Speeding High Efficiency Truck Adoption:

Recommended Policies, Incentives and Investments

This report was written by CALSTART, with funding from the Energy Foundation. Bill Van Amburg and Jamie Hall served as the report's principal authors, with input from members of the High Efficiency Truck Incentives Task Force (see Appendix 1 for a list of Task Force members).

For questions or comments on the report or the recommendations presented here, please contact Bill Van Amburg, Senior Vice President (bvanamburg@calstart.org) or Jamie Hall, Policy Director (jhall@calstart.org). For questions regarding CALSTART's role in accelerating the transition toward cleaner, more efficient truck technologies, please contact the report authors or visit our website at www.calstart.org.

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TABLE OF CONTENTS

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EXECUTIVE SUMMARY

Industry, government, and truck fleet owners all agree on the need for a move to more efficient trucks. For the first time ever, the US Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) will implement standards that will decrease fuel consumption and related emissions in the trucking sector, with regulations expected to be in place for MY 2014. The industry is ready and willing to be part of the solution, but also feels regulations alone are not sufficient for success: what is needed with regulations are the necessary incentives and support structures to provide a comprehensive approach.

The goal of this report is to identify the best incentives and complementary policies to overcome technology and market barriers and support an accelerated transition to more-efficient, cleaner trucks. CALSTART surveyed truck fleet users, manufacturers, and suppliers in order to better understand the primary implementation barriers, needs, and policy options that could address these issues. After the initial survey, CALSTART then worked with a multi-disciplinary Task Force of industry and vehicle user representatives to further refine the policy recommendations. The primary results are summarized below.

Truck efficiency matters, but standards alone are not enough to drive the market

More than 90% of fleet user and industry representatives surveyed for this work characterized greater efficiency in trucks as "very important" or as "critical/must have" for their business. However, standards alone are not sufficient to drive the change needed in this sector. Throughout the survey and follow up Task Force work, participants cited several key barriers to the development and deployment of efficient truck technologies:

- **High incremental cost** is the overwhelming issue cited and the primary barrier to widespread adoption of efficient truck technologies. Additionally both fleets and manufacturers noted they would ideally like to see a return on investment (ROI) in the neighborhood of 2-5 years.

Additionally, manufacturers cited high component costs and to- date limited supply chains for key components as an issue.

- **Availability of appropriate technology** is still a problem for the industry. Heavy duty vehicles are used in a very wide variety of applications, and advanced efficiency options do not yet exist for all truck sizes and uses.
- **Good information on performance, availability, and durability** of new technologies is still lacking. Questions and concerns over maintenance costs, reliability, and long term durability are widespread, slowing deployment and impeding customer acceptance.

Comprehensive investments and incentives are needed to support high efficiency trucks

Both the broader survey and the Task Force members noted that to spur near-term manufacturing and purchase there is a need for funding support at multiple points in the commercialization process, from research and development, to manufacturing, to actual purchasing and deployment. The top policy options cited by industry include:

- **Vouchers for truck purchase**: Purchase vouchers were identified as the preferred incentive tool, in place of tax credits and grant programs. Vouchers are a simple, streamlined incentive that can greatly improve the business case for new technologies, helping fleets purchase more efficient trucks and helping manufacturers and suppliers increase sales and build the production volumes needed to comply with standards. Vouchers involve little uncertainty or administrative burden, can be utilized by tax-exempt fleets, and effectively lower capital costs right at the point of purchase. Voucher models at the state level have proven highly successful.
- **Smart, targeted public support for research and development (R&D):** Both fleets and manufacturers support increased public investment in R&D. Increased funding should allow for designed-in cost reductions, and should also increase the availability of efficiency technologies for various applications.
- **Manufacturing assistance and incentives:** Fleets and manufacturers also agreed that advanced technology manufacturing grants are necessary to drive down technology costs and ensure continuing U.S. leadership and job growth in this sector.

Policy Framework: Supporting the Transition to High Efficiency Trucks

Based on survey results, external research, review of existing programs, and discussion of needs, the Task Force developed the following policy framework for high efficiency truck support. Industry respondents want to see strong, consistent, performance-based incentives that are designed in a way that makes sense for their business:

- Ensure strong, consistent, long term funding and incentives.
- Create a performance-based approach to purchase incentives.
- Provide recognition and reward for co-benefits (multiple rather than single outcomes).
- Directly target purchase cost differential.

Effective management and streamlined administrative processes were also identified as key to the success of public incentive and support programs:

- Ensure simple rules, streamlined processes, and fast turnaround times.
- Minimize delays, uncertainty, and political interference.

Valuing Co-Benefits

Improving truck efficiency will yield multiple economic and environmental co-benefits. These public co-benefits are *in addition* to the fuel savings. Research for this report demonstrates that when the full value provided by greater efficiency and co-benefits is quantified it provides a strong justification for incentives and investments. Some of these benefits include:

- **U.S. leadership and substantial job growth** in the advanced truck and technologies sector. One recent study found that the strong expansion of high-efficiency trucks can generate $24 billion in net economic benefits and grow 124,000 jobs in the U.S. by 2030.[1] American companies are currently the industry leaders in several of the enabling technologies necessary for high-efficiency trucks.
- **Improved energy security and the reduction of imported oil**. The transportation sector accounts for more than 70 percent of petroleum use in the United States.[2] Indeed, the only way to fully address the issues of reducing oil imports and increasing energy security as it relates to oil is in reducing its use in transportation. Given their high per vehicle use of fuel, trucks are significant contributors to petroleum use, but also prime platforms for its reduction via efficiency and fuel switching.
- **Reductions in criteria air pollution and related healthcare costs.** Transportation-related emissions are a major cause of poor air quality. This has very real economic consequences due to missed work days, increased incidence of respiratory problems, more frequent hospitalizations, and premature deaths. Nationwide health costs just from diesel emissions for 2010 have been estimated at $139 billion[3].
- **Reductions in conventional global warming pollution.** Nationwide, medium and heavy duty vehicles account for 18 percent of all global warming emissions from the transportation-sector.[4]
- **Reductions in black carbon and particulate matter.** Combustion of diesel fuel in medium and heavy duty trucks is a major source of particulate matter and so-called "black carbon." Black carbon is a major contributor to global warming, and reductions in black carbon can bring about near term climate change benefits.
- **Reduced noise pollution.** Conventional medium and heavy duty trucks are a source of noise pollution on roadways and in the neighborhoods where they operate. Some advanced vehicle technologies, such as hybridization and electrification, can significantly reduce the noise associated with these trucks while in driving and work site operations.
- **Greater freight efficiency and reduced long-term operating costs** for fleets, provided capital costs come down. Reductions in operating costs are of paramount importance to fleets, which operate with thin profit margins.

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[1] Union of Concerned Scientists and CALSTART, "Delivering Jobs: The Economic Costs and Benefits of Improving the Fuel Economy of Heavy Duty Trucks." May, 2010. http://calstart.org/Libraries/Publications/Delivering_Jobs_Final_Report.sflb.ashx

[2] U.S. Energy Information Administration, Annual Energy Review. http://www.eia.doe.gov/emeu/aer/pecss_diagram.html

[3] Clean Air Task Force, Diesel and Health in America: the Lingering Threat. 2005. http://www.catf.us/resources/publications/view/83

[4] Environmental Protection Agency (EPA). 2008. Inventory of U.S. greenhouse gas emissions and sinks, 1990–2006. EPA 430-R-08-005. Washington, DC.

For this analysis, we focused on three of these important "co-benefits" of increased truck efficiency: (1) GHG emission reductions, (2) reductions in oxides of nitrogen (NOx) emissions,[5] and (3) energy security or petroleum reduction benefits. These were chosen because they represent important, yet distinct, categories of benefits. GHG emissions reductions are important for the fight against climate change, and are at the heart of the new standards for MY 2014 trucks. NOx emissions are one of the most important sources of poor air quality and related health problems. Energy security and petroleum reduction are primarily economic and geopolitical issues. Estimated co-benefit values are summarized in Table ES-1 for a sample of fuel efficiency gains and corresponding fuel consumption reductions.[6]

Table ES-1: Summary of Selected Co-Benefit Value Estimates for Truck Efficiency Improvements

	Fuel Efficiency Gain	Corresponding Fuel Consumption Reduction	Value of NOx Emission Reductions	Value of GHG Emission Reductions	Value of Energy Security	*Total Value of Selected Co-Benefits*
Heavy Heavy Duty	5%	**4.8%**	$2,500	$1,800	$1,300	***$5,700***
	20%	**16.7%**	$8,800	$6,400	$4,600	***$19,900***
	50%	**33.3%**	$17,600	$12,800	$9,200	***$39,700***
Medium Heavy Duty	5%	**4.8%**	$300	$300	$200	***$900***
	20%	**16.7%**	$1,000	$1,200	$900	***$3,000***
	50%	**33.3%**	$1,900	$2,400	$1,700	***$6,100***

The diversity of co-benefits here emphasizes the fact that there are many reasons to push for greater truck efficiency. For a long-haul Class 8 combination truck, **the per vehicle life cycle value of the selected co-benefits from fuel efficiency ranges from more than $5,000 for a 5 percent fuel economy gain, to nearly $40,000 for a 50 percent fuel economy gain.** While not as high, there are meaningful societal co-benefits from more efficient medium duty trucks (Class 4-7) as well, ranging from around $900 for a 5 percent fuel economy gain to more than $6,000 for a 50 percent gain. These vehicle platforms also are often the first markets for technology that eventually transitions to Class 8 trucks, and therefore are important early proving grounds.

