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2006
Applicable Statutes/Executive Orders

- Executive Order 13149 (2000)
Alternative Fuel Vehicle (AFV)

- Capable of using alternative fuel
  - Methanol, ethanol, other alcohols
  - Propane, Natural Gas
  - Hydrogen, Electricity, Biodiesel**

- “Dedicated” or “Dual-fuel”
  - “Bi-fuel” – 2 distinct tanks
  - “Flex-fuel” – single tank
Ethanol

- Feedstock: Corn, wheat barley, grasses
- Energy: 1 gal ethanol = 0.72 gal gasoline
- Often used as an additive to gas
- 85% or above Ethanol blends = “alternative fuels” under EPAct
- Some emission reductions (CO and NOx)
- Corrosive
- Engine calibration and fuel system issues
Natural Gas

- Primarily Methane (CH4)
- CO, NOx, CO2 down 90, 60 and 35%
- 3,000 or 3,600 psi typically
- Incremental vehicle costs: $1,000s
- CNG commercial grade outlet $0.25M to 0.5M or more
- 0.1% of total gasoline demand in 2003
- Performance and maintenance issues generally not a problem
Biodiesel

- From vegetable oils or animal fats
- 20% biodiesel mix common (B20)
- B20: Less CO2, PM, CO, SO2, more NOx
- Manufactured domestically
- Good lubricity properties
- Is a solvent
- Generally slightly more expensive
- Cold start issues
MTBE

- Synthetic oxygenate to increase combustion efficiency
- Possible carcinogen
- Ethanol may replace MTBE
Other Fuels/Vehicle types

- Methanol (from natural gas typically)
- Electric (ZEVs)
- HEVs
- LPG (Propane)
  - Still a few LPG AFVs in the federal fleet
- Fuel cell vehicles
Agency “X” Compliance Strategy

100 new vehicles: need 75 credits

One strategy:

- 50 conventional vehicles 0
- 10 “dedicated” vehicles 20
- 40 bi-fuel vehicles 40
- 6,750 gal biodiesel 15

Total credits 75
EPAct: What’s Broken

- Agencies are gaming the system – acquiring AFVs without using alternative fuel
  - Does nothing to support the intent of EPAct
  - Poor stewards of tax money
  - Failure to take advantage of environmental benefits of AFVs

- Failure to develop an acquisition strategy that takes full advantage of an agency’s limited resources
Agencies “doing extremely well” with EPAct Compliance

<table>
<thead>
<tr>
<th>Agency</th>
<th>2004 EPAct compliance %</th>
<th>% time alt. fuel used in AFVs</th>
<th>petroleum reduction %</th>
</tr>
</thead>
<tbody>
<tr>
<td>DoD Army</td>
<td>99</td>
<td>0.8</td>
<td>(16.8)</td>
</tr>
<tr>
<td>DoD Navy</td>
<td>100</td>
<td>9.1</td>
<td>13.9</td>
</tr>
<tr>
<td>DoD AF</td>
<td>96</td>
<td>9.9</td>
<td>5.3</td>
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<tr>
<td>USPS</td>
<td>79</td>
<td>5.4</td>
<td>0.2</td>
</tr>
<tr>
<td>DOE</td>
<td>99</td>
<td>21</td>
<td>1.8</td>
</tr>
<tr>
<td>Interior</td>
<td>106</td>
<td>64.3</td>
<td>1.8</td>
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<tr>
<td>DoD USMC</td>
<td>243</td>
<td>21.4</td>
<td>27.5</td>
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<tr>
<td>HHS</td>
<td>60</td>
<td>34</td>
<td>10</td>
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<tr>
<td>NASA</td>
<td>198</td>
<td>27.6</td>
<td>15.3</td>
</tr>
<tr>
<td>EPA</td>
<td>83</td>
<td>15</td>
<td>17.7</td>
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<tr>
<td>State</td>
<td>110</td>
<td>20.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Treasury</td>
<td>2480</td>
<td>16.3</td>
<td>20.1</td>
</tr>
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</table>
## Other Agencies

<table>
<thead>
<tr>
<th>Agency</th>
<th>2004 EPAct compliance %</th>
<th>% time alt. fuel used in AFVs</th>
<th>petroleum reduction %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>95</td>
<td>7</td>
<td>8.6</td>
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<tr>
<td>VA</td>
<td>24</td>
<td>1.5</td>
<td>(12.3)</td>
</tr>
<tr>
<td>DOT</td>
<td>29</td>
<td>10.1</td>
<td>11.7</td>
</tr>
<tr>
<td>Labor</td>
<td>19</td>
<td>---</td>
<td>(2.5)</td>
</tr>
<tr>
<td>Commerce</td>
<td>46</td>
<td>10.3</td>
<td>(51.9)</td>
</tr>
<tr>
<td>Justice</td>
<td>86</td>
<td>21.7</td>
<td>17</td>
</tr>
<tr>
<td>CIA</td>
<td>8</td>
<td>1</td>
<td>---</td>
</tr>
<tr>
<td>GSA</td>
<td>91</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>EOP</td>
<td>29</td>
<td>76.8</td>
<td>69.6</td>
</tr>
<tr>
<td>HUD</td>
<td>---</td>
<td>0.4</td>
<td>15.8</td>
</tr>
</tbody>
</table>
Why can’t/won’t federal agencies comply with EPAct and/or E.O. 13149?

