Cost Effectiveness of Alternative Diesel Fuel Options

Alternative Diesel Fuel Symposium

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Disclaimer

- This analysis does not necessarily represent the views of the California Energy Commission
- This analysis has not been approved or disapproved by the California Energy Commission
Presentation Overview

I Background
II Cost Effectiveness Analysis
III Discussion – Implications
IV Conclusion
Background

– Power Plant Siting
– Energy Efficiency Standards
– Energy Assessment
– Contingency Planning
– Fuels / Resource Assessment
– Transportation - Alternative Fuels and Technologies
Transportation Energy Policy Goals

- Reduce Petroleum Dependence
- Increase transportation efficiency and motor vehicle fuel economy
- Encourage market development that provides fuel choices
- Provide information on vehicle technology and fuel choices
### Past Energy Commission Investments
(Technology R&D and Demonstrations)

<table>
<thead>
<tr>
<th>Programs</th>
<th>Alternative Diesel Fuel (ADF) ($ millions)</th>
<th>Alternative Fueled Vehicles (AFV) ($ millions)</th>
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<tbody>
<tr>
<td>Clean Safe School Bus</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Clean Fuel Infrastructure</td>
<td>0</td>
<td>5.3</td>
</tr>
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<td>Carl Moyer</td>
<td>0.65</td>
<td>4.3</td>
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<td>Flexible Fueled Vehicle</td>
<td>0</td>
<td>42.0</td>
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<tr>
<td>Heavy-Duty Alternative Fuels</td>
<td>0</td>
<td>3.0</td>
</tr>
<tr>
<td>TETAP</td>
<td>0</td>
<td>3.0</td>
</tr>
<tr>
<td>Clean Diesel</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>Med-Duty CNG Demo</td>
<td>0</td>
<td>0.6</td>
</tr>
<tr>
<td>Efficient Vehicle Incentive</td>
<td>0</td>
<td>5.0</td>
</tr>
<tr>
<td>Electric Vehicle</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$0.7</strong></td>
<td><strong>$169.6</strong></td>
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Need For Cost Effectiveness (C-E) Analysis

■ Governmental programs need to gauge their relative effectiveness of investments
■ Difficulty in comparing ADF to AFVs
■ Emission differences between options continue to narrow
■ Need a common yardstick to compare the relative effectiveness of options
■ ADFs need to rationalize higher fuel prices for reducing petroleum and emissions
Cost-Effectiveness Limitations

- Is specific to the fleet evaluated, may not fully represent the technology
- Restricted to actual expenses - does not anticipate technology advancements or improved economics
- Snapshot of the dynamic transportation technologies
- Does not evaluate the potential benefits to California Fleets if each technology is expanded
- C-E analysis provides an analytical screening assessment of ADFs and AFVs
Cost Elements Considered

- Used California Fleets expenditures for 1999-2002
- Evaluated AFVs & ADF incremental expenses:
  - Vehicle capital price,
  - Infrastructure capital price,
  - Maintenance and
  - Fuel expenses
Cost Effectiveness Calculation

\[ C-E = (\text{annualized}) \ ? \text{vehicle} + \text{infrastructure} + \text{maintenance} + \text{fuel expenses} \]

Capital Recovery Factor: 5%
Infrastructure Life : 20 years
Vehicle Life : 12-15 years
Cost-Effectiveness of ADFs vs AFVs

- Studied: 12 heavy-duty vehicle / technology options
- Evaluated: Petroleum, Particulate Matter and NOx reductions
- Compared AFVs: Propane, LNG, CNG, Diesel Hybrid to:
  - Biodiesel, Diesel Water Emulsion, Fischer-Tropsch Diesel (with and without a diesel soot filter)
## Assumptions & Finding