Recommended Incentive and Support Structures

The top recommended policy options for each barrier in the commercialization process are outlined below. Note that membership on the Task Force does not necessarily imply endorsement of all of the recommendations outlined here. However, the group did come to strong general agreement on needs

[5] To highlight the potential benefits, the calculations in this report assume that fuel consumption reductions can be accompanied with proportional NOx emission reductions on a system level, which will include advanced emission-reducing solutions and technologies, in future high efficiency trucks. We use fuel consumption as the prime indicator of overall system efficiency. See Appendix 2 for more details.

[6] Note that fuel efficiency gain and fuel consumption reduction are two different ways of looking at the same efficiency improvement. For example, a 50% gain in fuel efficiency (measured in miles per gallon) will result in a 33% reduction in fuel consumption (measured in gallons per mile or gallons used over a given time period). While miles per gallon is the most well-known metric, fuel consumption reduction is a more useful metric for heavy duty vehicles. See appendix 2 for an example.

and policy structures, and there was little real difference in opinions by organization type – for the most part, fleets, manufacturers, and suppliers all identified the same challenges and opportunities.

- **Recommendation #1: Implement a streamlined voucher incentive program for high-efficiency vehicle and technology purchase.**

  Streamlined vouchers that reduce purchase cost at the point of purchase ranked highest on the list of incentives and support policies for advanced, high-efficiency truck technologies. Vouchers are preferable to tax credits, grants, loans, accelerated depreciation, and other purchase incentives because they are simple, direct, and immediate. They reduce capital costs for fleets at the point of purchase with minimal delay, uncertainty, or administrative burden. As noted above, these purchase vouchers should be performance-based, with greater rewards for greater benefits. In addition to new vehicles, certified retrofits that meet relevant standards should be eligible for voucher funding. In the absence of such a voucher program, the Task Force suggests tax credits for truck purchase as a "second best" alternative, particularly if provisions making these credits useful to public fleets (non tax-paying) is included.

  The Task Force believed that a simplified voucher providing a set amount of funds to off-set purchase of qualifying technologies was the preferred structure. The voucher would be paid at the time of truck delivery and therefore reduce capital costs to fleets. The recommended structure would be based on a percentage of the expected average incremental cost of technologies that can achieve a certain level of truck efficiency. No single technology or fuel is represented. To compensate for and recognize the greater impact of high fuel-use trucks, the voucher would include a factor valuing the oxide of nitrogen (NOx) reduction expected over a 10-year life of the vehicle. A draft voucher table is provided in Table ES-2 as an example.

Table ES 2. Preliminary Voucher Incentive Amounts for High Efficiency Truck Purchase

		Fuel Efficiency Above Baseline or Regulation (Regulation starts 2014)							
Fuel Efficiency Gain		**5%**	**10%**	**15%**	**20%**	**30%**	**40%**	**50%**	**60%**
Fuel Reduction		5%	9%	13%	17%	23%	29%	33%	38%
Gross Vehicle Weight Rating (lbs)	**8,500-14,000**					$10,500	$16,000	$19,000	$22,000
	14,001-21,000					$16,500	$20,000	$23,000	$36,000
	21,001-33,000				$13,500	$21,500	$23,000	$27,000	$32,000
	33,001-66,000				$18,000	$24,000	$30,000	$36,000	$42,000
	> 66,000	$11,000	$15,000	$19,000	$24,000	$32,000	$40,000	$48,000	

The above table represents a voucher amount equivalent to roughly half (50 percent) of the expected incremental cost of achieving the level of fuel efficiency shown, plus a value for ten years of NOx reductions from the average use of such vehicles. The 50 percent of incremental cost was deemed by the Task Force members as the minimum threshold level for an effective incentive, and many recommended higher levels. To adequately adjust this minimum level to reward fuel savings in the highest fuel-use vehicles, the final incentive includes an additional amount based on its criteria emission reduction value. Such reductions are generalized from average data for simplification and vary by class of truck and mileage. They show the greatest benefit in Class 8 line-haul tractors. See Appendix 2 for assumptions of emissions value and Appendix 3 for data on

expected incremental cost, which represents an average of a "market basket" of different technologies capable of achieving different levels of efficiency.

Testing and validation of efficiency gains will play an important role in any voucher program. EPA has developed draft truck fuel economy testing protocols[7] that manufacturers are already using to qualify for tax credits with the Internal Revenue Service (IRS). Additionally, EPA and NHTSA are developing new protocols to match their joint carbon emission and fuel efficiency rules. The Task Force recommends as a starting point using the draft protocols as the basis for determining the efficiency values of proposed technology products desiring to be listed as eligible for a voucher. It is important that testing protocols be developed in a way that gives credit to alternative fuel and full electric vehicles, which could be tested using an energy equivalency technique to show efficiency gains.

- **Recommendation #2: Provide long-term, substantial R&D funding for truck efficiency.**
  The Task Force believes that a bold and coordinated federal approach is needed to bring the next generation of high efficiency, low emission trucks and enabling technology to market. The Task Force believes that the program and approach laid out in the Advanced Vehicle Technology Act of 2009 would meet the industry's needs. This bill calls for roughly $200 million dedicated yearly to R&D investments in medium and heavy-duty truck technology, matched by industry, over a five year time horizon. Investments in passenger car R&D would receive a separate and commensurate amount of funding. It is critical that heavy trucks receive a targeted funding amount, as most federal investment has for the past decade been focused on passenger cars. However, on a per vehicle basis, trucks are much higher fuel users than cars and investments in this industry can have high fuel reduction payback.

- **Recommendation #3: Provide manufacturing grants for efficient transportation technologies.**
  Task Force members believe that mechanisms are needed to support the domestic manufacturing of advanced trucks and truck technologies. This assistance is especially important during times of industry transition, as manufacturers are retooling factories, changing their focus, and ramping up production of new advanced technologies such as batteries, hybrid components, advanced engines and advanced truck homologation. The passenger car manufacturers have access to a grant program to assist this transition in cars, known as the Advanced Vehicle Technology Manufacturing Incentive Program, known specifically as Section 136 of the enabling act, the Energy Independence and Security Act of 2007. Task Force members identified an expanded section 136 Advanced Vehicle Technology Manufacturing Incentive Program to include medium- and heavy-duty vehicles as a good framework for providing manufacturing assistance. The amended program would provide grants of up to 30 percent of the cost of reequipping, expanding or establishing a manufacturing facility in the United States, or performing vehicle integration in the U.S.

[7] Environmental Protection Agency (EPA), November 2007, SmartWay Fuel Efficiency Test Protocol for Medium and Heavy Duty Vehicles, EPA420-P-07-003

Costs, Benefits, and Potential Funding Mechanisms

The actual value estimates to society are extremely high from greater efficiency in trucking. Recent reports have documented the potential for meaningful long term paybacks to users in the thousands and tens of thousands of dollars over the full life cycle of high-efficiency trucks. However, these projections are based on price reductions in the currently high cost of these high-efficiency systems. Nonetheless, the societal benefits of greater efficiency are accrued from first deployment. **Research for this report demonstrates that when the full value provided by greater efficiency is quantified, it provides a strong justification for incentives and investments**.

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The Task Force strongly believes the policies outlined here are both justified based on their benefits and necessary for speeding efficient truck introductions. They will also have strong economic and energy security benefits for the nation. It also acknowledged that given budget realities the means must be found to pay for these policies, investments and incentives. Some, if not all, of the funding can come from a re-prioritization of existing federal support and funding programs to focus on these more-effective approaches.

Other possible approaches include: petroleum or fuel surcharges; fee-bates on heavy-duty vehicle purchases, with more efficient models per class of truck receiving a rebate, and less efficient models charged a fee; fuel "guzzler" fees; and increasing fees on older, lower-efficiency vehicles (to reward fleets that transition to more efficient vehicles).

While not a primary recommendation, and though there was certainly not universal agreement, our research showed a **higher than expected level of support for a modest surcharge on oil or fuel**, *provided that the revenues were re-invested in advanced technology support and incentives.*

- A relatively modest fuel surcharge of around 10 cents per gallon would generate more than $3 billion annually from diesel fuel alone, and around $17 billion per year if applied to both gasoline and diesel.
- Additionally, such a surcharge would help to shrink the price differential between conventional technologies and advanced alternatives, improving the business case for high efficiency trucks.