- Too expensive
- Can’t track alternative fuel use
- Little alternative fuel infrastructure
- Nobody watching
  - Earthjustice
Conventional fuel infrastructure

Alternative fuel infrastructure

Federal Agency Guidance

- **DOE Guidance**
  - Promulgated on DOE’s web site
  - “Federal Fleet Strategy Development Supplement”
  - DOE Compliance Strategy

- **DoD Guidance**
  - Published in 2003

- Various other compliance assistance tools
## DOE’s Four-Part Strategy

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Planned by 2005</th>
<th>2004 Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiesel</td>
<td>473,745 GGE</td>
<td>85,000 GGE</td>
</tr>
<tr>
<td>Alt. Fuel Use</td>
<td>1,222,511 GGE</td>
<td>400,000 GGE</td>
</tr>
<tr>
<td>Fuel economy</td>
<td>19.5 mpg</td>
<td>19.1 mpg</td>
</tr>
<tr>
<td>“Fleet efficiency”</td>
<td>2% petroleum reduction</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

1.8 % drop in petroleum consumption relative to 1999

Strategy shift, but older strategies still offered as guidelines
Problem Statement

Hypothesis: Federal agencies lack an objective, quantitative methodology for AFV acquisitions and E.O. 13149 compliance. A system of tiered models could improve the process.
Research Approach

Develop a system of IPs

- Objective functions based on fleet manager inputs, federal agency annual reports and conversations with fleet managers
- Assist with EPAct and E.O.13149 compliance
- Evaluate utility of methodology using a test agency
- Rapidly identify different EPAct compliance strategies
What Agency to Use?

- NREL suggested EPAct topic, military agency

- Navy allowed access to 2005 data

- 38% EPAct compliance in 2000, 72% in 2002, 100% in 2004, 280% in 2005

- Navy acquired 2,982 LDVs in 2005
“Covered” Fleets

- 20 or more LDVs centrally refueled
- Entity owns 50 vehicles nationally
- Metropolitan Statistical Area (MSA)
- States & alternative fuel providers are covered too, as well as federal agencies
- Feds: EOP, GSA, NASA, Agriculture, CIA, Commerce, DoD, DOE, HHS, HUD, Interior, Justice, State, DOT, Treasury, VA, EPA, USPS
Dissertation Process Summary

The Problem

Hypothesis: Federal agencies lack an objective, quantitative methodology for AFV acquisitions and E.O. 13149 compliance. A system of tiered models could improve the process.

Sub-Problems

- Literature Review 4.2.1
- Identify/Obtain Required Data 4.2.2
- Consider OR/Analytical Tools 4.2.3
- Construct Tiered IPs 4.2.4
- Post-run Analyses 4.2.5

Third-level problems

- Projected oil demand
- Type/quantity of vehicles replaced 4.2.2.1
- Networks, NLP, Simulation, LP...
- ID models needed 4.2.4.1
- Evaluation criteria

- Alt. fuel characteristics
- Inc. cost & avail of AFV’s 4.2.2.2
- IP decision for the model
- Link data 4.2.4.2
- Feedback to Navy

- E.O.s, rules, legislation
- Alt. fuel available / location 4.2.2.3
- Choose optimizer 4.2.3.1
- Create, run IPs 4.2.4.3
- Verify, validate, improve model

- Alternative fuel use
- Location of vehicles to be replaced 4.2.2.4
- Create fleet mgr survey 4.2.3.2

- Guidance for federal agencies
- Alt. fuel infrastr. costs 4.2.2.5

- Federal agency reports
- Fleet manager inputs 4.2.2.6

- Military-specific guidance & studies, lawsuits
## Survey Results

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Respondent 1</th>
<th>Respondent 2</th>
<th>Respondent 3</th>
<th>Respondent 4</th>
<th>Respondent 5</th>
<th>Respondent 6</th>
<th>Respondent 7</th>
<th>Respondent 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meet EPAct 75% requirement</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Meet E.O. 13149 requirements</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Reduction in dependence on foreign oil</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Opportunity for infrastructure investment</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Develop strategy centrally</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Constrain AFV spending to a budget</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>4</td>
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<tr>
<td>Small pollution reduction due to alternative fuel use</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Ability to develop a strategy quickly</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Local fleet inputs</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Local fleet inputs if central strategy process is available</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
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<tr>
<td>Exceed EPAct 75% to the greatest extent possible</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Acquire AFVs of one fuel type as opposed to another</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>AFVs actually use alternative fuel</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Replacement criteria determined centrally</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Acquired AFV must be located in MSA</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Interested in optimization model</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Other criterion</td>
<td>NA</td>
<td>NA</td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Model Construction Process

