HYBRID TECHNOLOGIES FOR MEDIUM- TO HEAVY-DUTY COMMERCIAL TRUCKS

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

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CONTENTS

June 10, 2008

HYBRID TECHNOLOGIES FOR MEDIUM- TO HEAVY-DUTY COMMERCIAL TRUCKS

TUESDAY, JUNE 10, 2008

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:06 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Nick Lampson [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE AND TECHNOLOGY

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Subcommittee on Energy and Environment

Hearing on

Hybrid Technologies for Medium- to Heavy-Duty Commercial Trucks

Tuesday, June 10, 2008
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witness List

Mr. Terry Penney
Technology Manager, Advanced Vehicle and Fuel Technologies, National Renewable Energy Laboratory

Mr. Eric Smith
Chief Engineer, Hybrid Medium Duty Truck, Eaton Corporation

Mr. Joseph Dalum,
Vice President, Dueco

Ms. Jill Egbert
Manager, Clean Air Transportation, Pacific Gas & Electric Company (PG&E)

Mr. Richard Parish
Senior Program Manager, Calstart Hybrid Truck Users Forum (HTUF)

HEARING CHARTER

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

Hybrid Technologies for Medium- to Heavy-Duty Commercial Trucks

TUESDAY, JUNE 10, 2008
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Tuesday, June 10 the Subcommittee on Energy and Environment of the Committee on Science and Technology will hold a hearing to receive testimony on the state of development of hybrid electric technologies for medium- to heavy-duty commercial vehicle applications and the role of the Department of Energy (DOE) in supporting research and development of these systems. The Committee will also receive testimony on a discussion draft of legislation to be introduced by Rep. Sensenbrenner.

Witnesses

Mr. Terry Penney, Technology Manager, Advanced Vehicle and Fuel Technologies, National Renewable Energy Laboratory

Mr. Eric M. Smith, Chief Engineer, Hybrid Medium Duty Truck, Eaton Corporation

Mr. Joseph Dalum, Vice President, Dueco Inc.

Ms. Jill Egbert, Manager, Clean Air Transportation, Pacific Gas & Electric Company (PG&E)

Mr. Richard Parish, Senior Program Manager, CALSTART Hybrid Truck Users Forum (HTUF)

The witnesses will discuss the considerable potential for energy savings and emissions reductions through deployment of hybrid electric systems in heavy duty trucks, the range of hybrid heavy truck technologies and applications, the major technical and market barriers in deploying these technologies, and their experience with the federal energy research programs.

The witnesses will also offer their views on the draft legislation to authorize a federal research and demonstration program on hybrid technologies for heavy-duty vehicles.

Background

There are significant potential economic and environmental benefits from improving medium- to heavy-duty vehicles through the electrification of drive trains and auxiliary power systems. Hybrid technologies (ex: battery and hydraulic) are being developed for a wide range of commercial vehicle platforms such as package delivery vans, refuse collection trucks, large utility "bucket trucks," military and construction vehicles, and even long-haul tractor trailer trucks. Conventional large truck models share the common characteristics of relatively low fuel efficiency and high emissions profiles since they must rely solely on a diesel or gasoline internal combustion engine for power. These inefficiencies are especially evident in trucks that require frequent starts and stops, or long periods of non-drive time engine idling in order to provide power for auxiliary systems such as bucket lifters and other work-related equipment, off-board power tools, air conditioning, and refrigeration. By switching some driving and auxiliary loads to hybrid systems large trucks stand to save a considerable amount of fuel and greatly reduce their emissions.

For defense applications, hybrid systems provide the added benefit of generating very little noise, providing power for radar and weapons systems, reducing overall weight and maintenance requirements, and allowing vehicles to run much longer between fueling. In fact, military requirements have been a major driver of innovation in hybrid technologies for heavy vehicles.