However, it is important to note that several fleets had concerns about the hardship that this surcharge would impose on them. While such an approach might be cost neutral over the medium term (the reduced fuel use caused by higher efficiency trucks eventually off-setting the higher unit cost of the fuel), there is a timing gap between the impacts of increases in fuel costs and the potential benefits of the new technology. Revenues would have to be reinvested in advanced technologies and, possibly, road infrastructure improvements so as to reduce fleet operating costs and make up for the increased fuel costs. However, even with reinvestment of the funds, this remains a sensitive issue that deserves further debate and consideration.

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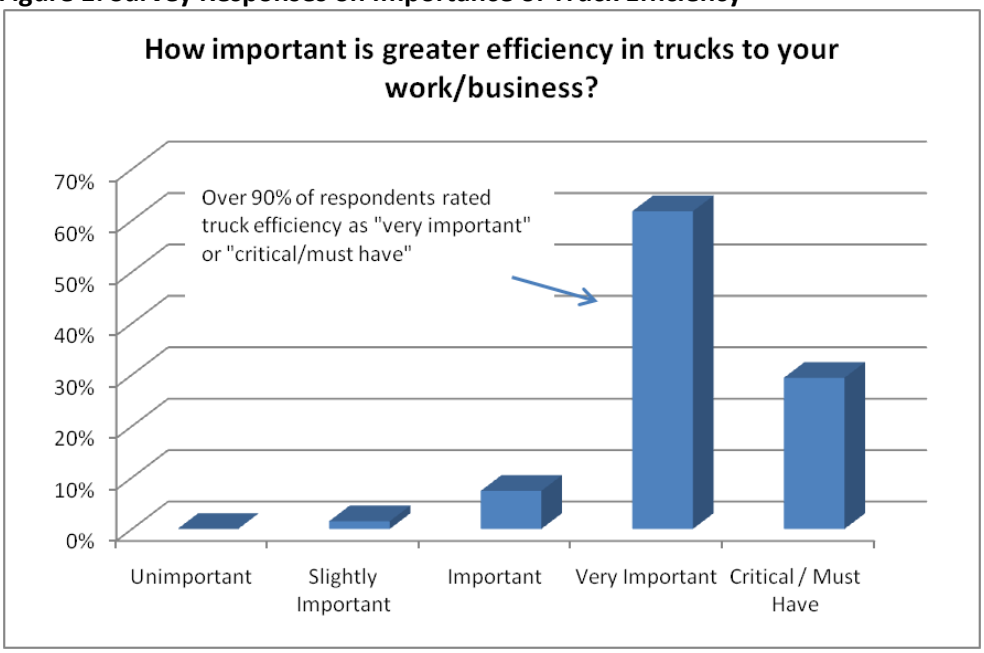
1. INTRODUCTION

Medium- and heavy-duty trucks account for only 4 percent of all vehicles on the nation's highways. Yet these trucks consume more than 20 percent of the diesel and gasoline burned to move all vehicles on U.S. roads. The fuel efficiency of these vehicles has not been regulated in the past. The U.S. Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) have developed standards that will require improvements in the efficiency and tailpipe emissions of the nation's medium- and heavy-duty trucks. This will be the first time that the fuel economy and greenhouse gas (GHG) emissions of these vehicles have been regulated, and the standards will start with MY 2014. Ultimately, the truck industry is not opposed to stronger regulation, even on this timeline. However, they do believe the regulations need to be part of a comprehensive approach that has both carrots and sticks.

To better understand the suite of policies, incentives, regulations and investments necessary for high-efficiency trucks to effectively enter the market, CALSTART undertook a survey of key industry and fleet members to assess the importance of efficiency in trucks, the barriers to wider adoption of high-efficiency truck technology, and the policies, investments and incentives that would spur its adoption. The findings were instructive.

Truck efficiency matters, but standards alone are not enough to drive the market. More than 90% of fleet user and industry representatives surveyed for this report characterized greater efficiency in trucks as "very important" or "critical/must have" for their business, as noted in figure 1 below.

Figure 1: Survey Responses on Importance of Truck Efficiency



The need for greater efficiency in trucks was echoed throughout the Task Force meetings as well. However, the vast majority of these respondents also noted that standards and a desire for increased efficiency alone are not sufficient to drive the market. Barriers remain, and complementary policies are needed to address them.

Based on industry input, this report (1) identifies key barriers to the development and deployment of more efficient truck technologies and (2) makes recommendations for public policies and investments to overcome these barriers. Section 2 provides a discussion of methods and process as well as a summary of key findings from the survey and Task Force meetings. Section 3 outlines a suggested policy framework for supporting the transition to high efficiency trucks. Section 4 includes a discussion of valuing co-benefits of fuel consumption reduction. The recommended incentive and support structures are outlined in Section 5. Finally, Section 6 focuses on potential funding mechanisms.

2. METHODS, PROCESS, AND TOP LEVEL FINDINGS

In anticipation of the heavy duty vehicle greenhouse gas emission and fuel efficiency standards put forward by EPA and NHTSA, CALSTART surveyed a broad group of heavy duty truck fleets, manufacturers, and suppliers to gather input about industry barriers and about complementary policies that could support the widespread transition toward cleaner, more efficient trucks and buses. The survey reached a good cross section of the industry, with 53% of the respondents representing fleets, 20% representing manufacturers, and 27% representing system and component suppliers.

The initial survey provided some high level feedback on the key barriers and needs, with general themes emerging across all respondent types. CALSTART then formed a High Efficiency Heavy Duty Incentives Task Force to further refine the group's initial recommendations. See Appendix 1 for a list of Task Force members. The Task Force held nine meetings throughout Fall 2010 in order to discuss needs, review incentive structures, and develop recommendations. Staff also researched existing programs and held conversations with additional industry experts and incentive program managers. Results of this work are summarized below.

Key Barriers: Cost, Availability, Lack of Good Information

This section summarizes key barriers noted in the survey and in Task Force meetings.

Incremental cost is the primary barrier to widespread adoption of efficient truck technologies. Nearly every industry representative cited incremental cost as the major barrier to sales and purchase of high efficiency trucks, systems, and components. It was the overwhelming barrier noted. While some incremental cost can be justified by savings due to higher fuel efficiency, most felt that the return on investment (ROI) is currently far too slow. Both fleets and manufacturers would like to see an ROI in the neighborhood of 2-5 years. Additionally, manufacturers cited high costs for components, such as batteries, as a key problem. Several respondents believe the high costs are due in part to low volume in the early market – a typical "chicken and egg" scenario.

Availability of appropriate technology is still an issue for some. While there has been some progress in the development and deployment of advanced efficiency technologies, concerns remain over the commercial availability of technologies that are properly suited for various tasks. Heavy duty vehicles are used in a wide variety of applications and specialization is important – one respondent complained of a "lack of high efficiency options in all truck classes" and another would like to see "technologies that provide efficiencies in the operating environment of a (telecommunications fleet)". This indicates a need for ongoing research, development and commercialization, as the high efficiency truck market is still young.

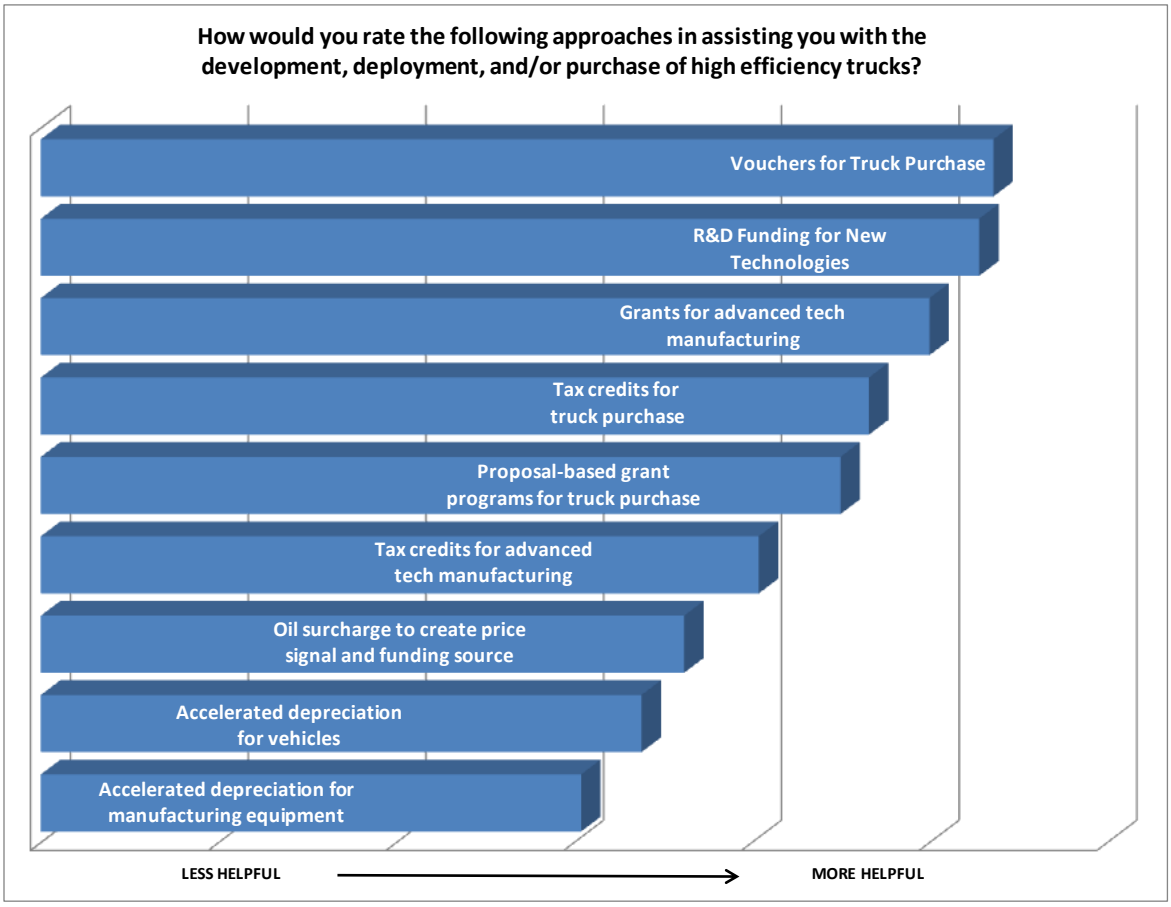
Better information is needed on performance, availability, and durability of new technologies. Both fleets and manufacturers cited a lack of reliable performance data as a barrier. For the fleets, complex new technologies seem like a risky investment. Concerns over maintenance costs, reliability,

