Emerging Fleet Technologies

Greater Yellowstone Interagency Climate Action Plan Working Session

Ryan Daley, NREL

19 – 22 April 2010
Agenda

• Overview – Achieving long-term sustainability

• Current Federal fleet composition & Vehicle availability

• Future of the Federal Fleet
Definitions for Federal Fleets

• Alternative Fuel Vehicles
  • Dedicated AFVs
  • Dual-fueled AFVs
  • Hybrid Electric Vehicles
  • Plug-In and all Electric Vehicles

• Low Greenhouse Gas Emitting Vehicles
  • Vehicle acquisitions must achieve a 7 or ↑
  • Light-duty trucks (gas, diesel, or CNG): 6 or ↑
  • Light-duty FFV passenger cars: 6 or ↑ when operated on E85
  • Light-duty FFV trucks: 5 or ↑ when operated on E85

• Fuels: Alternative vs. Renewable

EPA’s GHG Scores for Model Year 2010

<table>
<thead>
<tr>
<th>GHG Score</th>
<th>MY 2010 CO₂e emissions (grams/mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>≤ 237</td>
</tr>
<tr>
<td>9</td>
<td>238 to 283</td>
</tr>
<tr>
<td>8</td>
<td>284 to 329</td>
</tr>
<tr>
<td>7</td>
<td>330 to 375</td>
</tr>
<tr>
<td>6</td>
<td>376 to 421</td>
</tr>
<tr>
<td>5</td>
<td>422 to 467</td>
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<tr>
<td>4</td>
<td>468 to 513</td>
</tr>
<tr>
<td>3</td>
<td>514 to 559</td>
</tr>
<tr>
<td>2</td>
<td>560 to 605</td>
</tr>
<tr>
<td>1</td>
<td>606 to 651</td>
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<tr>
<td>0</td>
<td>≥ 652</td>
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Vision of Long-Term Transportation Sustainability

Moving towards Electric and Zero Emissions vehicles

- Gasoline
- Diesel
- Cellulosic Ethanol
- Algae Fuels
- Battery
- Fuel cell

- Corn Ethanol
- Biodiesel
- Plug-in Hybrid
- Hybrid
- Battery
- Fuel cell

- Diesel
- Cellulosic Ethanol
- Algae Fuels
- Battery
- Fuel cell

- Hybrid
- Biodiesel
- Plug-in Hybrid
- Hybrid
- Battery
- Fuel cell

- Gasoline
- Cellulosic Ethanol
- Algae Fuels
- Battery
- Fuel cell

- Diesel
- Algae Fuels
- Battery
- Fuel cell

2000s 2010s 2020s

Increasing Sustainability
## Vision of Long-Term Transportation Sustainability

### Renewable Fuel Options

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Emissions</th>
<th>Land Use</th>
<th>Displaces food</th>
<th>Cost competitive</th>
<th>Time to deployment</th>
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<tbody>
<tr>
<td>Fossil Fuels</td>
<td>Very High</td>
<td>Low</td>
<td>No</td>
<td>Yes</td>
<td>Deployed</td>
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<tr>
<td>Corn ethanol</td>
<td>High</td>
<td>High</td>
<td>Yes</td>
<td>Variable</td>
<td>Deployed</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>Medium</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Deployed</td>
</tr>
<tr>
<td>Cellulosic ethanol</td>
<td>Low</td>
<td>Medium</td>
<td>Maybe</td>
<td>Unknown</td>
<td>3+ years</td>
</tr>
<tr>
<td>Algae biofuels</td>
<td>Very Low</td>
<td>Low</td>
<td>No</td>
<td>Unknown</td>
<td>10+ years</td>
</tr>
<tr>
<td>Electric vehicles</td>
<td>Variable to None</td>
<td>Low</td>
<td>No</td>
<td>Yes</td>
<td>3-10 years</td>
</tr>
</tbody>
</table>

Future fuels promise to be more sustainable than current options

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National Renewable Energy Laboratory
Innovation for Our Energy Future
The Federal Fleet: An Overview

World’s largest vehicle fleet

- Over 650,000 vehicles
- 21 “covered” federal agencies

A leader in alternative fuel use

- **Today:** 148,238 AFVs (29% of federal light-duty fleet)
- **Hybrids:** 5,522 (221% Increase in FY09 from FY08)
- **Goal:** Reduce petroleum use 20% by 2015 (2005 baseline)
- **Goal:** Increase alternative fuel use 10% by 2015 (2005 baseline)
GYA Vehicle-Relevant Characteristics

- Geographic constraints
  - Driving long distances at highway speeds
  - Rough/steep terrain
  - Climate – especially long, cold winters

- Vehicle Inventory Composition
  - Most GYA vehicles are light-duty gasoline pickup trucks
  - These vehicles contribute 44% of your fleet based carbon emissions!

