

Reducing Heavy-Duty Long Haul Combination Truck GHG Emissions and Fuel Consumption

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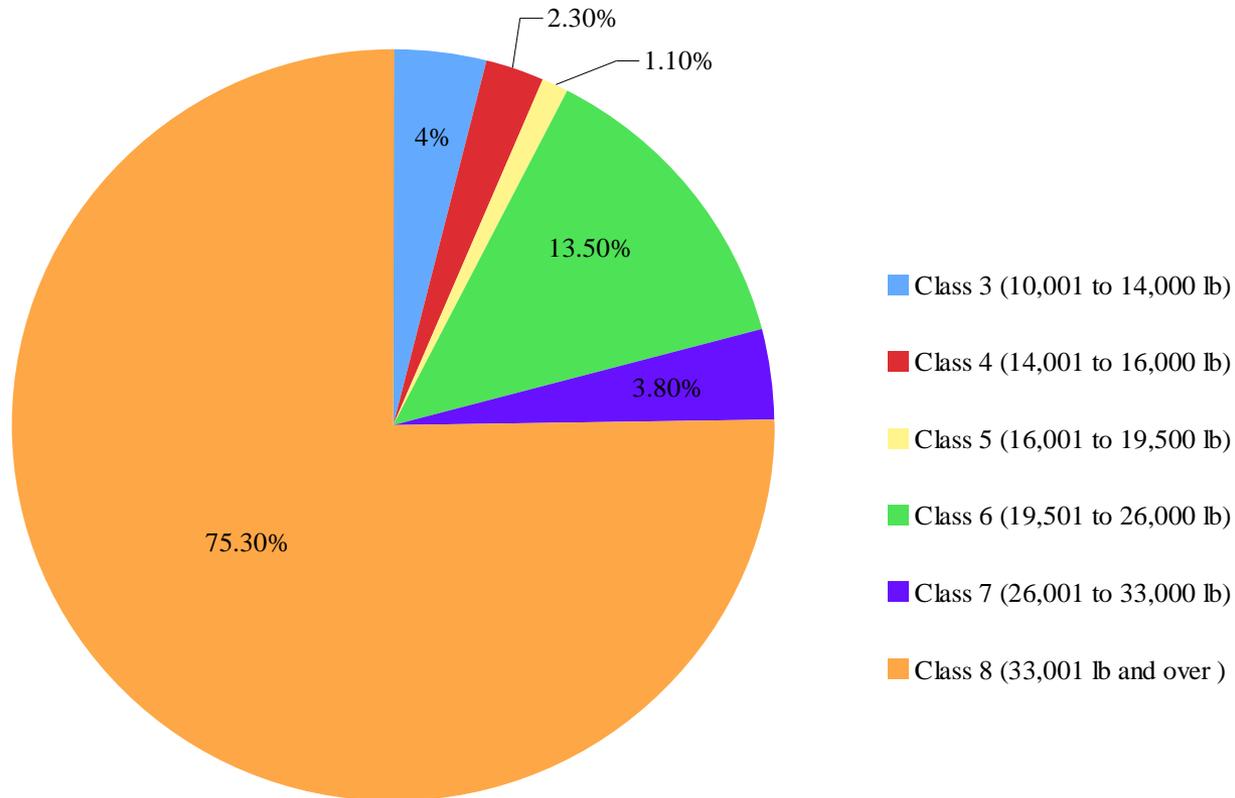
Mobile Source Technical Review
Subcommittee
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Introduction

- State and federal agencies are evaluating a host of opportunities to reduce GHGs
- In the US, trucks emit 6% of anthropogenic GHGs
- Emissions from these sources grew 79% from 1990-2007 – representing the largest % increase among mobile sources
- To assist policy-makers, NESCCAF and ICCT collaborated in a study to assess technology-based opportunities to reduce GHGs and fuel consumption from Class 8 long-haul trucks

Fuel Consumption by Medium and Heavy-Duty Vehicle Class



Study Goals

- Simulate improvements in fuel economy and GHG emissions from combined engine, transmission, and vehicle technologies
- Assess technical feasibility of reducing HD fuel consumption and GHG emissions
- Estimate GHG / fuel savings that could be achieved with widespread introduction of technologies
- Provide cost estimates for different combinations of technologies