and long term durability are widespread. One respondent noted that they are "just now starting to see the true cost to own and maintain the EPA '07 engines." Manufacturers and suppliers also cited a need for better information to improve customer acceptance.

Top Policy Options for Speeding the Adoption of Efficient Trucks

Task Force members noted that there is a need for funding support at multiple points in the commercialization process, from research and development, to manufacturing, to actual purchasing and deployment. Figure 2 below shows support levels for specific types of incentive and investment programs.

Figure 2: Ranked Policy Options for Supporting Efficient Trucks – Survey Responses



Vouchers for truck purchase rose to the top as the single most valuable policy option. Because they follow simple rules and provide funds at the time of purchase, these incentives can improve the business case for new technologies, helping fleets purchase more efficient trucks and helping manufacturers and suppliers increase sales and comply with standards. Respondents generally preferred vouchers to tax incentives and grant programs, though there was a clear acknowledgement that these types of programs are still helpful. Arguments in favor of a voucher approach are discussed in greater detail in Chapters 3 and 5. See also the box on "Success Stories" for examples of existing programs around the country that are working well.

Success Stories: Model Purchase and Deployment Programs Around the Nation
The two existing purchase assistance programs outlined below were identified by Task Force members as successful models that could be expanded or could provide valuable lessons for future programs.

California's Hybrid Truck and Bus Voucher Incentive Program (HVIP)
Many survey respondents and Task Force members cited the HVIP program run through the California Air Resources Board (CARB) as a prime example of a successful incentive program that they would like to see expanded to other states and regions and to the federal level. In 2010, the program provided almost $20 million in simplified purchase voucher funding for hybrid trucks and buses. Voucher amounts varied from $10,000 for smaller vehicles to $45,000 for the largest and most expensive trucks (Class 8 tractors and refuse trucks). Vouchers are requested at the time of truck order and redeemed at the time of purchase and delivery, thus directly reducing fleet capital cost. The program sold out in roughly seven months of operation and was responsible for more than 650 hybrid truck orders. In 2010 this program was recognized as the number one emerging state energy program in the nation by the American Council for an Energy Efficient Economy (ACEEE). CARB has provided an additional $19 million in voucher funding for 2011 and has signaled a desire to fund one to two more years because of its success. Additional information is available here: www.calforniahvip.org.

This voucher approach has several major advantages over the more commonly used tax incentives and grant programs. First, the voucher directly reduced capital costs at the point of purchase. This is the equivalent of actually reducing the purchase price. This approach is valuable for fleet managers who are working with fixed budgets and may never see the advantages of tax credits. Additionally, tax-exempt entities such as government fleets are able to take advantage of the voucher, whereas they cannot take advantage of tax credits. Finally, Task Force members appreciate the simplicity of the program, which has clear rules, set incentive amounts, and does not require a time-consuming grant-writing process. Because the program has clear rules and pre-set amounts for truck types, the voucher provides certainty of outcome for requesters. It is operated on a first-come basis but does have yearly limits on purchases, by fleet.

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Illinois Clean Diesel Grant Program
Some survey respondents also cited the Clean Diesel Grant Program run by the Illinois Environmental Protection Agency as a successful model. While this is a grant program, it is unusual in that it has a very low administrative burden for participating fleets. Illinois in this case is managing federal funds from the Diesel Emission Reduction Act (DERA) program but doing so in a streamlined fashion. The program has a short and simple application, provides a list of qualifying technology and allows participants to use existing purchase processes. This is very attractive for fleets that lack the resources to go through a full proposal-writing process. Additionally the Illinois EPA handles reporting requirements for participating fleets, thereby drastically reducing the demands placed on participating fleets and companies. The program has ease of participation as one of its major goals. More information is available at www.illinoisgreenfleets.org.

The vast majority of respondents also highlighted a strong need for smart, targeted public funding support for research and development targeting efficient trucks. R&D funding ranked as the second most important policy option, just behind purchase vouchers. This is not surprising given the fact that many survey respondents and task force members identified the availability of appropriate technologies and the need for designed-in cost reductions as an issue. Grant programs for R&D ranked higher than tax credits for R&D.

There was also broad agreement that manufacturing assistance and incentives are necessary to drive down technology costs and ensure continuing U.S. leadership and job growth in this sector. Advanced technology manufacturing grants ranked quite high, even among fleets.

Accelerated depreciation for vehicles and equipment generally did not score as well, and the Task Force ranked this as a much lower priority action. An oil surcharge with the funds reinvested in incentives received mixed responses. This option is discussed in greater detail in Chapter 6.

Success Story – Research and Development and Green Job Growth: Ohio Third Frontier

Third Frontier is an economic development initiative aimed at creating new technology-based products, companies, industries, and jobs in Ohio. From an economic-development standpoint, the program has been very successful. A recent study found that Third Frontier has generated 41,300 jobs and $6.6 billion in economic activity, representing almost $10 return on every $1 of state investment.[8]

Third Frontier is active at multiple points in the innovation process, facilitating collaboration with universities, providing entrepreneurial support, and awarding funds for R&D and product development. Third Frontier also strives to build industry clusters and to provide workforce development assistance.

Third Frontier is not by definition an environmental research and development program controlled by the government. It is instead an economic development program, with a focus on technology development in targeted areas. This primary focus on economic development may explain its success in making smart investments, meeting the needs of private businesses, and creating jobs in Ohio's clean energy economy. Third Frontier's governing commission includes representatives from the private sector, the Department of Development, the Board of Regents, and the Air Quality Development Authority. Additional information is available at ohiothirdfrontier.com

[8] SRI International. "Making an Impact: Assessing the Benefits of Ohio's Investment in Technology-Based Economic Development Programs. September 2009. [online] http://development.ohio.gov/ohiothirdfrontier/Documents/RecentPublications/Final_OH_Impact_Exec_Sum_SRI.pdf

3. POLICY FRAMEWORK: SUPPORTING THE TRANSITION TO HIGH EFFICIENCY TRUCKS

Based on survey results, external research, review of existing programs, and discussion of needs, the Task Force developed a framework for the policies needed to support the transition to clean, advanced trucks. The key elements of a policy package are outlined below, in terms of overall approach, program design, and program management. Specific program and incentive recommendations are detailed in the following section.

Program Design and Targets

Based on an assessment of needs and a review of existing and proposed programs in this field, the Task Force identified the following as key elements for the design of medium and heavy duty truck research, development, manufacturing, and deployment support programs:

- **Ensure strong, consistent, long term funding and incentives.** The transition toward cleaner, more efficient medium and heavy duty vehicles will require a substantial financial commitment from the public sector. The relatively low price of diesel fuel, current lack of high volume advanced technology manufacturing, and resulting large price differential between conventional and advanced technologies all point to the need for a combination of strong standards and similarly strong incentives. Short term, inconsistent, or otherwise limited funding will not be sufficient to change technology availability, costs, and purchase decisions over the long term.
- **Create a performance-based approach to purchase incentives.** Purchase incentives should be fuel and technology neutral, providing rewards that are based on the overall benefits achieved, and not tied to the specific technology employed. Performance-based incentives encourage technological innovation and diversification, rather than artificially slanting the market toward one politically popular technology. Tying rewards to performance also helps to maximize the return on investment, as large incentives are reserved for technologies that yield the greatest benefits. The increasing incentive amounts encourage technology developers to aim high, and allow fleets to purchase the most advanced technologies that benefit them, despite their higher price tags, leading to earlier action and accelerated reductions of fuel use.
- **Provide recognition and reward for co-benefits.** In seeking to move toward more efficient trucks, the administration is aiming to achieve several related goals. These include reduced petroleum dependence, lower greenhouse gas emissions, and improved air quality. Though these goals are intertwined, and emissions are closely related to fuel consumption, the reality is that different technology options will score differently across these three areas. Given this fact, and a desire to provide incentives for those technologies that provided multiple, not single, benefits, the Task Force members **strongly supported the development of a purchase incentive program that rewards technologies for the air quality, climate, and/or petroleum reduction "co-benefits" that they might provide**. Though the discussion of rewarding co-benefits centered mostly on purchase incentives, the concept could also be applied to R&D and manufacturing support – co-benefits could factor into the evaluation criteria in a project

solicitation, or into the formulas used in determining funding amounts. See "Valuing Co-Benefits" below for a greater discussion of this issue.

