West Coast Partnership to Promote Alternative Fuel Corridors

Plug-In Electric & Hydrogen Fuel Cell Technologies & Infrastructure

Alternative Fuel Infrastructure Corridor Coalition (AFICC)
Washington, Oregon, and California

Webinar Session #4
Tuesday, November 6, 2018
10:30 a.m. – 12:00 p.m. PT
Overview

• Overview of Alternative Fuel Infrastructure Corridor Coalition (AFICC)

• AFICC Technical Webinar Objectives

• Discussion Leader Presentations: Plug-In Electric and Hydrogen Fuel Cell Technologies and Infrastructure

• Workgroup Discussion
West Coast MD/HD Alternative Fuel Corridors

Interstate collaboration is needed to develop west coast corridors for MD/HD AFV fueling similar the one shown here for LD ZEVs. This would help to address:

- Emission reductions
- Fuel supply diversity
- Sustainable freight, public works, refuse collection, transit & school bus
- Local job creation and economic development
MD/HD Alternative Fuel Infrastructure Corridor Coalition

1. Convene a stakeholder coalition focused on M/HD alternative fuel infrastructure deployment.

2. Conduct stakeholder workgroups & targeted outreach to identify desired/unfunded M/HD alternative fuel stations.

3. Synthesize stakeholder input into a plan document.

4. Use the plan to support project development, leverage existing funds, and seek joint applications to US DOT and other competitive funding programs.

5. Obtain federal funding assistance to help implement infrastructure in California, Oregon and Washington (i.e., natural gas, propane, electric vehicle charging and hydrogen for public and private M/HD fleets).
AFICC Project Overview

Establish Framework
- Define Workgroup Discussion Objectives
- ID Key Stakeholders
- ID Coalition-Supporting Resources
- ID Direct Outcomes

Facilitate Workgroup Sessions [CA, OR & WA]
Collect Feedback, Compile Info, & Research Q's

Draft Implementation Plan
- Include Themes & Priorities
- Outline Strategy & Actions
- Provide Recommendations
- ID AFV Project Partnerships
- Estimate Project Costs & ID Funds

Needs
- Prioritize Hot Spots (Areas of Congestion, Communities, Intermodal Freight Hubs)
- ID Alt. Fuel Infrastructure Gaps
- ID Best Techs/Fuels for Transportation Activities/Project Areas

Develop AFV Stakeholder Synthesis
- Summarize Workgroup Feedback
- Respond to Questions
- Outline Critical Barriers & Challenges
- Evaluate Needs & Costs for AFV Infrastructure

Opportunities
- ID partnerships with Freight Shippers, Carriers, BCOs, Ports, Railroads, Truck Associations (LMCs/IOOs) Truck Stops, Warehouses, EDCs, and Cities on Coordinated Alt. Fuel Corridor Projects

Present Outcomes to Partners
Today’s Webinar Objectives

Learn from vehicle manufacturers, fuel suppliers and fleets about the benefits, application and business case for plug-in electric and hydrogen fuel cell vehicle technologies.

1) Latest emerging technologies and costs;

2) Operational suitability;

3) Infrastructure considerations;

4) Fleet best practices; and

5) Opportunities for alternative fuel corridors.
Today’s Discussion Leaders

Program Facilitators

• Alycia Gilde, Director, CALSTART
• John Mikulin, Environmental Protection Specialist, EPA Region 9

Presentations by:

• Tim Weaver, Vice President of Corporate Development, Chanje
• Brendan Riley, President, GreenPower Motor Motor Company, Inc.
• Rob Del Core, Managing Director, Hydrogenics, USA, Inc.
• Alan Mace, Heavy-Duty Market Manager, Ballard Power System
Tim Weaver, Vice President of Corporate Development
November 6, 2018
Specifications

Dimensions
- Wheelbase (in/m): 156.3 / 4,993
- Overall Length (in/m): 338.1 / 8,600
- Overall Width Excluding Mirrors (in/m): 86.4 / 2,200
- Overall Height (in/m): 79.4 / 2,010
- Curb Weight (lb/kg): 10,093 / 4,581
- Gross Vehicle Weight Rating (lb/kg): 16,095 / 7,300
- Total Payload (lb/kg): 6,003 / 2,722
- Cargo Volume (cu ft): 87

Mechanical
- Drive Configuration: FWD
- Motor Type: Synchromagnetic Permanent Magnet
- Number of Motors: Dual Motor System
- Motor Cooling Method: Liquid Cooling
- Battery Capacity: 160 kWh
- Battery Chemistry: LiFePO4
- On-Board Charger: 15.2 kW
- Charge Port: J1772 Level 2
- DC Fast Charge CCS

Performance
- Total Peak Power (hp/kW): 750 / 556
- Total Peak Torque (lb-ft/Nm): 630 / 856
- Top Speed (mph/kph): 88 / 142
- Max. Gradeability (%): 30
- Turning Radius (ft/m): 25.0
- MPG:

Chassis
- Body Construction: Unibody
- Front Suspension: Independent
- Rear Suspension: Leaf Spring
- Tire Size: 215 / 75R16.5
Why Now?