Study Objectives

- Build on substantial work being done by government agencies, fleets & national labs
- Assess the GHG / fuel economy benefits of packaging technologies – some of which are commercially available - to achieve cost-effective climate change and fuel economy benefits
- Include some relatively expensive technologies to provide a robust overview of the range of opportunities

Research Steering Committee

- Guidance and direction on study design and implementation was provided by Research Steering Committee that included:
 - Engine manufacturers
 - Vehicle manufacturers
 - State and federal agencies
 - Fleets
 - Non profits and environmental groups
 - Suppliers
 - Developers of new HD technologies

Technical Approach

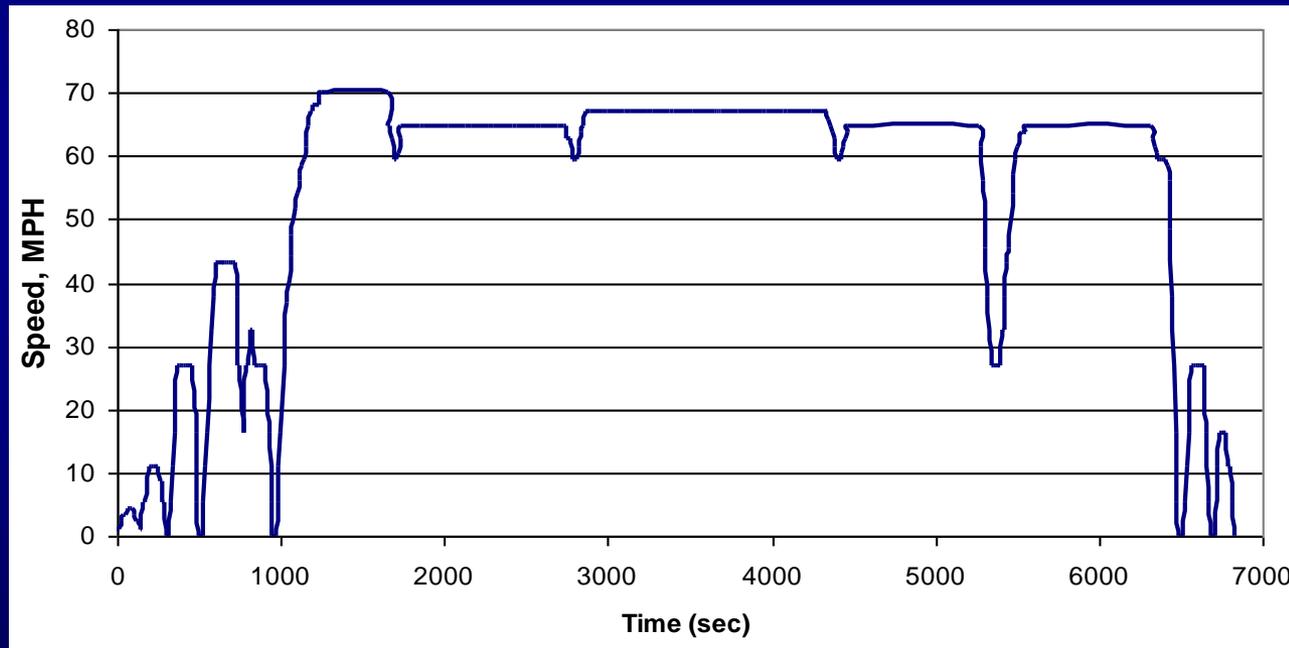
- Engine and vehicle simulation modeling conducted using RAPTOR and GT-Drive
- Cost analysis relied on published information and conversations with suppliers and OEMs
- Cost benefit analysis assumed 7% annual discount rate, prices of \$2.50 and \$3.53/gallon for diesel, 3 year and 15 year vehicle life
- Fleet-wide GHG and fuel consumption reductions estimated using model developed by TIAX, LLC
- Contractors:
 - SwRI conducted engine and vehicle simulation modeling
 - TIAX conducted cost analysis and cost/benefit calculations

Technical Approach (continued)

- Selected baseline vehicle representative of the current population
 - KW T-600 tractor with standard 53' van trailer
- Selected baseline engine representative of the current population
 - Volvo D13, 485 HP @ 1900 RPM
- Created a comprehensive list of potential fuel saving technologies and then selected a subset of the most promising technologies to simulate