- Fuel Availability
  - Biodiesel available in Yellowstone & Grand Teton NP
  - E85 available in Yellowstone NP
  - Propone available in numerous locations around the ecosystem, not in the parks
  - No CNG in vicinity
GYA Vehicle-Relevant Characteristics

Greater Yellowstone Area
Mobile Source Fuel Usage and Carbon Emissions by Vehicle Type

- Total Carbon Equivalent Emissions (MTCE)
- GYA Fuel Usage (gallons)
Propane Vehicle Opportunities in GYA

Medium and Heavy Duty vehicles
- Transit buses (4 different OEMs)
- Shuttle Busses (4 OEMs)
- Custom Chassis/Specialty vehicles (2 OEMs)

Barriers:
- Vehicle availability
- Fuel Availability
- No Light Duty Vehicles
- GSA Availability?
Natural Gas Vehicles – Where are we?

Natural Gas Domestic Supply

Natural Gas Fueling Stations: 835 in the U.S.

Natural Gas Vehicles (NGV) in the U.S.
- > 100,000 on the road
- 8 Heavy-Duty Engine models; > 40 OEM models
- 84 small volume manufacturer models
- 5 NGVs on GSA schedule – 1 compact sedan, 2 pickups, 2 vans
Natural Gas Vehicles – Where are we going?

U.S. Average Retail Fuel Prices

Cost per GGE

- Propane
- E85
- B99/B100
- B20
- Gasoline
- Diesel
- CNG
NGV Opportunities in GYA

CNG vehicle technology is well developed

Medium and Heavy Duty vehicles
- Transit buses (7 different OEMs)
- Shuttle Busses (2 OEMs)
- Custom Chassis (5 OEMs) for MD and HD Vehicles
- Other Specialty vehicles (i.e. refuse, concrete mixers, etc.)?

Barriers:
- Vehicle availability
- CNG infrastructure is not widely available, generally used by individual fleets and privately owned
- Incremental cost is high ($11,000 - $25,000 per vehicle)
Biodiesel

Ready to use

• U.S. produced 683 Million gallons in 2008
• 17 existing fueling stations within the GYA – from Bozeman to Jackson Hole

Potential Advantages

• Can use up to a 20% in any vehicle (this is the minimum blend needed for compliance with EPAct)
• When handled properly, B20 can be used year round in cold climates
• Only minor modifications required to use higher blends
• Doubles as a lubricity additive
• Wide variety of feedstocks

Disadvantages

• Potential cold-weather impacts of blends higher than B20
• Not as environmentally or energetically sustainable as “renewable diesel”
Biodiesel

Biodiesel use in diesel vehicles offers more immediate opportunities to reduce GHG emissions

Vehicle opportunities
- Construction equipment and Heavy-duty diesel vehicles
- Expand biodiesel use by converting gasoline light-duty trucks to diesel?
- Heavy-duty Diesel Electric Hybrids
  - 22 model year 2010 vehicles available
  - Mostly busses, some trailers, vocational, utility trucks

Barriers:
- Light-duty vehicle availability
- Data – Where are you diesel vehicles located?
- Where are your biodiesel stations located? (Lat/Long coordinates)
Ethanol

Corn based ethanol

- Low Ethanol blends (E10) have a higher energy content than higher blends (E85) and therefore command a higher price = most corn ethanol (99%) is blended into E10, not E85
- Corn Ethanol will not substantially reduce gasoline consumption

Cellulosic ethanol

- Source: dedicated energy crops & waste biomass
  - Does not compete with food production
  - Requires less land than corn ethanol
  - More efficient conversion to fuel
- DOE Target: Cost competitive by 2012
- Federal Mandate: 16B gallons by 2022
- **Cellulosic ethanol will be produced as E85**
  - E10 demand satisfied by corn ethanol
  - *Cellulosic ethanol’s success dependant on widespread E85 infrastructure*
Ethanol

Algae based biofuels – A potential game changer?