### Heavy-Duty Vehicles

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>LNG Waste Management San Diego</td>
<td>$35,000</td>
<td>$1,266,666</td>
<td>4.0</td>
<td>4.0</td>
<td>0.2**</td>
<td>-0.15</td>
<td>12</td>
<td>45</td>
<td>100%</td>
<td>50%</td>
<td>0.03g/hp - 65%</td>
<td>0.01g/hp - 80%</td>
<td>0.1g/hp - (15%)</td>
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<tr>
<td>LNG Transit Bus (OCTA)</td>
<td>$40,000</td>
<td>$2,200,000</td>
<td>5.0</td>
<td>5.0</td>
<td>0.2**</td>
<td>-0.45</td>
<td>15</td>
<td>20</td>
<td>100%</td>
<td>50%</td>
<td>0.1g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
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<tr>
<td>LNG Class-8 Dual-Fuel (Harris Ranch)</td>
<td>$33,000</td>
<td>$640,000</td>
<td>8.0</td>
<td>8.0</td>
<td>0.2**</td>
<td>-0.45</td>
<td>15</td>
<td>18</td>
<td>100%</td>
<td>50%</td>
<td>0.1g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
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<tr>
<td>CNG School Bus (Tehachapi)</td>
<td>$29,269</td>
<td>$2,840,000</td>
<td>5.0</td>
<td>5.0</td>
<td>0.17**</td>
<td>-0.45</td>
<td>15</td>
<td>43</td>
<td>100%</td>
<td>50%</td>
<td>0.1g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
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<tr>
<td>CNG Transit Bus (Averaged)</td>
<td>$49,500</td>
<td>$2,866,166</td>
<td>3.0</td>
<td>3.0</td>
<td>0.17**</td>
<td>-0.45</td>
<td>15</td>
<td>43</td>
<td>100%</td>
<td>50%</td>
<td>0.1g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
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<tr>
<td>Propane (LA DOT)</td>
<td>$16,000</td>
<td>$20,000</td>
<td>4.0</td>
<td>2.5</td>
<td>0.01</td>
<td>-0.45</td>
<td>15</td>
<td>40</td>
<td>100%</td>
<td>63%</td>
<td>0.03g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
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<tr>
<td>Diesel Hybrid Transit Bus (NYTA)</td>
<td>$103,000</td>
<td>$0</td>
<td>4.0</td>
<td>6.0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>43</td>
<td>100%</td>
<td>50%</td>
<td>0.1g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
<td></td>
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<tr>
<td>Diesel Truck (DPF &amp; 15-ppm S)</td>
<td>$6,000</td>
<td>$50,000</td>
<td>8.0</td>
<td>8.0</td>
<td>0</td>
<td>0.05</td>
<td>12</td>
<td>100</td>
<td>100%</td>
<td>0%</td>
<td>0.03g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
<td></td>
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<tr>
<td>Projected Fischer-Tropsch (DPF)</td>
<td>$6,000</td>
<td>$50,000</td>
<td>6.0</td>
<td>6.0</td>
<td>0</td>
<td>0.30</td>
<td>12</td>
<td>100</td>
<td>100%</td>
<td>10%</td>
<td>0.03g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
<td>95%</td>
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<tr>
<td>Projected Fischer-Tropsch</td>
<td>$0</td>
<td>$50,000</td>
<td>6.0</td>
<td>6.0</td>
<td>0</td>
<td>0.30</td>
<td>12</td>
<td>NA</td>
<td>100%</td>
<td>8%</td>
<td>0.03g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
<td>30%</td>
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<tr>
<td>Diesel Water Emulsion</td>
<td>$0</td>
<td>$50,000</td>
<td>6.0</td>
<td>6.0</td>
<td>0</td>
<td>0.25</td>
<td>12</td>
<td>NA</td>
<td>100%</td>
<td>5%</td>
<td>0.03g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
<td>64%</td>
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<td>Biodiesel E20</td>
<td>$0</td>
<td>$50,000</td>
<td>6.0</td>
<td>5.9</td>
<td>0</td>
<td>0.20</td>
<td>12</td>
<td>NA</td>
<td>100%</td>
<td>20%</td>
<td>0.03g/hp - 80%</td>
<td>0.03g/hp - 80%</td>
<td>0.01g/hp - 80%</td>
<td>22%</td>
</tr>
</tbody>
</table>