Chanje MDEV vs Diesel ICE - Total Cost of Ownership Analysis (Without Incentives)

- Driven by decrease in diesel fuel cost
- Driven by decrease in battery cost

Total Cost of Ownership

$80,000 - $200,000

2010 - 2020

Diesel - Electric

1 Includes fuel and maintenance
Source: United States Energy Information Administration
Value Proposition

MDEVs provide superior operating costs: ~70% less than ICE vehicles

Chanje all-in Total Cost of Ownership (including maintenance) no longer a barrier to entry for customers
  * is at parity with other equivalent performance ICE vehicles now

Diesel and ICE vehicle costs continue to increase while battery costs continue to decrease

<table>
<thead>
<tr>
<th></th>
<th>$/Gallon</th>
<th>M−Duty MPG</th>
<th>$/Mile</th>
<th>Well-to-Wheel</th>
<th>Pump-to-Tail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>$3.00</td>
<td>11</td>
<td>$0.27</td>
<td>115.0k lbs</td>
<td>92.0k lbs</td>
</tr>
<tr>
<td>CNG</td>
<td>$2.00</td>
<td>9</td>
<td>$0.22</td>
<td>122.0k lbs</td>
<td>85.4k lbs</td>
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<tr>
<td>LPG</td>
<td>$3.00</td>
<td>9</td>
<td>$0.33</td>
<td>124.6k lbs</td>
<td>96.0k lbs</td>
</tr>
<tr>
<td>Electric</td>
<td>$.15/kWh</td>
<td>50+ MPGe</td>
<td>$0.10</td>
<td>60.0k lbs</td>
<td>0 lbs</td>
</tr>
</tbody>
</table>

Significant Operating Cost Benefits (Without Incentives)

Source: GREET

CHANJE ENERGY INC
Trends Leading to Market Expansion

Trends Driving EV Adoption:

- Customer Demand
- Operational Cost Savings
- Fleet Standardization
- Corporate Sustainability
- Urban Access/Emissions Restrictions
- Polices at the federal and local level both encouraging and mandating zero-emission transport
- Growth in Telematics Solutions
- Ongoing Driver Shortage
- Driver Dissatisfaction
- Connected Trucks/Digital Driver Aids

Source: Technavio, BNEF and Wall Street Research
GreenPower MOTOR COMPANY

The EVolution of Transportation

TSXV: GPV         OTCQX: GPVRF
GreenPower projects massive uptick in new bus sales in the emerging micro-transit industry over the next decade.
GreenPower buses are more cost effective. The following table compares a forty foot Diesel, CNG and GreenPower electric bus over a lifespan of 12 years or 500,000 miles.
Environmental Impact

California has some of the strictest emissions emits over 4,000 metric tons of poison into the air that we breathe. The synapse zero emissions school bus is a win-win for the environment and the budget.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Metric Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC Exhaust</td>
<td>244</td>
</tr>
<tr>
<td>CO</td>
<td>1556</td>
</tr>
<tr>
<td>NOx</td>
<td>1900</td>
</tr>
<tr>
<td>SO2</td>
<td>18</td>
</tr>
<tr>
<td>PM10 Exhaust</td>
<td>142</td>
</tr>
<tr>
<td>PM10 OC</td>
<td>59</td>
</tr>
<tr>
<td>PM10 BC</td>
<td>82</td>
</tr>
<tr>
<td>PM10 Sulfate</td>
<td>1</td>
</tr>
</tbody>
</table>

*Total Metric Tons: 4002*
## CALIFORNIA INCENTIVES

<table>
<thead>
<tr>
<th>MODEL</th>
<th>2018 Voucher (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV550 Double Decker</td>
<td>$175,000</td>
</tr>
<tr>
<td>EV350 Forty Foot</td>
<td>$150,000</td>
</tr>
<tr>
<td>EV250 Thirty Foot</td>
<td>$120,000</td>
</tr>
<tr>
<td>Synapse 72 School Bus</td>
<td>$220,000</td>
</tr>
<tr>
<td>Synapse Shuttle</td>
<td>$120,000</td>
</tr>
<tr>
<td>EV STAR</td>
<td>$90,000</td>
</tr>
</tbody>
</table>

