Support for Government Performance and Results Act (GPRA) Analysis

2013 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review
May 16th, 2013

Jacob Ward
U.S. Department of Energy, Vehicle Technologies Office (VTO)

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<table>
<thead>
<tr>
<th>Timeline</th>
<th>Barriers*</th>
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<tbody>
<tr>
<td>Start Date: October 2012</td>
<td>• Risk aversion*</td>
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<tr>
<td>End Date: September 2013</td>
<td>• Constant advances in technology*</td>
</tr>
<tr>
<td>Percent Complete: 40%</td>
<td>• Cost*</td>
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<tr>
<td></td>
<td>• Computational models, design, and simulation methodologies*</td>
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<td></td>
<td>• Complex benefits analysis</td>
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*from 2011-2015 VTP MYPP

<table>
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<tr>
<th>Budget</th>
<th>Partners</th>
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<tbody>
<tr>
<td>Total Project Funding (DOE)</td>
<td>Formal Collaborator</td>
</tr>
<tr>
<td>• $200,000 (Dave Anderson)</td>
<td>• ANL, ORNL, TA Engineering</td>
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<tr>
<td>• $150,000 (Jacob Ward, see VAN007)</td>
<td>Interactions</td>
</tr>
<tr>
<td>• $100,000 (Fred Joseck)</td>
<td>• All U.S. DRIVE Partners, outside companies (OEMs, suppliers...)</td>
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Objectives & Relevance

- **Objective**: calculate VTO benefits
  - Petroleum savings
  - GHG emissions reduction
  - Levelized cost of driving (light duty vehicles)

- **Relevance**:
  - Satisfy requirements of the Government Performance and Results Act
  - Link projected reductions in petroleum use and GHG emissions to VTP technical areas
  - Inform VTP managers about impacts of achieving technology targets

**VTO Subprograms**
- Advanced Combustion
- Electrification
- Advanced Materials
- Fuels and Lubricants

**GPRA Analysis**

**Macroeconomic indicators**
- petroleum consumption
- GHG emissions
- Fleet economy
Objectives & Relevance (continued)

• Outputs inform regular VTO analytical product updates:
  – EERE annual scenario portfolio analysis
  – Levelized Cost of Driving Program Record
  – Well-to-Wheels Record

• The GPRA analysis process was used for evaluation of the VTO SuperTruck Project

• Results from GPRA analysis have been used in developing technology targets for VTP initiatives:
  – U.S. DRIVE Partnership
  – EV Everywhere Grand Challenge
Approach: VTO Scenario Comparison

- Compare two scenarios to isolate the VTO technology portfolio:
  - Baseline “No-Program” scenario, which excludes all VTO-supported technology
  - Target scenario, in which vehicles meet VTP performance and cost targets:

  Advanced Combustion
  Electrification
  Advanced Materials
  Fuels and Lubricants

(Performance, cost)

Scenarios are a combination of times, powertrains, and uncertainties:

Time periods:
- 2015
- 2020
- 2030
- 2045

Powertrains:
- Internal Combustion
- Hybrid
- Plug-in hybrid
- Battery electric
- Fuel cell

Uncertainties:
- 10% (optimistic)
- 50% (mid-range)
- 90% (pessimistic)
**Approach: VTO Scenario Comparison**

**Process**
- Technology attribution
- Macro vehicle stock model
- Market penetration
- Vehicle modeling and simulation

**Approach**
- Based on estimated contribution to reduction in fuel/mi by technology
- Calculate fleet stock, and fuel use and GHG emissions by the fleet (VISION model using coefficients from GREET)
- Estimate sales shares by vehicle class and drivetrain type (LDVs: MA3T; HDVs: TRUCK model)
- Convert performance/cost inputs to vehicle-level attributes, including price, fuel economy, etc. (LDVs: Autonomie, HTs: HTEB)

**Data/Output**
- Strategic planning tools (fuel economy improvement by subprogram area, etc.)
- Macro-level petroleum consumption, GHG emissions, and fleet fuel economies
- Market penetration scenarios
- Fuel economy, vehicle incremental cost

**Tools and Models**
- Autonomie: Vehicle simulation tool (ANL), see #VAN008
- HTEB: Heavy Truck Energy Balance model (TA Engineering)
- MA3T: Market Acceptance of Advanced Automotive Technologies (ORNL)
- VISION: Stock/energy/Emissions accounting model (ANL), see #VAN006
- GREET: Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model, see #VAN002
Technical Accomplishments: Projected Fuel Economies

- LDV fuel economy is projected to increase much faster in the Target case
  - VTO technologies offer 50-85% improvements in fuel economy

- Class 7&8 combination truck fuel economy is projected to increase much faster in the Target case
  - VTO technologies offer 40-50% improvements in fuel economy
Much more rapid market penetration by HEVs and PHEVs in the “Target” case.