- **Directly target purchase cost differential.** Purchase incentives should aim to **reduce capital costs at the point of purchase**. This is more direct, more efficient, and more effective than trying to influence purchase decisions through tax credits. Many fleets do not benefit directly from tax credits, and therefore it does not change their capital outlay or their purchase decision. Similarly, R&D and manufacturing assistance should also be tied to expected reductions in technology costs over the long term. The transition toward more efficient technologies will not be successful if we cannot reduce the cost differential between conventional and advanced technologies. Recognizing this fact and aligning public assistance accordingly is smart policy.

Program Management and Administration

Effective management and streamlined administrative processes are key to the success of public incentive and support programs. The Task Force identified the following as high priority considerations for program management and administration:

- **Ensure simple rules, streamlined processes, and fast turnaround times.** Task Force members agreed that programs can more effectively drive investment and purchase decisions if they are simplified and streamlined. Confusing rules, long review processes, and onerous application and reporting requirements will reduce overall participation, as not all fleets and businesses have the resources needed to manage a complex application process. Delays can also cause major problems for businesses, particularly if they are small and do not have the ability to fill a hole left by public funds that do not arrive on time. Purchase vouchers have some of the lowest transaction costs of any of the incentive structures that we reviewed, and Task Force members cited this fact as a key reason for their success. They also provide certainty of outcome and allow a fleet to follow its normal procurement timeline. Eliminating long review processes and complicated contracting would be very powerful.
- **Minimize delays, uncertainty, and political interference.** Government programs are often characterized by delays, unpredictability, and political interference. Examples include delayed releases of RFPs for grant programs, tax credits that must be renewed on a yearly basis, and direction of government funding toward a single fuel or technology that enjoys powerful political support. Purchase incentives, manufacturing assistance, and R&D support will all be much more powerful if they are shielded from these pitfalls. These problems can be minimized through smart program design, commitment to long-term funding, technology neutrality and careful consideration of where to administer a given program.

4. VALUING CO-BENEFITS

The actual value estimates to society are extremely high from greater efficiency in trucking. Recent reports have documented the potential for meaningful long term paybacks to users in the thousands and tens of thousands of dollars over the full life cycle of high-efficiency trucks. However, these projections are based on price reductions in the currently high cost of these high-efficiency systems. Nonetheless, the societal benefits of greater efficiency are accrued from first deployment. Research for this report demonstrates that when the full value provided by greater efficiency is quantified it provides a strong justification for incentives and investments. Ultimately, these investments can be expected to yield substantial public benefits, including:

- **U.S. leadership and substantial job growth** in the advanced truck and technologies sector. One recent study found that the strong expansion of high-efficiency trucks can generate $24 billion in net economic benefits and grow 124,000 jobs in the U.S. by 2030. American companies are currently the industry leaders in several of the enabling technologies necessary for high-efficiency trucks.[9]
- **Improved energy security and the reduction of imported oil**. The transportation sector accounts for more than 70 percent of petroleum use in the United States. [10] Indeed, the only way to fully address the issues of reducing oil imports and increasing energy security as it relates to oil is in reducing its use in transportation. Stationary power generation has little to almost no impact on oil consumption. Given their high per vehicle use of fuel, trucks are significant contributors to petroleum use, but also prime platforms for its reduction via efficiency and fuel switching. On an investment basis, trucks represent a lower cost reduction strategy when measured on amount of emissions or fuel reduced per vehicle, and per unit of investment.
- **Reductions in criteria air pollution and related health care costs.** In 2008, medium- and heavy duty vehicles consumed 37 billion gallons of diesel and gasoline.[11] This level of petroleum consumption contributes to poor air quality, which is a major contributor to large increases in health care spending. According to a 2005 report by the Clean Air Task Force, the nationwide health damages from diesel emissions are estimated at $139 billion in 2010, as a result of premature deaths, hospital admissions, asthma attacks, and other health problems stemming from poor air quality.[12]
- **Reductions in conventional global warming pollution.** Nationwide, medium and heavy duty vehicles account for 18 percent of all global warming emissions from the transportation-sector.[13] Advanced truck efficiency technologies have the potential to reduce these emissions

[9] Union of Concerned Scientists and CALSTART, "Delivering Jobs: The Economic Costs and Benefits of Improving the Fuel Economy of Heavy Duty Trucks." May, 2010. http://calstart.org/Libraries/Publications/Delivering_Jobs_Final_Report.sflb.ashx
[10] U.S. Energy Information Administration, Annual Energy Review. http://www.eia.doe.gov/emeu/aer/pecss_diagram.html
[11] http://www.fhwa.dot.gov/policyinformation/statistics/2008/
[12] Clean Air Task Force, Diesel and Health in America: the Lingering Threat. 2005. http://www.catf.us/resources/publications/view/83
[13] Environmental Protection Agency (EPA). 2008. Inventory of U.S. greenhouse gas emissions and sinks, 1990–2006. EPA 430-R-08-005. Washington, DC.

- **Reductions in black carbon and particulate matter.** Combustion of diesel fuel in medium and heavy duty trucks is a major source of particulate matter and so-called "black carbon." Black carbon is a major contributor to global warming, and reductions in black carbon can bring about near term climate change benefits.
- **Reduced noise pollution.** Conventional medium and heavy duty trucks are a source of noise pollution on roadways and in the neighborhoods where they operate. Diesel engines, particularly on these larger vehicles, produce noise pollution that has been valued at roughly 5 cents per vehicle mile.[14] Some advanced vehicle technologies, such as hybridization and electrification, can significantly reduce the noise associated with these trucks.
- **Greater freight efficiency and reduced long-term operating costs** for fleets, provided capital costs come down. Reductions in operating costs are of paramount importance to fleets, which operate with thin profit margins.

High efficiency trucks can provide significant co-benefits. These co-benefits are *in addition* to the fuel savings. However, for the sake of simplicity, this report focuses on just three of the many co-benefits that are provided by advanced truck technologies: additional reductions in nitrogen oxides, greenhouse gases and petroleum that would not have been achieved without the efficiency gain. Using currently accepted values for the costs/benefits of these reductions, the societal gains are significant.

- **Reductions in the emission of oxides of nitrogen, or NOx:** NOx emissions reductions are estimated to be worth $15,000 per ton reduced. To highlight the potential benefits, the calculations in this report assume that fuel consumption reductions can be accompanied with proportional NOx emission reductions on a system level, which will include advanced emission-reducing solutions and technologies, in future high efficiency trucks. We use fuel consumption as the prime indicator of overall system efficiency. See Appendix 2 for more details.
- **Climate change benefits associated with truck efficiency improvements:** GHG emissions are assumed to decrease in line with fuel consumption reduction. In order to generate dollar estimates, we used a price of $22 per ton.
- **Improvements in energy security as a result of petroleum reduction:** our nation's dependence on petroleum has negative implications for our economic and national security. The energy security benefits of reduced oil consumption have been estimated at $0.16 per gallon.

The Tables below provide estimates for co-benefit values for both heavy-heavy duty and medium-heavy duty vehicles. NOx emissions, GHG emissions, and energy security benefits are all directly related to fuel consumption reduction.[15] Please see Appendix 2 for the assumptions and sources used in these calculations.

[14] Victoria Transport Policy Institute, 2009. Transportation Cost and Benefit Analysis: Techniques, Estimates, and Implications. http://www.vtpi.org/tca/tca0511.pdf

[15] Note that fuel efficiency gain and fuel consumption reduction are two different ways of looking at the same efficiency improvement. For example, a 50% gain in fuel efficiency (measured in miles per gallon) will result in a 33% reduction in fuel consumption (measured in gallons per mile or gallons used over a given time period). While miles per gallon is the most well-known metric, fuel consumption reduction is a more useful metric for heavy duty vehicles. See appendix 2 for an example.

