Up to 25%</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Repower with all-electric engine (includes infrastructure)</th>
<th>Government Owned</th>
<th>Non-Government Owned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 100%</td>
<td>Up to 75%</td>
<td></td>
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</table>

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<tr>
<th>Purchase new all-electric vehicle (includes infrastructure)</th>
<th>Government Owned</th>
<th>Non-Government Owned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 100%</td>
<td>Up to 75%</td>
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Option (10) Diesel Emission Reduction Act (DERA) Option

$100k DERA Base Funds + $100K EMT Voluntary Match + $50K DERA Bonus = $250K Total Project Cost

Source: NASEO VW Beneficiary Mitigation Plan Toolkit
Case Studies: Bus Fleet Projects in KY and CA
Hybrid Horsepower for Kentucky Schools

- 2009 American Recovery and Reinvestment Act award of $13M to KY Dept. of Ed. to cover the incremental costs of hybrid buses over traditional diesel buses.

- Utilizing a master purchase agreement streamlined paperwork and allowed many districts to order hybrid school buses.

- 157 hybrid school buses throughout the state.

- ~35% improvement in fuel efficiency.

Sources:
https://www.afdc.energy.gov/case/1045
http://kentuckycleanfuels.org/projects/hybrid-horsepower/
CA Rural School Bus Pilot Project

- $10 million California Air Resources Board and North Coast United Air Quality Management District pilot to encourage turnover of California’s school bus fleet to zero emission and cleaner-burning school buses.

- Eligible school bus technologies: fuel cell; battery electric; plug-in hybrid; vehicle charging equipment; renewable diesel, natural gas, and propane.

- Project could fund as many as 60 new school buses statewide.

Sources:
https://www.arb.ca.gov/newsrel/newsrelease.php?id=895
Resources

- Your state’s lead agency (listed on VW Clearinghouse and NACAA sites below)
- NASEO-NACAA VW Clearinghouse: http://vwclearinghouse.org/
- NACAA: http://4cleanair.org/Volkswagen_Settlement_Information
- NASEO: http://www.naseo.org/volkswagen-settlement; http://www.naseo.org/publications
- DOE Clean Cities: https://cleancities.energy/gov
- DOE Alternative Fuels Data Center: http://www.afdc.energy.gov
- EPA: https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement (settlement background)
Thank You

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Program Announcements
Accelerator Goals

- **Identify** strategies to overcome barriers to building ZE K-12 schools and realizing the associated health, savings, and resiliency benefits
- **Share** solutions, resources, and technologies that help schools achieve ZE goals
- **Develop** replicable road maps to build ZE schools and achieve associated benefits
- **Increase** visibility and replication of best practice approaches and successful models

Implementing partners

National partners
K-12 School Districts are Eligible

**Known** – Still large potential for industrial/commercial energy savings, historic improvement focus has been on ad hoc projects, low hanging fruit

**We believe** - Best way to achieve the fullest EE potential is to adopt programs & policies that improve energy performance on a continuing basis

**Value of 50001 Ready Program** – Positions your organization to achieve and sustain energy and cost savings through informed systematic decision making

**What is 50001 Ready?**

- DOE program assisting and recognizing organizations for adopting a culture of continuous energy performance improvement
- Self-attesting, no certifications, no external audits, do-it-yourself with DOE free online resources
- Online energy management tools and guidance, can be rebranded/repurposed if desired

Participants are eligible for technical assistance. Contact Crystal Mcdonald at crystal.mcdonald@ee.doe.gov for more information.
Questions & Answers
Contacts

- Crystal McDonald, Office of Energy Efficiency and Renewable Energy, DOE
  Crystal.McDonald@EE.Doe.Gov

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