The power demands on heavy duty trucks are as varied as the applications. While several truck companies are testing hybrid models, significant technical hurdles remain, and there is no one-size-fits-all hybrid solution for the entire sector. Through the course of an average drive cycle the charging and discharging of a hybrid electric or hydraulic system on a trash truck, with its frequent starts and stops, dumpster lifting, and trash compaction, will be considerably different than that of a utility truck which may idle in one place for several hours in order to operate the bucket lifting boom and other equipment. Long haul tractor trailer rigs (Class 8) may prove even more challenging since they seldom brake during a drive cycle, providing little opportunities for battery systems to recharge. The next generation of trucks may also include plug-in hybrid electric models which can charge larger banks of batteries through direct connection to the electricity grid.

While the total number of these vehicles is small compared to passenger vehicles, their fuel consumption and emissions justify the high costs of development of hybrid models. According to figures by the Oshkosh Truck Corporation there are approximately 90,000 refuse collection trucks in the U.S. but their collective fuel consumption is roughly equivalent to 2.5 million passenger vehicles (based on 10,000 gallons/year per truck). Estimates done by the Eaton Corporation show that as little as 10,000 hybrid electric trucks could reduce diesel fuel usage by 7.2 million gallons/year (approx. one million barrels of oil), reduce NO_X emissions by the amount equivalent to removing New York City's passenger cars for 25 days, and reduce carbon dioxide emissions by 83,000 tons.

The energy storage options for hybrid trucks generally include batteries, hybrid hydraulic systems, and ultracapacitors. Batteries receive the most attention and research funding because of their applicability throughout the transportation sector. To expand the use of electricity in the vehicles sector batteries must be smaller, lighter, cheaper, and more powerful. Vehicle batteries typically fall into one of three families of technologies: lead-acid, nickel metal hydride (NiMH), and lithium-ion (Li-Ion). Lead-acid batteries have many advantages including their relative simplicity and low cost, wide-scale availability, domestic manufacturing capacity, and established recycling infrastructure. NiMH batteries are found in the current generation of hybrid vehicles and will be the battery of choice for many of the first generation heavy hybrid trucks. However, high weight and low power density are significant issues for both lead-acid and NiMH batteries, and they may not be optimal for future plug-in hybrid applications. Many in the industry believe the future of hybrids depends on breakthroughs in new battery technologies, such as the lithium ion (Li-ion) batteries with their low weight and high power density. But, in addition to solving remaining technical issues such as heat management, the costs of manufacturing Li-ion batteries remain prohibitively high for large-scale deployment in vehicles. There is also concern that the U.S. is falling behind in the race to develop and manufacture batteries, and a significant effort is underway to build up a domestic supply chain.

The Department of Energy has funded research in this area over the years, most recently through the 21st Century Truck Partnership which conducts R&D through public-private efforts with the trucking industry. Other federal agencies involved in the 21st Century Truck Partnership include the Department of Defense, the Department of Transportation, and the Environmental Protection Agency. Federal research capabilities exist in DOE laboratories such as the National Renewable Energy Laboratory and Argonne National Laboratory, the EPA's National Vehicle and Fuel Emissions Laboratory, and the Army's National Automotive Center. Despite the potential economic and environmental benefits of hybrid trucks and the considerable technical hurdles that remain, the 21st Century Truck Partnership is facing decreased funding as the Administration chooses to shift the focus of federal research to the passenger vehicle market.

Draft Legislation

Representative James Sensenbrenner will have draft legislation available for the Committee and witnesses to review. Specifically, the draft legislation would accelerate research of plug-in hybrid technology in trucks by creating grants for manufacturers to build, test, and ultimately sell plug-in hybrid utility and delivery trucks. The Act would also encourage DOE to expand its research in advanced energy storage technologies to include heavy hybrid trucks as well as passenger vehicles.

Chairman LAMPSON. The hearing will come to order. I want to welcome the Members of the Subcommittee and our distinguished panelists to today's hearing on hybrid technologies for medium- to heavy-duty commercial trucks.

