Welcome!

We will get started at 10:00 AM Pacific Time.
Introduction to EVs and FCVs

Clean Fuels 101 Webinar Series
Part 4 of 5
December 20, 2017

Western WA Clean Cities
• November 15: Introduction to Washington’s Clean Fuels
• November 29: Fleet Efficiencies
• December 13: Biomass Fuels - Biodiesel, Renewable Diesel & Ethanol
• December 20: Electric Vehicles & Hydrogen Fuel Cells
• January 10: Gaseous Fuels - Natural Gas & Propane Autogas

All webinars will begin at 10:00 AM Pacific Time.
Today’s Speakers
Robin Gold  
*Coordinator: Alternative Fuels & Technology*  
Western Washington Clean Cities,  
Puget Sound Clean Air Agency

Timothy Lipman  
*Researcher and Co-Director*  
Transportation Sustainability Research Center,  
University of California - Berkeley

Jacob Leachman  
*Associate Professor*  
Department of Mechanical and Materials Engineering,  
Washington State University
Electric Vehicles
TLAs

• **HEV = Hybrid electric vehicle**
  - Runs mainly on fuel; battery recharges through regenerative braking only

• **PEV or PHEV = Plug-in hybrid**
  - Plugs in to recharge batteries; also uses fuel

• **BEV = Battery electric vehicle**
  - Runs exclusively on battery power; no fuel and no internal combustion engine
  - Zero tailpipe emissions
Chevy Bolt: 238 miles
Nissan Leaf: 150 miles
Tesla 3: 220 miles
XL Hybrids Ford F-150 upfit
Workhorse E-GEN step van
Thomas Built C2 Jouley
Proterra EV bus
little monsters
Electricity carbon intensities

<table>
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<tr>
<th></th>
<th>Emission Factor*</th>
<th>Carbon Intensity</th>
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<tbody>
<tr>
<td></td>
<td>MgCO2e/MWh</td>
<td>gCO2e/MJ</td>
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<tr>
<td>Puget Sound Energy</td>
<td>0.490</td>
<td>136.11</td>
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<tr>
<td>Peninsula Light</td>
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<tr>
<td>Tacoma Power</td>
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<td>Snohomish PUD</td>
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<tr>
<td>Lakeview Power &amp; Light</td>
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<tr>
<td>Seattle City Light</td>
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<td>6.67</td>
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1 MWh = 3600 MJ
*Data from 2017 PSCAA Regional Emissions Inventory, 2015 data (Cascadia Consulting)
Zero emission ≠ zero impact

• Electricity has environmental impacts
• Non-exhaust emissions such as tire and brake wear cause over 85% of particulate matter from cars
• Batteries contain rare earth metals like lithium, and may not be recyclable
• Every car on the road contributes to traffic congestion
JOLTS & VOLTS
Jan 9, 2018
Seattle Municipal Tower

More information:  http://wwcleancities.org/499/Jolts-Volts
Hydrogen
Hydrogen fuel cell vehicles

- Also called FCEVs or FCVs
- Only sold or leased in select markets in the US-- mainly California
- Most public hydrogen fuel stations are in CA, with a few in East coast states
- Some transit companies around the country are using fuel cell buses
How it works

• Hydrogen gas is stored in high-pressure tank(s), up to 10,000 PSI
• Hydrogen + oxygen generate electricity in fuel cell stack
• Converted to appropriate voltage and stored in a battery
• Battery powers an electric motor, just like an EV
• Tailpipe emissions are water and heat
Hydrogen production
Hydrogen advantages

• No harmful tailpipe emissions
• Extended range - good for both cars and heavier duty applications
• Quick to fill up - similar to gas/diesel
• Domestic product with numerous possible production sources
Hydrogen limitations

- Energy inefficient as compared to battery electric vehicles (~30%)
- Over 95% of hydrogen currently comes from fossil fuel sources
- Very expensive fueling infrastructure
- Vehicles are also expensive
- Hydrogen is $13-16 per GGE
- Very high pressure, and flammable
Hydrogen Carbon Intensities (California)

- Natural Gas
- Nat Gas w/ Renewables
- Landfill Gas + Nat Gas
- Solar Electrolysis
- Landfill Gas Reforming

gCO2e/MJ
Thank you!