(1) CARB approved $180 million in funding for the HVIP in 2018

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### CALIFORNIA HVIP + CEC INCENTIVES

- Presently there are over 70 school districts in California actively looking for 550 all-electric school buses
- California Vouchers $220,000 + $15,000
- Many states have prioritized their allocation from the $2.9 billion VW Mitigation Trust fund to purchase all-electric school buses
- Level 2, 20kW charging ($1500 per EVSE) or DC Fast charge
- Seatbelts standard
- Multiple range configurations
Infrastructure = Adoption

EV Star: Leverage Existing Charge
Brendan Riley  
(510) 910-3377

Fraser Atkinson  
(604) 220-8048

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For additional information on GreenPower, go to our website at www.GreenPowerBus.com  
For company filings go to www.sedar.com
Coast Collaborative, Alternative Fuel Infrastructure Corridor Coalition (WCC-AFICC)

Webinar: Plug-In Electric and Hydrogen Fuel Cell Technologies & Infrastructure

November 6, 2018

Rob Del Core

Managing Director

Hydrogenics USA
Shifting Power Across Industries Around the World

- **HYDROGEN GENERATION**
  - Electrolyzers
  - Industrial Hydrogen Supply

- **POWER SYSTEMS**
  - Fuel cells
  - Stand-by Power
  - Mobile Power Modules
  - MW Power Plants

- **RENEWABLE HYDROGEN**
  - Energy Storage
  - Hydrogen Refueling Station
  - Power-to-X
  - Grid Balancing Services

Locations:
- **Canada**
  - Mississauga, Ontario
  - Montreal
- **Belgium**
  - Oevel
  - Gladbeck
- **Russia**
  - Moscow
- **USA**
  - Carlsbad, California
- **Germany**
  - Daesan
- **Korea**
  - Selangor
- **Indonesia**
  - Jakarta
Why Hydrogen Fuel Cell Transportation

Positive feedback from Operators for adopting hydrogen-powered vehicles:

- Zero emission
- No range anxiety
- Fast fuelling
- Offer flexibility in operation
- Using electrolyzer to produce hydrogen fuel onsite, operators enjoy energy independence => more cost and operation control
- Integration ready with renewable energy source – onsite with fleets or offsite co-located with solar and wind farms
Zero Emission Goods Movement & Transportation in California

Fuel Cell Transit Bus and Port Truck, California
• Funded by CEC, to develop New Flyer fuel cell bus and Freightliner fuel cell trucks, Hydrogenics’ Celerity bundled with Siemens ELFA drive

Fuel Cell Range Extend Drayage Truck, California
• Powered by Hydrogenics fuel cell

Fuel Cell Port Truck, California
• Funded by DOE ZECT, SCAQMD to develop hydrogen fuel cell Daimler class 8 freight tuck using Hydrogenics’ Celerity fuel cell power system for zero emission cargo transportation

Fuel Cell Range Extend UPS Medium Duty Delivery Van, California
• 17 UPS fuel cell delivery van powered by Hydrogenics fuel cell
Onsite Hydrogen Refueling Infrastructure with Electrolyzers

Clean and renewable hydrogen generation: onsite and on-demand

Ontario Hydrogen Station

CalState LA Hydrogen Station

5MW Electrolyzer Block Process and utilities and sub-station
Offsite/Remote Renewable Hydrogen Fuel Production Plants Co-located with Wind and Solar Farms

- Multiple MW Electrolyzers integrated with remote renewable energy farms along regional freeways
- Perfect for refueling long haul freight trucks crossing states
- Perfect for delivering renewable hydrogen fuel to refueling stations in nearby cities
- Hydrogenics is currently partnering with Stratos Fuel to develop a renewable hydrogen production facility using wind energy in California
Scale Consumption Matches Scale Supply:
Multiple Heavy Duty Port Applications Coupled with Remote 100% Renewable Hydrogen Production to **Bring Down TCO**

Let's do some math:

5 X 100 X 1 X 1 X

can easily consume ~4,000 kg of hydrogen per day, and supply of this scale of hydrogen can come from

2 X

5 MW Electrolyzer Block in Remote Wind and Solar farm

Multiple Dispensers in and close to ports

This Scale Bundled Hydrogen Solution can Multiply to Substantially Bring Down the Cost Through **Planned and Committed Projects**
Thank you for your attention