Duty Cycle

- A duty cycle meant to simulate long haul operation was used for evaluating the selected technologies



Technologies and Policies Modeled with Standard Trailer

- Baseline vehicle
- Variable valve actuation
- Advanced exhaust gas recirculation
- Mechanical turbocompound
- Electrical turbocompound
- Parallel hybrid system
- Bottoming cycle
- Improved aerodynamics and tires
- Advanced aerodynamics and tires
- Hybrid, bottoming cycle, and slower road speed
- Slower road speed (60 mph)

Technologies Modeled with Longer and Heavier Trailer

- Longer and heavier trailer alone (Rocky Mountain Double) and advanced aerodynamics and tires
- Longer and heavier trailer with electrical turbocompound, hybrid, advanced aerodynamics and tires
- Longer and heavier trailer with bottoming cycle, hybrid, 60 mph, advanced aerodynamics and tires

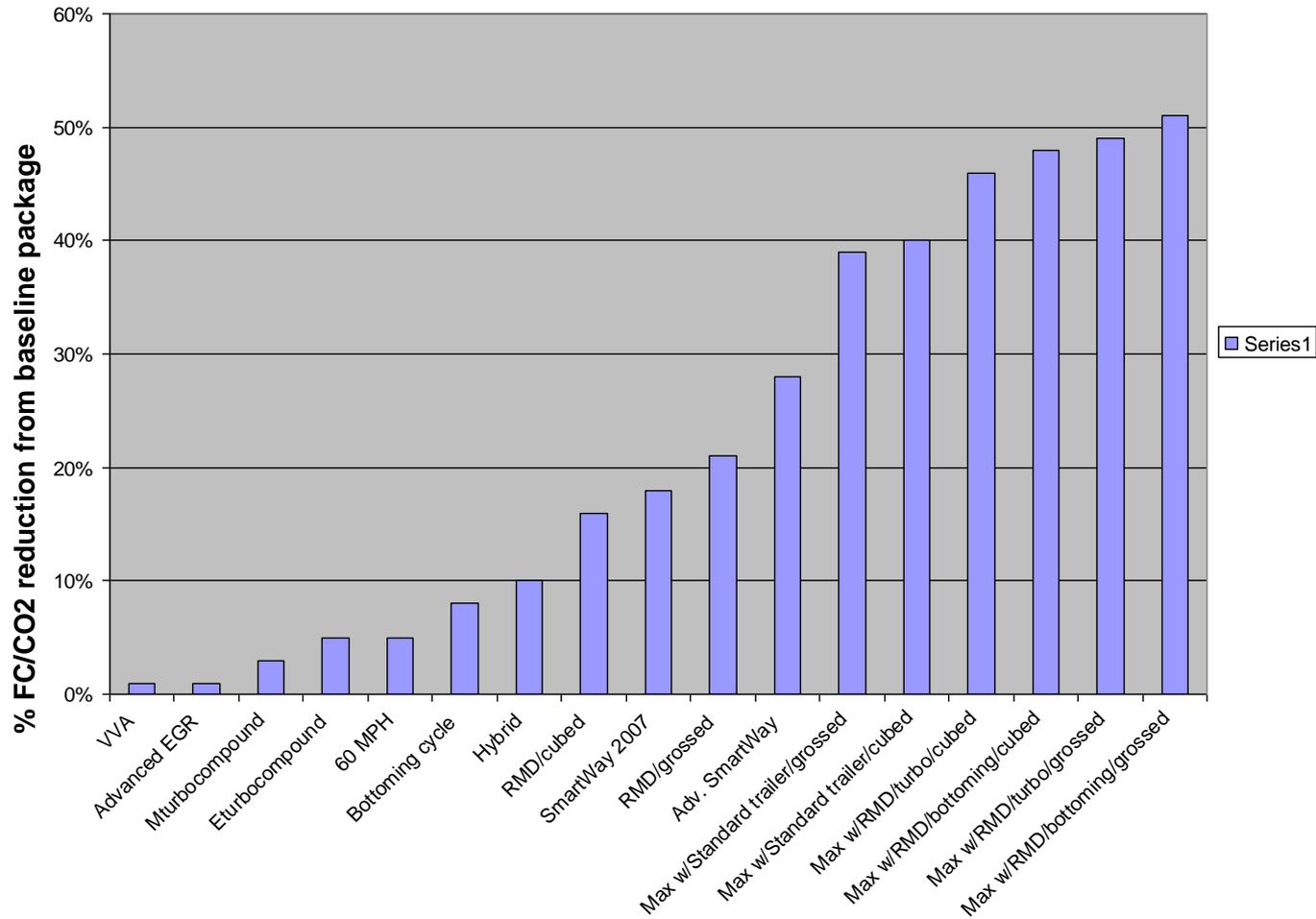
Results – Individual Measures

Measure	Fuel Consumption/ CO2 Reduction (%)	Incremental Vehicle Cost (\$) ^a	Lifetime Cost of Ownership (15 years, 7%) ^a	Time to Payback ^a (Years)
Baseline	n/a	n/a	n/a	n/a
Building Block Technologies				
SmartWay 2007 (SW1)	17.8%	\$22,930	-\$23,600	3.1
Advanced SmartWay (SW2)	27.9% ²	\$44,730	-\$55,800	3.8
Parallel hybrid-electric powertrain (HEV)	10%	\$23,000	\$100	7
Mechanical turbocompound	3.0%	\$2,650	-\$5,500	2.0
Electric Turbocompound	4.5%	\$6,650	-\$5,500	3.5
Variable Valve Actuation (VVA)	1.0%	\$300	-\$2,500	0.6
Bottoming cycle	8.0%	\$15,100	-\$4,800	5.2
Advanced	1.2%	\$750	-\$2,600	1.4
Operational Measures				
Rocky Mountain Double (RMD) trailers - 48' + 28' Trailers	16.1% (grossed out) 21.2% (cubed out)	\$17,500	-\$34,100	2.1
60 mph speed limit	5.0%	\$0	-\$13,900	n/a