Table 1: Selected Co-Benefit Value Estimates for Efficient Heavy Heavy Duty Vehicles (>33,000 lbs Gross Vehicle Weight Rating)

Fuel Efficiency Gain	Corresponding Fuel Consumption Reduction	Value of NOx Emission Reductions	Value of GHG Emission Reductions	Value of Improved Energy Security	*Total Value of Selected Co-Benefits*
5%	**4.8%**	$2,500	$1,800	$1,300	***$5,700***
10%	**9.1%**	$4,900	$3,500	$2,500	***$10,800***
15%	**13.0%**	$6,900	$5,000	$3,600	***$15,500***
20%	**16.7%**	$8,800	$6,400	$4,600	***$19,800***
30%	**23.1%**	$12,200	$8,900	$6,400	***$27,500***
40%	**28.6%**	$15,100	$11,000	$7,900	***$34,000***
50%	**33.3%**	$17,600	$12,800	$9,200	***$39,700***

For a long-haul Class 8 combination truck, **the per vehicle life cycle value of co-benefits from fuel efficiency ranges from more than $5,600 for a 5 percent fuel economy gain, to nearly $40,000 for a 50 percent fuel economy gain.** While not as high, there are meaningful societal co-benefits from more efficient medium duty trucks (Class 4-7) as well, ranging from around $900 for a 5 percent fuel economy gain to more than $6,000 for a 50 percent gain. These vehicle platforms also are often the first markets for introducing technology that eventually transitions to Class 8 trucks, and therefore are important early proving grounds.

Table 2: Selected Co-Benefit Value Estimates for Efficient Medium Heavy Duty Vehicles (14,000 to 33,000 lbs Gross Vehicle Weight Rating)

Fuel Efficiency Gain	Corresponding Fuel Consumption Reduction	Value of NOx Emission Reductions	Value of GHG Emission Reductions	Value of Improved Energy Security	*Total Value of Selected Co-Benefits*
5%	**4.8%**	$300	$300	$200	***$900***
10%	**9.1%**	$500	$700	$500	***$1,700***
15%	**13.0%**	$800	$900	$700	***$2,400***
20%	**16.7%**	$1,000	$1,200	$900	***$3,000***
30%	**23.1%**	$1,300	$1,700	$1,200	***$4,200***
40%	**28.6%**	$1,600	$2,000	$1,500	***$5,200***
50%	**33.3%**	$1,900	$2,400	$1,700	***$6,100***

Climate change, health, and improved energy and national security are just some of the important co-benefits associated with greater truck efficiency. Note that efficiency gains will have additional benefits that are not quantified here. Among others, these include job growth, reduced operating costs for fleets, and reductions in particulate matter and black carbon.

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5. RECOMMENDED INCENTIVE AND SUPPORT STRUCTURES

With a good understanding of their needs and the pitfalls they often faced, the Task Force and staff reviewed a wide variety of potential incentive and support structures. The top recommended policy options for each barrier in the commercialization process are outlined below. As noted above, purchase incentives were cited overwhelmingly as the top need by task force members. The strong feeling was that commercialization cannot take place if early products cannot reach and be sold into the market, thus justifying continued private investment and fleet consideration. Consequently, we direct a primary focus of our recommendations on outlining the preferred approach.

Note that membership on the Task Force does not necessarily imply endorsement of all of the recommendations outlined here. However, the group did come to strong general agreement on the needs and policy structures, and there was little real difference in opinions by organization type – for the most part, fleets, manufacturers, and suppliers all identified the same challenges and opportunities.

Recommendation #1: Implement a purchase voucher incentive program

Streamlined vouchers that reduce vehicle purchase cost ranked highest on the list of incentives and support policies for advanced truck technologies. In a voucher program, public funds are used to reduce technology costs at the point of purchase. Vouchers can encourage the purchase of new vehicles as well as certified retrofits that provide similar benefits and meet the relevant standards and criteria. Fleets see a lower purchase cost, while dealers receive full price for the vehicles (or retrofits) because public funds make up the difference between the original price and the reduced voucher price.

Vouchers are preferable to tax credits, grants, loans, accelerated depreciation, and other purchase incentives because they are simple, direct, and immediate.

Vouchers are preferable to tax credits, grants, loans, accelerated depreciation, and other purchase incentives because they are simple, direct, and immediate. They directly lower the incremental price of the advanced technology at the point of purchase. The administrative burden is small and there is minimal delay. The purchasing organization does not need to have tax liability in order to take advantage of a voucher. There is no question as to whether or not a fleet will "win" the voucher based on some subjective judgment of their project or proposal. The guidelines are clear, the process is simple, and the result is a lower purchase price for fleets and an increase in sales for manufacturers and suppliers.

As noted above, the Task Force believes these purchase vouchers should be performance-based, with greater rewards for greater benefits. The voucher would therefore not be directed at any one fuel or technology, but would instead be based on the benefits provided by any number of technologies. The key performance metric should be fuel efficiency above the baseline required by the new standards; in

the early years before the standards, this would mean efficiency above the baseline (defined by EPA as a 2010 vehicle). As noted above, the vouchers should ideally provide some reward for technologies that yield co-benefits, such as air quality improvements, carbon or petroleum reductions. In order to reward co-benefits, the voucher could be structured such that it includes a multiplier or straight plus-up amount for these co-benefits.

Structuring a voucher program that recognizes and rewards co-benefits without becoming complex and cumbersome requires careful consideration and balance. Based on Task Force discussions, a minimum level of voucher amount was established that was determined would motivate or change fleet purchase behavior and encourage production by manufacturers. It is based on a combination of factors, including expected incremental costs of technologies that achieve the desired levels of efficiency as well as the value of co-benefits provided. CALSTART researched expected incremental costs and used data provided by industry, including members of the Task Force, and data from the National Academy of Sciences study of truck fuel efficiency. The co-benefit estimates outlined earlier in this report provide a sense of some of the societal benefits expected as a result of improvements in truck efficiency. Taking into account these co-benefits, the Task Force recommends a simplified voucher structure based on the following table.

Table 3: Preliminary Voucher Incentive Amounts

		Fuel Efficiency Above Baseline or Regulation (Regulation starts 2014)							
Fuel Efficiency Gain		**5%**	**10%**	**15%**	**20%**	**30%**	**40%**	**50%**	**60%**
Fuel Reduction		5%	9%	13%	17%	23%	29%	33%	38%
Gross Vehicle Weight Rating (lbs)	**8,500-14,000**					$10,500	$16,000	$19,000	$22,000
	14,001-21,000					$16,500	$20,000	$23,000	$36,000
	21,001-33,000				$13,500	$21,500	$23,000	$27,000	$32,000
	33,001-66,000				$18,000	$24,000	$30,000	$36,000	$42,000
	> 66,000	$11,000	$15,000	$19,000	$24,000	$32,000	$40,000	$48,000	

The above table represents a voucher amount equivalent to roughly half (50 percent) the expected incremental cost of achieving the level of fuel efficiency shown, plus a value based on ten years of NOx reductions from the average use of such vehicles. It should be noted such reductions are generalized from average data for purposes of simplification and vary by class of truck and mileage. They show the greatest benefit in Class 8 line-haul tractors. See Appendix 2 for assumptions of emissions value and Appendix 3 for data on incremental cost, which represents an average of a "market basket" of different technologies capable of achieving different levels of efficiency.

In terms of implementation, such a voucher amount structure could be kept as is or modified based on other co-benefit rewards. Additionally, such a voucher could serve as the starting point of a multi-year program which declines in value over time as vehicle volumes increase in the market and incremental costs drop.

Testing and validation of efficiency gains will play an important role in any voucher program. EPA has developed draft truck fuel economy testing protocols for its SmartWay program[16] that manufacturers

[16] Environmental Protection Agency (EPA), November 2007, SmartWay Fuel Efficiency Test Protocol for Medium and Heavy Duty Vehicles, EPA420-P-07-003

are already using to qualify for tax credits with the Internal Revenue Service (IRS). Additionally, EPA and NHTSA are developing new protocols to match their joint carbon emission and fuel efficiency rules. The Task Force recommends as a starting point using the draft SmartWay protocols as the basis for determining the efficiency values of proposed technology products desiring to be listed as eligible for a voucher. It is important that testing protocols be developed in a way that gives credit to alternative fuel and full electric vehicles, which could be tested using an energy equivalency technique to show efficiency gains.

The voucher program outlined above represents a "next generation" incentive program, with broad industry support, that is well-suited to accelerating the transition toward cleaner, more efficient trucks. In the absence of such a voucher program, the Task Force suggests tax credits for truck purchase as a "second best" alternative. For entities that are able to take advantage of them, tax credits provide some financial incentive for the purchase of advanced technologies. Like the vouchers outlined above, tax credits could also be performance-based and structured in a way that rewards co-benefits. Consistent, long term, and predictable tax credits can provide a much-needed incentive for the purchase of high efficiency trucks. However, the voucher approach is preferred for all of the reasons outlined above.

Recommendation #2: Provide Long-term, Substantial R&D Funding

R&D funding ranked as a close second in our list of policy tools to support high efficiency truck technologies. The Task Force believes that a bold and coordinated federal approach is needed to bring the next generation of high efficiency, low emission trucks to market. Historically, heavy-duty vehicles have received neither consistent, sufficient, nor commensurate R&D funding compared to passenger cars. The Task Force believes that the program and approach laid out in the proposed Advanced Vehicle Technology Act of 2009 would meet the industry's needs. This bill calls for roughly $200 million dedicated yearly to R&D investments in medium and heavy-duty truck technology, matched by industry, over a five year time horizon. Investments in passenger car R&D would receive a separate and commensurate amount of funding. It is critical that heavy trucks receive a targeted funding amount, as most federal investment has for the past decade been focused on passenger cars. However, on a per-vehicle basis, trucks are much higher fuel users than cars and investments in this industry can have high fuel reduction payback, particularly on a per-platform basis.