** includes fuel cost
Fig. 1. Displaced Petroleum per Million Dollars Expended

- Propane - Class 5-6
- Projected Fischer-Tropsch
- Projected Fischer-Tropsch (DPF)
- Biodiesel B20
- Liquefied Natural Gas
- CNG School Bus
- CNG Transit Bus (NY)
- Diesel Hybrid Transit Bus (NY)
- Diesel Water Emulsion

Prototype
Fig. 2  Lifetime NOx Reduction per Million Dollars Expended
(in 1999-2002)

Assumes 4.0 g NOx baseline. Wide bars represent certification, verification or best estimates for each option. Uncertainty bars indicate the in-use findings for CNG and LNG technologies, for the others they represent the range of performance determined by varying assumptions.
Fig. 3. Particulate Matter and Toxics Reduction per Million Dollars Expended

Particulate Matter Reduction (Tons/10 Million Dollars)

- Low Sulfur Diesel Truck (DPF) +10 c/gall
- Diesel Water Emulsion (DPF)
- Projected Fischer-Tropsch (DPF)
- Propane - Class 5-6 +20 c/gall
- Projected Fischer-Tropsch
- Biodiesel E20
- Diesel Hybrid Transit Bus (NY)
- CNG School Bus
- liquefied Natural Gas
- CNG Transit Bus (Averaged)
Fig. 4

Visualization of the Aggregate Reductions - Equally Weighting Petroleum, NOx and PM Reductions

1999-2002 investments Lifetime Reductions

- Petroleum Reduction
- PM & Toxics Reduction
- NOx Reduction

Relative Reduction Among Options:
- Projected Fischer-Tropsch (DPR)
- Projected Fischer-Tropsch
- LNG Class-8 Truck (Harris Ranch)
- Diesel Water Emulsion
- LNG Waste Management San Diego
- Diesel Hybrid Transit Bus (NY)
- CNG Transit Bus (Averaged)
- LNG Transit Bus (OCTA)
- CNG School Bus
- Biodiesel 228
Fig. 4b

Visualization of the Aggregate Reductions - Equally Weighting Petroleum, NOx and PM Reductions

What if these investments were made post 2010?

- Petroleum Reduction
- PM & Toxics Reduction
- NOx Reduction

Relative Reduction Among Options

- Propane Class-6
- Low Sulfur Diesel Truck (DPF)
- Projected Fischer-Tropsch (DPF)
- Projected Fischer-Tropsch
- LNG Class-8 Truck (Harris Ranch)
- LNG Waste Management San Diego
- Diesel Hybrid Transit Bus (NY)
- LNG Transit Bus (AVP)
- CNG Transit Bus (QCTA)
- CNG School Bus
- Biodiesel B20
Findings

- Propane, ULSD & Diesel Particulate filters investments provide the most cost-effective environmental benefits.
- FTD and biodiesel are cost-effective petroleum & particulate matter reduction options.
- Generally the least capital intensive fuel technologies are associated with the highest cost-effectiveness: Propane, ULSD, FTD.
- Most expensive technologies: CNG & LNG had the lowest C-E performance.
Regarding NOx Reduction: LNG & Propane performed well

- Diesel Water Emulsions environmental benefits are cost-effective with AFV’s.

- Biodiesel’s overall cost-effectiveness ranking improves post 2010

- Capital intensive fuel systems cost-effectiveness performance degrades post 2010
Conclusion

- Cost-Effectiveness Analysis is a basic screening tool, provides a simple comparison of options

- Alternative Diesel Fuels provide relatively cost-effective: petroleum, particulate matter and NOx reductions
Conclusion

- As emission standards are tightened, ADFs maintain and improve their relative benefits compared to traditional AFVs.