- Construct a series of IP models...
- Objective functions to be based in part on Fleet Manager inputs
- Some required components of the model
  - Outgoing vehicles/locations, potential incoming vehicles
  - Infrastructure availability
  - MSA determination by zip code
  - Zip code latitude/longitude
  - Acceptable replacements
  - Alternative fuel station construction costs
  - Potential construction sites
  - Budget, travel distances
Model variations

Objective values
- Maximize EPAct credits
- Minimize cost
- Maximize alternative fuel use
- Maximize “Public Good”

Variations
- Alternative fuel infrastructure construction
- Budget
- 75% EPAct requirement
- Min cost
- HEVs
- “Must Use” alternative fuel
- NDAA 2002 variants (7)
- “Public Good” variants (6)
U.S. Navy (July 2004 data for 2005)

2,368 “Reports Carryout” excerpt from GSA
- 72 Police, medical, MDV, bus, VI, PR

2,296
- 114 “Heavy” Service Utility & Stake Trucks…

2,182

1,638 Sedans
267 Vans
137 Pickups
118 SUVs
22 Other
Problem: Maximize the number of acquired AFVs that have access to alternative fuels

Subject to:

- EPAct 75 percent acquisition requirement is met
- Overall budget not exceeded (includes AFV and infrastructure construction costs)
- Each outgoing vehicle must have an acceptable incoming replacement
- EPAct credit scheme (i.e. 2 credits for a dedicated AFV)
- A maximum distance willing to travel to an alternative fuel station is not exceeded
- Alternative fuel infrastructure construction options considered
- Alternative fuel available if a dedicated AFV is acquired
- Integer and non-negative constraints
### Navy 2005 actual results

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDV EPAct credits</td>
<td>2,162</td>
</tr>
<tr>
<td>$ spent</td>
<td>$1.2M*</td>
</tr>
<tr>
<td>Number of funded AF stations from AFV budget</td>
<td>$0</td>
</tr>
<tr>
<td>Number of AFVs/HEVs acquired</td>
<td>2,161/0</td>
</tr>
<tr>
<td>% AF use in AFVs</td>
<td>10.6%</td>
</tr>
<tr>
<td>Number of AFVs with access to alternative fuel</td>
<td>unknown</td>
</tr>
<tr>
<td>Public Good</td>
<td>negative</td>
</tr>
<tr>
<td>Number of fire trucks can buy with excess funds</td>
<td>0</td>
</tr>
</tbody>
</table>

*estimate
## Selected Strategy “Winners”

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Compares favorably to Navy 2005 results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1 Max EPAct</td>
<td>EPAct credits, overall cost*</td>
<td>*If min cost applied 75% still met, $ left over</td>
</tr>
<tr>
<td>1-2 Min cost</td>
<td>Cost</td>
<td>75% still met, $ left over</td>
</tr>
<tr>
<td>2-7 Max AF use</td>
<td>Cost</td>
<td>75% still met, $ left over</td>
</tr>
<tr>
<td>2-10 Max AF use</td>
<td>AF use, AF construct., cost</td>
<td>75% still met, $ left over</td>
</tr>
<tr>
<td>3-2 Max EPAct</td>
<td>Cost, AF use</td>
<td>75% not met</td>
</tr>
<tr>
<td>4-X (Various)</td>
<td>AF use, AF construct., cost</td>
<td>NDAA 2002 met, $</td>
</tr>
<tr>
<td>5-1 Min cost</td>
<td>Cost, “Agency good”</td>
<td>75% still met, $ left over</td>
</tr>
<tr>
<td>5-2 Max AF use</td>
<td>AF build/use, “Agency good”</td>
<td>75% still met</td>
</tr>
<tr>
<td>5-4 Max public good</td>
<td>Public good maximized</td>
<td>75% still met</td>
</tr>
<tr>
<td>5-6 Max public good</td>
<td>Public good maximized</td>
<td>No solution restrictions</td>
</tr>
</tbody>
</table>
Major Conclusions and Recommendations

• Any reasonable EPAct and E.O. 13149 compliance strategy must consider infrastructure construction

• OMB/GSA/DOE need to recommend optimal compliance strategies similar to those suggested in this dissertation.

• DOE must update its guidance documents containing outdated and sub-optimal strategies with poor assumptions. Same for DoD.
Major Conclusions and Recommendations Continued

• DOE needs to ensure agency annual reports are more accurate, including its own.

• Conventions like FedFleet need to ensure that workshops are available discussing true optimal strategy options similar to those suggested in this dissertation.

• Federal agencies need to adopt an EPAct/E.O. 13149 compliance strategy similar to those suggested in this dissertation.