Recommendation #3: Provide Manufacturing Grants for Efficient Transportation Technology

Particularly for manufacturers and suppliers, manufacturing support ranked as an important part of the overall advanced truck policy package. Task Force members believe that grant programs are needed to support the domestic manufacturing of advanced truck technologies. This assistance is especially important during times of industry transition, as manufacturers are retooling factories, changing their focus, and ramping up production of new advanced technologies such as batteries, hybrid components, and advanced engines.

Task Force members identified an expanded Advanced Vehicle Technology Manufacturing Incentive Program as a good approach for manufacturing assistance. This program, originally created as Section

136 of the Energy Independence and Security Act of 2007, was originally designed to provide assistance to manufacturers of light duty vehicles and components. In summer of 2010, Senator Wyden put forward language as part of the above mentioned Advanced Vehicle Technology Act of 2009 (S. 2843) that would expand the program to include medium and heavy duty trucks. The amended program would provide grants of up to 30 percent of the cost of reequipping, expanding or establishing a manufacturing facility in the United States, or performing vehicle integration in the U.S.

6. POTENTIAL FUNDING MECHANISMS

CALSTART and members of the Task Force note that the incentives outlined above carry with them both costs and benefits. Benefits were discussed above (see Chapter 4, "Valuing Co-Benefits") and some were quantified in this report. The Task Force strongly believes the policies outlined here are both justified based on their benefits and necessary for speeding efficient truck introductions. They will also have strong economic and energy security benefits for the nation. It also acknowledged that given budget realities the means must be found to pay for these policies, investments and incentives.

Some, if not all, of the funding can come from a re-prioritization of existing federal support and funding programs to focus on these more-effective approaches. For instance, vehicle deployment and similar grants run through existing federal or state programs could be modified to operate as vouchers, either in whole or in part. The Clean Cities program under the Department of Energy could be provided funding for such purposes. A portion of Diesel Emission Reduction Act (DERA) funds could be reserved for such an approach, or provided to states for their use in vouchers. Research and development funds could also be redirected from more mature industry segments and used to adequately fund transportation. If public policy focus shifts consistently to desiring energy security and reducing fuel use, such investment shifts in programs are critical.

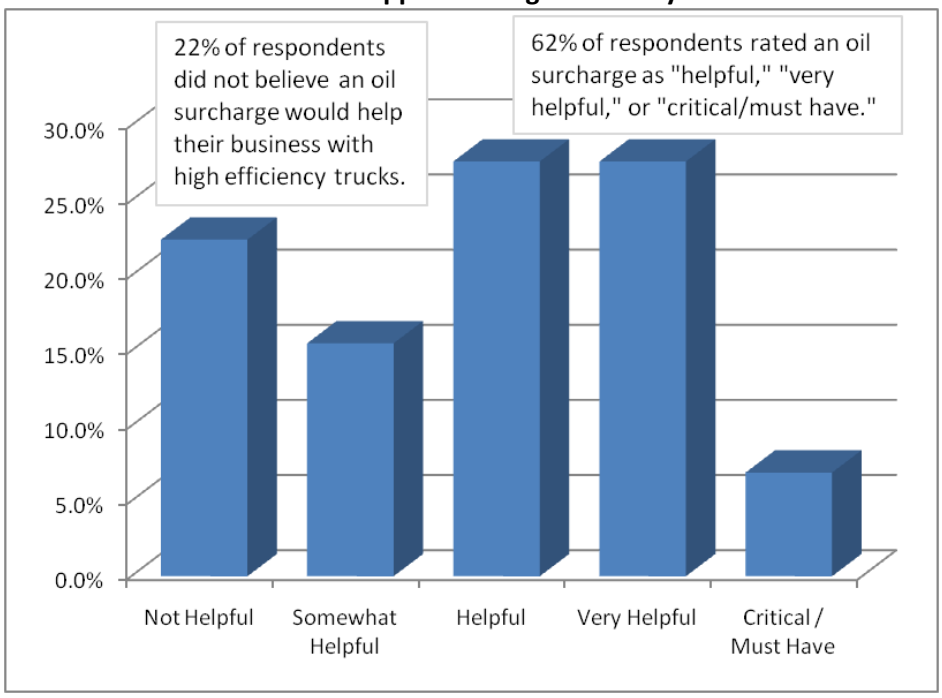
Other possible approaches include:

- Petroleum or fuel surcharges (see discussion below)
- Fee-bates on heavy-duty vehicle purchases, with more efficient models per class of truck receiving a rebate, and less efficient models charged a fee
- Fuel "guzzler" fees or taxes to discourage the production and purchase of inefficient vehicles[17]
- Increasing fees on older, lower-efficiency vehicles to reward fleets that transition to more efficient vehicles and to accelerate fleet turnover.

Though results were mixed, our research showed a higher than expected level of support for a modest surcharge on oil, *provided that the revenues were re-invested in advanced technology support and incentives.* More than 60% of survey respondents ranked such an oil surcharge as either "important," "very important," or "critical/must have." See Figure 3 for survey responses on the oil surcharge concept. Fleets were less likely to embrace this concept than were manufacturers and suppliers, but even among the fleet respondents, more than 50% ranked an oil surcharge as either "helpful" or "very helpful." We do note that roughly one quarter of fleet respondents were opposed to the idea.

[17] For more information on the existing light duty vehicle "gas guzzler tax," please visit the EPA gas guzzler tax website: http://www.epa.gov/fueleconomy/guzzler/index.htm

Figure 3: Survey Responses on Value of an Oil Surcharge with Funds Reinvested in Incentives and Support for High Efficiency Trucks



A relatively modest fuel surcharge of around 10 cents per gallon, which falls into the range of yearly variability for fuel, would generate more than $3 billion annually from diesel fuel alone, and around $17 billion per year if applied to both gasoline and diesel. Additionally, such a surcharge would help to shrink the price differential between conventional technologies and advanced alternatives, improving the business case for high efficiency trucks.

It is important to note that several fleets had concerns about the hardship that this surcharge would impose on them. Revenues would have to be reinvested in advanced technologies and, possibly, road infrastructure improvements so as to reduce fleet operating costs and make up for the increased fuel costs. Even with reinvestment of the funds, this remains a sensitive issue that deserves further debate and consideration.

Appendix 1: Task Force Members

The following individuals served on the High Efficiency Heavy-Duty Truck Incentives Task Force. Their names and company affiliations are listed for information and does not necessarily imply the agreement on all points of this study by the companies listed. However, study results enjoyed a high degree of consensus and listed members agreed to the listing of their names.

Mike Allison, Duke Energy
Kevin Alston, Goldring
Susan Alt, Mack Trucks & Volvo Trucks North America
William Batten, Eaton
Paul Beach, Quallion
Ralph Bedogne, EMP
Melody Bennett, King County
Mike Britt, UPS
David Bryant, Daimler Trucks North America
Scott Carson, Smith Electric Vehicles
Joe Dalum, Odyne
Jim Doutt, EBO Group/eZE Drives
John Duffy, PACCAR
Wayne Farley, AEP
Larry Fuehrer, BAE Systems
Joe Gold, PepsiCo
Alex Hampshire, Southern Company
Brian Heldebrandt, Verizon
Brad Hicks, ArvinMeritor
Matt Jarmuz, Odyne
Spiro Kattan, New York City Sanitation
Tom Kelly, Mack Trucks
Josh Lepage, Navistar
Claude Masters, Florida Power and Light
David Mazaika, Quantum Technologies
Ken McKenney, Verizon
Allen M. Mitchell, Snohomish County
Kelly Mills, Westport Innovations
Larry Mousseau, Fleet Technology Group
Gerald Owens, Oncor Electric Delivery
Tammy Packard, ArvinMeritor
Summer Pennino, EVI
Jason Ritter, PACCAR
Susan Robinson, Waste Management
Michael Roeth, North American Council for Freight Efficiency
Steve Saltzgiver, Coca-Cola Refreshments
Jesse Shroyer, Smith Electric Vehicles
Jordan Smith, Southern California Edison
James Steffen, Service Master
Matthew Stewart, City of Chicago
Bruce Stockton, Con-Way Transport
Bonnie Trowbridge, Lightning Hybrids Inc.
Serge Viola, Purolator Courier

Appendix 2: Co-Benefit Assumptions

This report provided estimates for co-benefit values associated with truck efficiency improvements. These values are summarized in Tables ES, 1, and 2in the report. The key assumptions used are outlined below.

Calculation of Fuel Consumption Reduction

The co-benefit tables presented in this report show both "fuel efficiency gain" and "fuel consumption reduction." These are two different ways of looking at the same thing. The calculations below show the difference between fuel efficiency gain and fuel consumption reduction for a truck that travels 100k miles per year with an initial fuel efficiency of 5 mpg and an improved fuel efficiency of 7.5 mpg.

