The Intersection of Transportation and Renewable Energy

UC Davis - Policy Forum

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Transportation at NREL

• The National Renewable Energy Laboratory explores...
  o Battery electric, hybrid, fuel cell electric, and conventional vehicles
    – Not just passenger vehicles but also trucks, trains, planes, boats, etc.
  o Biofuels, hydrogen, natural gas, propane, and petroleum-based fuels
  o Charging and fueling infrastructure.

• Battery and Fuel Cell Electric Vehicles Research
  o Battery materials
  o Thermal Management
    – Cabin heating and cooling
  o Component and system Efficiency
    – Load and parasitic reduction
    – Wireless power transfer
  o Integration with renewables
    – Communication and charge control
    – Leveraging storage capability (Vehicle-to-grid)
  o Third rail and autonomous vehicles
Transportation Supporting Renewables

• Renewable and vehicle integration studies
• Hydrogen system architecture
• Status of hydrogen deployments
• Policy needs for hydrogen systems
Transportation Supporting Renewables

• **Renewable Energy Futures – REF**
  - Implications for high renewable penetration across the US
  - Includes transportation electrification

www.nrel.gov/analysis/re_futures

Effects of vehicle efficiency improvements and use increases on net energy consumption by 2050

<table>
<thead>
<tr>
<th></th>
<th>LDVs</th>
<th>Trucks</th>
<th>Aviation</th>
<th>Inland Marine</th>
<th>Ocean Marine</th>
<th>Rail</th>
<th>Pipeline</th>
<th>Off-road</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle energy efficiency improvements</strong></td>
<td>61%</td>
<td>50%</td>
<td>65%</td>
<td>30%</td>
<td>75%</td>
<td>35%</td>
<td>20%</td>
<td>18%</td>
</tr>
<tr>
<td><strong>Vehicle use increases</strong></td>
<td>75%a</td>
<td>87%a</td>
<td>217%b</td>
<td>32%a</td>
<td>450%c</td>
<td>47%a</td>
<td>16%a</td>
<td>20%d</td>
</tr>
<tr>
<td><strong>Net changes in total energy consumption</strong></td>
<td>-32%</td>
<td>-17%</td>
<td>+11%</td>
<td>-8%</td>
<td>+38%</td>
<td>-4%</td>
<td>+1%</td>
<td>-6%</td>
</tr>
</tbody>
</table>

- EIA projections extrapolated.
- FAA projections extrapolated.
- Growth in dollar value of trade (EIA).
- Projected at half the population growth.

• **Transportation Energy Futures – TEF**
  - Explores opportunities for deep reduction of petroleum use and GHG emissions from a variety of technologies.

www.nrel.gov/analysis/transportation_futures
Multi-sector Integration with Hydrogen

Electric Grid

- Electrolyzer
- Fuel Cell or combustion
- Fuel Cell Vehicles
- Grid Services

Hydrogen

- Hydrogen Storage
- Reformer
- Pipeline Injection
- Chemical and Industrial Processes, etc.

Natural Gas Grid

- Direct injection or methanation

Water

- Natural Gas Grid Services
Hydrogen storage and Power-to-gas (PtG) projects

• Germany has 22 green hydrogen and PtG projects as of 2012 (see figure)


• Recently Announced: 2 MW Power-to-Gas project planned for Ontario, Canada
  o Acts as energy storage for grid management and regulation provision

Hydrogen Energy Storage Policy Needs

- Hydrogen Energy Storage: Grid and Transportation Services Workshop
- Sacramento, CA, May 14 – 15, 2014
- Policy Needs
  - Policies that allow participation in different credit markets
  - Hydrogen codes and standards
  - Energy Storage definition

Outline

• NREL background
• NREL transportation research
  o First, transportation extends beyond passenger vehicles (trucks, trains, planes)
  o How EV enables >RENPEN (integration with elec. and transport sector)
    – DOE transportation goals
    – Smart Charging
    – Wireless Charging
    – Third Rail (relates?)
    – Self-driving vehicles
  o How FCEV enables >RENPEN (integration with elec., transport, gas and industrial supply)
    – System Architecture
    – Current/future installations
    – Workshop
    – Needs
      ▪ Energy Storage definition
      ▪ Hydrogen codes and standards (follow biogas injection)
      ▪ Policy that allows participation in multiple (non-simultaneous) credits
Comparison to H2A

Integration with the grid can lower feedstock costs and increase revenue

- **H2A Current Central Hydrogen Production Scenarios**

<table>
<thead>
<tr>
<th>Name</th>
<th>Technology</th>
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<tbody>
<tr>
<td>FC</td>
<td>Fuel Cell</td>
</tr>
<tr>
<td>EY</td>
<td>Electrolyzer</td>
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<tr>
<td>SMR</td>
<td>Steam Methane Reformer</td>
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</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>All Ancillary Services</td>
</tr>
<tr>
<td>Eonly</td>
<td>Energy Arbitrage only</td>
</tr>
<tr>
<td>Baseload</td>
<td>“Flat” operation</td>
</tr>
</tbody>
</table>

Integration with the grid can lower feedstock costs and increase revenue.
Multi-sector Integration with Hydrogen
Final Thoughts