Little penetration of all-electric of fuel cell vehicles in these cases (little public charging or hydrogen infrastructure assumed)

Rapid penetration by best-in-class (BIC), since incremental cost is low

Adv Conv. and HEVs grow more gradually in market share

(Not shown: Analogous results for Class 7&8 Single Unit trucks and Class 4-6 trucks)
Technical Accomplishments: Projected Benefits

2050 Petroleum Use, Million barrels per day

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<thead>
<tr>
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<th>No-Program</th>
<th>Target</th>
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<tbody>
<tr>
<td>LDVs</td>
<td>5.4</td>
<td>2.9</td>
</tr>
<tr>
<td>M + HDVs</td>
<td>4.3</td>
<td>2.9</td>
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Annual GHG Emissions, Million MT CO$_2$eq/yr

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<tr>
<th></th>
<th>No-Program</th>
<th>Target</th>
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<tbody>
<tr>
<td>LDVs</td>
<td>1090</td>
<td>660</td>
</tr>
<tr>
<td>M + HDVs</td>
<td>730</td>
<td>490</td>
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</table>
• Benefits from hybridization are significant for LD HEVs and PHEVs
• Benefits from increased engine and drivetrain efficiency are large for heavy and medium duty trucks

(No benefit attributed to reduction in aerodynamic or rolling resistance of LDVs, since VTP has no projects for these for LDVs.)
Cost per mile broken out by component shows tradeoff between cost of fuel and cost of advanced-technology components

Error bars show range between Target Case and No Program Case

HEV and PHEVs are cost-competitive with Advanced SI vehicle in the Target Case

Levelized Cost of Driving = Purchase price of vehicle plus present value of fuel per lifetime vehicle-miles-traveled

Assuming:
- Fuel prices from AEO2012 High Oil Price Case
- 14,500 mi/year
- Ownership 5 year
- 7% discount rate
- Vehicle purchase and fuel costs only (no resale, insurance, maintenance costs)
Thanks to...

- T. Stephens, ANL, who leads LDV analysis and overall documentation (partner)
- A. Birky, TA Engineering, Inc., who perform simulations and analysis of medium and heavy trucks (partner)
- A. Rousseau, ANL, who performs light duty vehicle simulations (collaborator)
- Z. Lin (ORNL) on vehicle choice modeling (coordinating)
- EIA to maintain desired consistency with Annual Energy Outlook (coordinating)
- Cummins, Peterbilt, Detroit Diesel, Daimler, Navistar and Volvo to analyze new technologies for heavy trucks (coordinating)
Remainder of FY13
• Establish baseline case using AEO 2013
• Model/simulate vehicle performance and costs
• Project market shares and stock
• Calculate fuel use and emissions for U.S. fleet
• Update modeling and simulation assumptions
  – Testing procedures and sizing algorithms
• Include energy balance for each vehicle on each cycle
• Create an outputs database that can be used for other studies (i.e. cost sensitivities)

Proposed future improvements
• Improve fidelity of models (under separate funding)
• Include other costs (maintenance, resale value, etc.) in levelized cost
Successful achievement of EERE-VTP technology goals is estimated to result in the following benefits:

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<th>2030</th>
<th>2050</th>
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<tr>
<td>On-road fuel economy improvement (%)</td>
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<td></td>
</tr>
<tr>
<td>LDVs</td>
<td>50%</td>
<td>85%</td>
</tr>
<tr>
<td>HTs</td>
<td>40%</td>
<td>50%</td>
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<tr>
<td>Annual oil savings (million bpd)</td>
<td>2.8</td>
<td>3.8</td>
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<tr>
<td>Annual primary energy savings (quad/yr)</td>
<td>6.7</td>
<td>9.7</td>
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<tr>
<td>GHG emission reduction (million mt CO$_2$eq/yr)</td>
<td>400</td>
<td>580</td>
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Scenarios analyzed provide a cause-effect link between specific program targets and future benefits:
- Benefits from hybridization are significant for LD HEVs and PHEVs
- Benefits from increased engine and drivetrain efficiency are large for heavy and medium duty trucks
Questions

Jacob Ward
Analysis Manager,
Vehicle Technologies Office

202-586-7606
jacob.ward@ee.doe.gov