Initial fuel efficiency = 5 mpg
New fuel efficiency = 7.5 mpg
Fuel efficiency gain = (7.5-5)/5 = 50%

Initial fuel consumption = 100,000 miles / 5 mpg = 20,000 gallons per year
New fuel consumption = 100,000 miles / 7.5 mpg = 13,333 gallons per year
Fuel consumption reduction = (20,000-13,333)/20,000 = 33.3%

This demonstrates how a fuel efficiency gain of 50 percent is equivalent to a fuel consumption reduction of 33 percent. While it is common to talk about fuel efficiency gain (in miles per gallon – MPG) in the U.S., many fleets prefer to deal in fuel consumption reduction (in gallons per unit of time or work). For emissions calculations, fuel consumption reduction is the important percentage.

Vehicle Fuel Efficiency and Usage Assumptions

All of the co-benefit assumptions are based on savings in fuel consumption and are calculated with the following assumptions in mind.

Heavy-heavy duty: includes trucks with GVW of 33,000 lbs or greater. Vehicles are assumed to have a baseline fuel efficiency of 5.78 mpg before efficiency improvements. Vehicles are assumed to travel 100,000 miles per year over a 10 year lifetime.

Medium-heavy duty: includes trucks with GVW of 14,000 to 33,000 lbs. Vehicles are assumed to have baseline fuel efficiency of 7.7 mpg before efficiency improvements. Vehicles are assumed to travel 25,000 miles per year over a 10 year lifetime.

Assumptions used in calculating benefits from reduced NOx emissions

NOx emissions reductions are valued at $15,000 per ton reduced, based on maximum values used in California's air quality incentive programs. The Carl Moyer Program, for example, has a NOx cost effectiveness limit of $16,000 (2008 guidelines).

NOx emissions factors for medium and heavy duty vehicles are drawn from work done by the California Air Resources Board (CARB) for the 2008 Truck and Bus Rule (http://www.arb.ca.gov/regact/2008/truckbus08/appg.pdf). These emissions factors are:

- Heavy heavy duty: begins at 1.46 grams/mile, deteriorating at a rate of .0413 grams/mile every 10,000 miles. Over a 10 year lifetime at 100,000 miles per year, the baseline average is therefore 3.525 grams/mile.
- Medium heavy duty: beings at 0.859 grams/mile, deteriorating at a rate of .054 grams/mile every 10,000 miles. Over a 10 year lifetime at 25,000 miles per year, the baseline average is therefore 1.534 grams/mile.

The calculations in this report assume that NOx emissions will not increase from current certification levels (no "backsliding") and can be reduced on a vehicle system level while increasing overall vehicle system efficiency. This is already being accomplished with some technologies, such as hybrid systems. We recognize that the engine is a prime driver of NOx emissions and that at the engine and cylinder level there are significant barriers to reducing fuel consumption while simultaneously reducing NOx emissions. However, there are a wide range of options that can and are being used to reduce NOx and achieve compliance with the most stringent NOx standards, while achieving improvements in fuel economy, on a total vehicle system approach. These include sophisticated after treatment schemes, advanced SCR, potential engine-off applications, turbines, alternative combustion cycles, thermal and kinetic energy recovery, hybridization, engine downsizing (enabled by the substitution of electric or other hybrid drive technologies), and utilization of alternative engine cycles (such as Atkinson cycle engines), among other approaches. To highlight the potential benefits, the calculations in this report assume that fuel consumption reductions can be accompanied with proportional NOx emission reductions on a system level, which will include advanced emission-reducing solutions and technologies as mentioned above, in future high efficiency trucks. We use fuel consumption as the prime indicator of overall system efficiency.

Assumptions used in calculating benefits from reduced GHG emissions

Greenhouse gas emissions reductions are valued at $22 per metric ton, based on language included by US EPA in the new truck standards. The greenhouse gas content of diesel fuel is assumed to be 10.1 kg/gallon (http://www.epa.gov/oms/climate/420f05001.htm). Greenhouse gas emissions benefits GHG emissions are assumed to decrease in line with fuel consumption reduction, with a 1 to 1 relationship.

Assumptions used in calculating petroleum reduction and energy security benefits

The energy security benefits of petroleum reduction are valued at $0.16 per gallon, based on work done by researchers at Resources for the Future (http://www.rff.org/documents/RFF-DP-06-23.pdf) This value is speculative and does not take into account political costs, such as constraints imposed on foreign policy.

Appendix 3: Technology Cost Assumptions

There are already several technologies in the marketplace and in early production that can greatly increase truck fuel efficiency, and it is expected that the number of these products and the range of technologies will increase substantially in the coming years. While current incremental costs are high due to low production volumes, this is also expected to decrease in the coming years, depending on speed of market penetration, engineering improvements and other factors.

To develop a baseline case for the expected incremental costs associated with different levels of efficiency improvement, CALSTART used several sources to develop an aggregated average incremental cost. This average represents no single technology or approach. Rather, it is a "market basket" average, using expected incremental costs of various technologies and technology packages that are expected to achieve the different levels of efficiency in the chart. The technologies included in the market basket include:

- Aerodynamics: fairings, skirts, boat tails, etc
- Engine improvements
- Weight reduction
- Tire improvements: low rolling resistance, etc.
- Transmission improvements: direct drive, friction reduction, etc
- Idle Reduction: APU, automatic engine idle management, etc.
- Hybridization: engine off, power electronics, etc.

CALSTART developed incremental cost data on these technologies from several sources. A key primary source was the recent National Academy of Sciences (NAS) report[18] on technologies and approaches for improving medium- and heavy-duty truck fuel efficiency. An important additional source was direct cost data from manufacturers and suppliers, including Task Force members. This information was collected in confidential form, and aggregated with other sources so no one technology or source is reflected in the cost data. The incremental costs represent near-term (pre 2015) expected costs; the data is weighted 2-1 in most cases to reflect costs reflected in the NAS report.

The incremental cost data was compiled by fuel efficiency level and by weight class of truck, as this was the preferred structure for an incentive program. Task Force members then recommended a starting point of 50 percent of incremental cost as a defensible incentive amount to consider for spurring purchase.

The following chart shows the assumptions used in this report for what are expected to be 50 percent levels of near-term incremental costs of technologies that achieve these different levels of efficiency.

[18] National Academy of Sciences (NAS), March 2010, Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles, ISBN-10: 0-309-14982-7

Table A3-1: 50 Percent of Expected Incremental Costs of Technologies Achieving Increasing Fuel Efficiency Levels

Fuel reduction	5%	9%	13%	17%	23%	29%	33%	38%
Fuel Efficiency Gain	**5%**	**10%**	**15%**	**20%**	**30%**	**40%**	**50%**	**60%**
Class/Weight								
8.5-14k GVWR					$10,000	$15,000	$18,000	$21,000
14-21k					$15,000	$18,000	$21,000	$24,000
21k-33k				$12,500	$20,000	$20,000	$25,000	$30,000
33k-66k GCVW				$15,000	$20,000	$25,000	$30,000	$35,000
66k+	$8,500	$10,000	$12,000	$15,000	$20,000	$25,000	$30,000	

The Task Force noted that while this was a starting point, it did not adequately reward use of those technologies that had the greatest impact – that is, technologies on vehicles with higher mileage and/or fuel use. This is particularly important in long haul Class 8 tractors, which can travel as much as 120,000 miles per year. To compensate for this, and to acknowledge some (but not all) of the co-benefits inherent in the use of these efficiency technologies, a co-benefit "kicker" or plus up was added to the 50 percent incremental costs to create recommended voucher chart shown in this report. Benefits from oxides of nitrogen (NOx) reductions were selected as the co-benefit to add to the incremental cost as additional NOX reduction has become a critical local air quality issue throughout the United States with recent changes to the National Ambient Air Quality Standards (NAAQS) enacted by EPA in 2010.

The NOx benefits added stem from the assumptions outlined in Appendix 2. It is not an absolute reduction but a generalized one, for simplicity of implementation, based on expected average truck usage patterns and mileage by weight class. To highlight the potential benefits, the calculations in this report assume that fuel consumption reductions can be accompanied with proportional NOx emission reductions on a system level, which will include advanced emission-reducing solutions and technologies (see appendix a), in future high efficiency trucks. We use fuel consumption as the prime indicator of overall system efficiency. See Appendix 2 for more details.

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CALSTART is a non-profit organization focused on the growth of the clean transportation technology industry. CALSTART has 160 member companies representing a broad array of clean vehicles, fuels, and technologies. CALSTART provides services and consulting help to spur advanced transportation technologies, fuels, systems and the companies that make them. CALSTART's main activities include:

- Providing value-added services for member companies
- Working with teams to commercialize new technologies
- Helping fleets and ports cost-effectively "green" their operations
- Supporting positive pro-environment and business public policy.

One of CALSTART's main strengths is its access to an unparalleled array of information sources through its diverse activities and extensive network. The clean transportation technology industry is rapidly changing and CALSTART's close contact with fleet managers, policymakers, researchers, scientists, technology developers, and manufacturers puts the organization in a unique and valuable position.

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