- Need inputs: sunlight, CO\textsubscript{2}, Water
  - Can sequester the CO\textsubscript{2} from power plant stacks
  - Can be produced in high density on non-arable land
  - Can potentially be produced using salt water
- Costs are not well understood
- In preliminary development from researchers and startups
- 10+ years until commercial deployment

![Land Requirements Chart]

**CO\textsubscript{2} emissions**

- Gasoline: 600 g CO\textsubscript{2}/mi driven
- Corn E-85: 400 g CO\textsubscript{2}/mi driven
- Cellulosic E-85: 200 g CO\textsubscript{2}/mi driven
- Algae Biofuels: 100 g CO\textsubscript{2}/mi driven

Source: Solazyme, Inc

![CO\textsubscript{2} Emissions Chart]

**90% Reduction**

Sources: ORNL Bioenergy Feedstock Development Program, Algenol
**Flex Fuel Vehicles (FFVs)**

FFVs are the most widely available and least expensive AFVs available

**Light-Duty Vehicle opportunities**
- 34 different Model Year 2010 vehicles
- 78 different vehicles models/configurations available through GSA
- Incremental cost is minimal ($0 - $3,000 per vehicle)

**Barriers:**
- Infrastructure – 1 fueling station (Mammoth Hot Springs) within 100 miles of Yellowstone
- GHG Emissions benefits are questionable
- Lost power content and fuel economy compared to gasoline
Hybrid Electric Vehicles (HEVs)

Light & Medium Duty Vehicles
- More vehicles available from GSA lease
- Chevy Silverado (4x2 and 4x4)
- Ford Escape (4x2 and 4x4)
- Honda Insight & Ford Fusion
- More vehicles should be available in coming years
- White House pushing Hybrid acquisitions

Barriers:
- Incremental cost is high
- Don’t contribute to alternative fuel use mandates
- Replacing existing AFVs with access to alt fuel with Hybrids could actually increase petroleum use
Plug-in Hybrid Electric Vehicles (PHEVs)

Advantages

- Cheaper (smaller) batteries
- Same environmental and energy advantages as EV’s if driven in all-electric range
- Better range than EVs
- Different design approaches may work best with GYA driving patterns (Prius vs. Volt)

Availability??

- 5 small, start-up companies converting Prius’ and Escapes
Electric Vehicles (EVs)

Potential Advantages

• Quiet, clean, and quaint = Happy Tourists
• Zero oil, low GHG emissions, and pollution removed from population
• Electricity storage stabilizes grid and enables renewables
• Electric motor has great performance characteristics

Vehicle Availability

• Neighborhood Electric Vehicles (NEVs) are well-established and inexpensive
  • 30 mile range, cost $7-14K, 25 mph
  • Full-speed EVs: 19 vehicles at the North American Auto Show
    • Major manufacturers such as Nissan, Ford, Mitsubishi in 2010
    • Priced from $25K to $109K
Electric Vehicles (EVs) - Charging

EV infrastructure buildup will be cheaper and faster than that of ethanol

- Relatively cheap and convenient
- EVs use existing capital stock more effectively
- EVs must be charged at off-peak hours
- Grid should have ample capacity
- New Technologies allow discharge to grid
- Smart Grid

Charger

- Converts to DC, increases voltage, and controls amperage
- SAE J1772- new standard plug

<table>
<thead>
<tr>
<th>Charger Type</th>
<th>Charge Time</th>
<th>Cost (with installation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Charger</td>
<td>8 hours</td>
<td>$4,000</td>
</tr>
<tr>
<td>Fast Charger</td>
<td>1 hour</td>
<td>$6,000</td>
</tr>
</tbody>
</table>
Conclusions

- GYA has numerous opportunities to reduce GHG emissions through the fleet, but geographic constraints & mission needs complicate the possibilities

- **Downsize!!**
  - Light-duty gasoline trucks offer the greatest per vehicle fuel savings (hybrids & diesel)
  - Biodiesel infrastructure well developed and widespread in Yellowstone NP
  - Medium & Heavy Duty trucks/equipment – Biodiesel & CNG (but lack CNG infrastructure)
  - Acquire light-duty diesel trucks?
  - NEVs may offer immediate benefits in some locations
  - Long-term possibilities with PHEVs & EV’s?
  - A proper analysis cannot be completed without complete and accurate data

Silverado/Sierra 4WD Hybrid: 21 mpg vs. 15 mpg

Smith Electric Trucks
INCREASED DEPLOYMENT OF NGVs:

- CNG and LNG fuel consumption increasing
- Fuel cost savings of CNG over gasoline and diesel is expected to increase due to increases in domestic supplies
- Carbon intensity of CNG is less than diesel in HDVs

**Carbon Intensity of Various Fuels in California HDVs**

- ULSD: 94.7
- Biodiesel (Soy): 83.3
- Renewable Diesel (Soy): 82.2
- LNG: 83.1
- CNG: 75.2
- Hydrogen (NG): 74.8
- Electricity: 46.0
- Renewable Diesel (Tallow): 39.3
- Biodiesel (Grease): 15.8
- Dairy CNG: 13.5
- Landfill CNG: 12.5

Where are we going?

- Where are we going?