ROB DEL CORE
Managing Director
Hydrogenics USA, Inc.
Mobile: +1 858 386 8930
Email: rdelcore@hydrogenics.com
Hydrogen Fuel Cell Vehicles

Alan Mace

November 6, 2018
Hydrogen and Fuel Cells for Range, Power, Payload & Utilization

“Fuel cell vehicles provide drivers with the same driving experience they have today with the internal combustion engine: a driving range of 300 – 400 miles, a refueling time of three to five minutes, and normal performance in both hot and cold weather.” (Fuel Cell & Hydrogen Energy Association)
The future of clean transit will be electric.
There are different options to re-charge an electric bus

<table>
<thead>
<tr>
<th>TROLLEY E-BUS</th>
<th>OPPORTUNITY E-BUS</th>
<th>OVERNIGHT E-BUS</th>
<th>FUEL CELL E-BUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric drive</td>
<td>Electric Drive</td>
<td>Electric drive</td>
<td>Electric drive</td>
</tr>
<tr>
<td>Direct electric</td>
<td>Small battery</td>
<td>Large battery</td>
<td>Small battery &amp; fuel cell engine</td>
</tr>
<tr>
<td>Powered directly by grid</td>
<td>Grid charging along the road</td>
<td>Grid charging at depot</td>
<td>Hydrogen refilling at depot</td>
</tr>
<tr>
<td>Overhead power lines</td>
<td>Charging stations</td>
<td>No route infrastructure</td>
<td>No route infrastructure</td>
</tr>
</tbody>
</table>
Fuel cells enhance the performance of electric buses.

- **250-300 miles** Proven range
- **Significant reduction in vehicle weight** (carry more passengers)
- **Rapid refueling speeds** (6 to 10 minutes)
- **1:1 replacement of conventional vehicles**
Fuel cell electric buses can replace diesel buses without significant changes to operation and service.

- No need to adapt routes and schedule
- No roadside infrastructure
- 1:1 replacement of conventional buses
Fuel cell electric buses have demonstrated performance in service

- More than 15 years of road-experience
- Over 7M miles in service
- Bus availability >85%
- FC module availability > 96%
- >30,000hrs stack durability
- Operation in challenging routes and climates
Fuel cell bus cost is declining with technology advancements and manufacturing volume

“\[\text{I see this increase in demand making the FCEBs’ purchasing costs on par with diesel buses in the near future.}\]”

Kirt Conrad, CEO Stark Area Regional Transit Authority
Hydrogen provides flexibility to transit fleets

- Scalable to support hundreds of buses
- Small footprint
- Renewable sources (wind, solar, biogas)
- Redundancy and backup (enable operators to respond to natural disasters)

4,300ft² footprint for a 75 bus station with 2x 4.5t storage of liquid H2
Hydrogen fueling stations: flexible solutions for each depot

OCTA Station ~ 60’ x 30’ (up to 40 buses)
Liquid hydrogen delivery

AC Transit – Emeryville
On site H2 production (Electrolyser)

“Once you are used to using a gas, like CNG, the transition to hydrogen is really easy.”
Kirt Conrad, CEO Stark Area Regional Transit Authority

20 bus depot (Europe): Hydrogen storage & dispensing area,
Compressed H2 delivery (55”x45” – 20 buses)
Committed to sustainable mobility, and clean air for everyone.

Alan Mace
alan.mace@ballard.com
541 678 8086
Discussion

Please raise hand to speak or submit a comment via GoToWebinar.

1. What infrastructure considerations should a fleet be aware of to successfully deploy an electric or hydrogen fuel cell fleet (small vs. large)?
2. Where do we see important infrastructure development opportunities to support alternative fuel corridors for electric/hydrogen fuel cell technologies?
3. What incentives are available for electric and hydrogen fuel cell vehicles and infrastructure?
4. How can multi-state planning lead to more infrastructure deployment assistance resources?
5. Are any webinar participants interested in developing electric charging and/or hydrogen fueling infrastructure for medium and/or heavy-duty equipment operating in California, Oregon, or Washington?
Save the Date for Our Next Webinars

Alternative Fuel Infrastructure Needs: Expanding Our Clean Corridors for MD/HD Vehicles

WASHINGTON

Monday, December 10th
1:00 p.m. – 2:30 p.m.

OREGON

Thursday, December 13th
1:00 p.m. – 2:30 p.m.

Partners will provide input on critical gaps & infrastructure needs along key corridors & evaluate actions and funding opportunities to support partnership, coordination & project implementation.
Contact Us

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