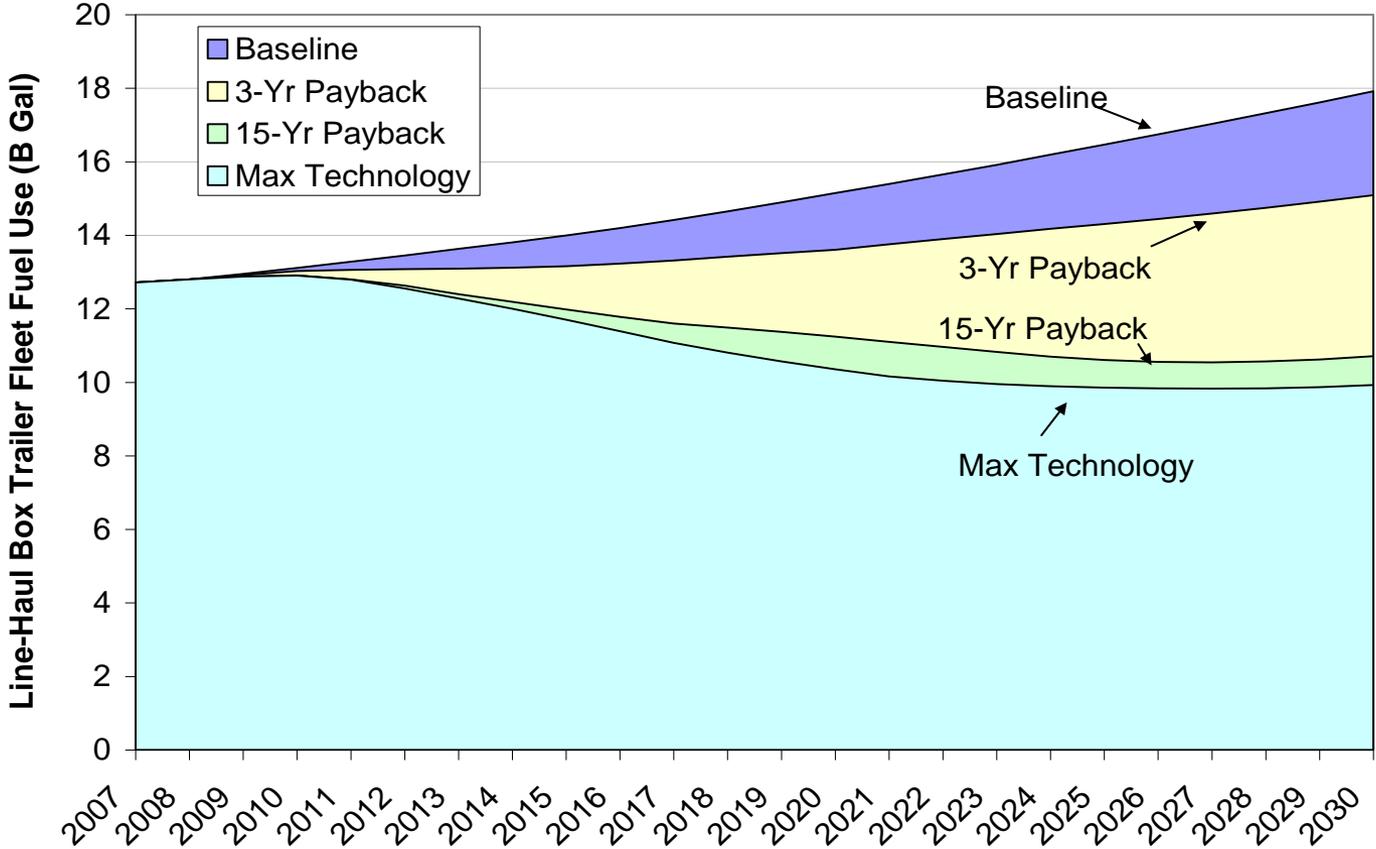
Results – Packaged Measures

Package	Fuel Consumption/ CO2 Reduction (%)	Incremental Vehicle Cost (\$) ^a	Lifetime Cost of Ownership (15 years, 7%) ^a	Time to Payback ^a (Years)
Maximum Reduction Combination Packages				
Maximum reduction combination 1 (standard 53' trailer, hybrid, BC, SW2, 60 mph)	38.6% (grossed out) 40.2% (cubed out) ⁶	\$71,630	-\$27,300 ⁵	4.8
Maximum reduction combination 2 (RMD, hybrid, el. turbocompound, VVA, SW2, 60 mph)	48.7% (grossed out) ⁶ 46.2% (cubed out) ⁶	\$80,380	-\$41,600 ⁵	4.3
Maximum reduction combination 3 (RMD, BC, hybrid, SW2, 60 mph)	50.6% (grossed out) ⁶ 48.3% (cubed out) ⁶	\$89,130	-\$37,200 ⁵	4.7

Summary of Findings – Simulation Modeling

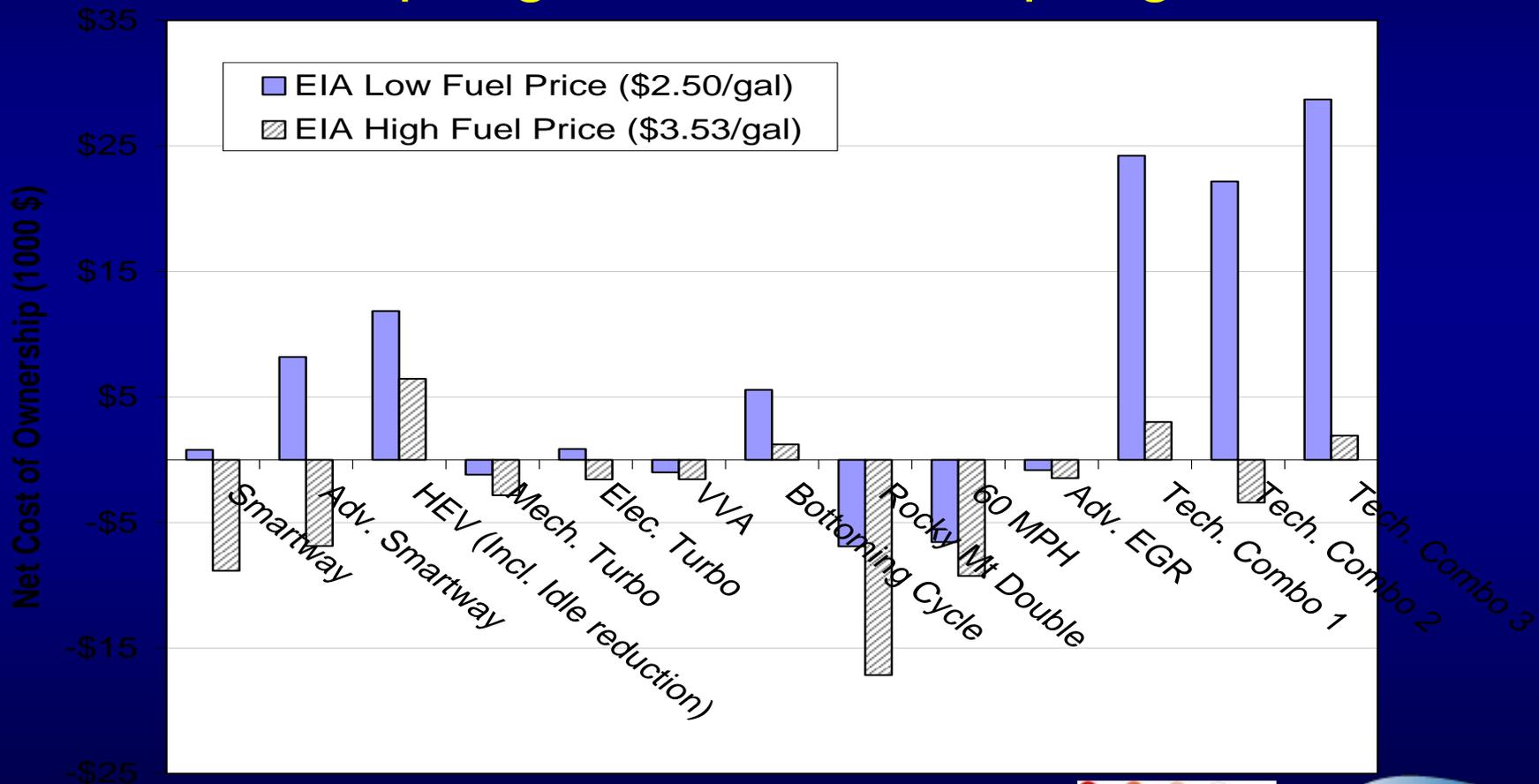


GHG Emissions and Fuel Use Avoided in the U.S. Fleet



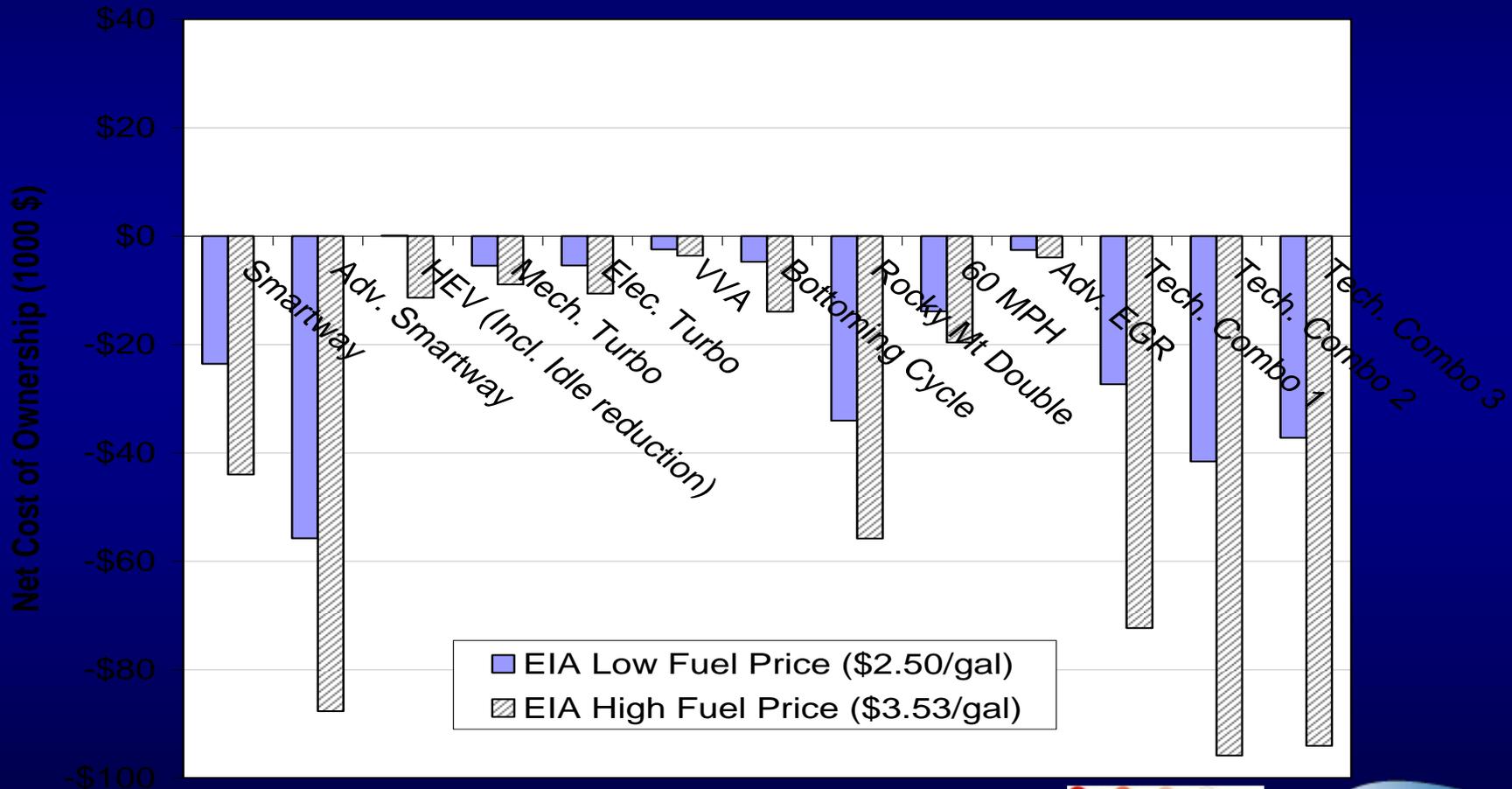
Results

3-year ownership case at both
\$2.50 per gallon and \$3.50 per gallon



Results

15-year cost of ownership scenario at both \$2.50 per gallon and \$3.50 per gallon



Conclusions

- GHG emissions and fuel consumption can be reduced up to 40% in a standard size heavy-duty long haul truck in the 2012-2017 timeframe with the introduction of drivetrain and vehicle technologies
- With changes to tractor length and weight, fuel consumption and GHG emissions can be reduced by up to 50%
- These benefits can be achieved at a cost savings assuming a 15 year payback period and a very conservative fuel cost assumption of \$2.50 per gallon

Conclusions

- Implementing technologies with ≤ 3 -year payback could reduce GHGs by 12% and save over 2 billion gallons per year in the 2030 time frame compared to BAU
- Implementing technologies with a ≤ 15 -year payback could reduce GHGs by 39% and save 7 billion gallons of fuel per year by 2030
- Implementing feasible technologies regardless of cost could save 8 billion gallons per year and 88 million tons of CO₂ by 2030 (44% reduction)
- Additional fuel savings / GHG reductions can be achieved by applying many of these technologies / approaches to other HDV classes & existing fleet

Conclusions

- Assuming the industry's 18 – 36 month payback expectations and a steady diesel fuel price, the expected savings will be modest absent regulatory drivers or incentives
- Given that some of these options are currently available and others are in development, it is clear that achieving substantially greater reductions will require incentives or regulations to promote the deployment of GHG-reducing / fuel saving technologies

Discussion

Given:

- The current or expected availability of cost-effective strategies to reduce fuel use / GHG emissions
- The non-integrated nature of HD truck manufacturing
- The short payback period expected in trucking industry
- The fact that multiple federal agencies have regulatory authority over this sector
- The variety of different state regulations governing longer-heavier trailers
- The economic climate
- The possibility of a national cap on GHGs

Discussion Questions

- What combination of technological developments, economic incentives (to manufacturers and the trucking industry), federal regulations, and changes in state regulations are needed to maximize the deployment of cost-effective strategies?
- What can the MSTR do to assist in the development of a comprehensive approach for achieving fuel use and GHG emission reductions from long-haul trucks?

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