With concerns about our over-reliance on foreign oil, the sky-rocketing costs of fuels, and the effects of our transportation sector on air quality and carbon emissions, technological strides in the commercial truck market stand to offer tremendous benefits to our economic and environmental health.

Though it is easy to overlook, these vehicles are pervasive throughout our economy. From school buses to trash collectors, utility trucks to delivery vans, long-haul tractor trailers to road work equipment, one would be hard pressed to identify an aspect of our daily lives that didn't at some point depend on medium-to-heavy trucks, heavy-duty trucks. They also represent a substantial portion of the U.S. fuel consumption and emissions.

The truck industry is due for a major technological shift. But advances in this sector don't come easily, and there is no one-size-fits-all solution. The demands on these vehicles are as varied as their uses. Consequently, there remains a need for a robust federal program to partner with industry and develop this wide range of hybrid platforms.

The focus for hybrid vehicle technology development has largely been on passenger vehicles. Passenger vehicles have paved the way both in terms of advancing the technologies and expanding public awareness of capabilities of hybrid systems. You need only to visit your local dealership and see the waiting lines and lists for hybrid models to know that the general public is serious about saving fuel and reducing emissions.

But there is a larger market for hybrids beyond the family automobile. Reducing fuel costs and meeting environmental regulations is vital to the bottom line of any company that relies on heavy trucks. Yet the Administration has chosen to shift resources to the passenger automobile and away from its 21st Century Truck Program. Given the significant gains to be made in the commercial truck sector and its indispensable role in our economy, we should ensure that federal research and development programs continue to address the need to improve fuel efficiency of heavy-duty vehicles.

We are joined by our colleague, Mr. Sensenbrenner, Ranking Republican Member of the Investigations and Oversight Subcommittee, who will soon introduce legislation to enhance the federal role in the development of heavy hybrid vehicles. I would like to thank him for elevating this subject to the level that it deserves, and I look forward to the opportunity to consider his legislation at the appropriate time.

And at this time I would yield to my distinguished colleague from South Carolina, our Ranking Member, Mr. Inglis, for an opening statement.

[The prepared statement of Chairman Lampson follows:]

PREPARED STATEMENT OF CHAIRMAN NICK LAMPSON

I want to welcome Members of the Subcommittee and our distinguished panelists to today's hearing on hybrid technologies for medium- to heavy-duty commercial trucks.

With concerns about our over-reliance on foreign oil, the skyrocketing costs of fuels, and the effects of our transportation sector on air quality and carbon emissions, technological strides in the commercial truck market stand to offer tremendous benefits to our economic and environmental health.

Though it is easy to overlook, these vehicles are pervasive throughout our economy. From school buses to trash collectors, utility trucks to delivery vans, long-haul tractor trailers to road work equipment, one would be hard pressed to identify an aspect of our daily life that did not at some point depend on medium- to heavy-duty trucks.

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The truck industry is due for a major technology shift. But, advances in this sector don't come easy, and there is no one-size-fits all solution. The demands on these vehicles are as varied as their uses. Consequently, there remains a need for a robust federal program to partner with industry and develop this wide range of hybrid platforms.

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At this point I will turn to the distinguished Ranking Member of this subcommittee, Mr. Inglis for his opening statement.

Mr. INGLIS. Thank you, Mr. Chairman. Thank you for holding this hearing.

Transportation needs innovation. The transportation sector is our primary consumer of oil and exhales more carbon dioxide emissions than any other source. The more we pay at the pump each week, the easier it is to realize the obvious benefits of alternatives to oil. It seems that rising oil prices rouse our attention to ways that we could "do energy" a different way. This hearing is a case in point.

In previous hearings of this subcommittee we have talked about reinventing the car. We have heard the economic, environmental, and national security benefits that will accrue to pursuing hybrid, battery, and hydrogen technologies to power tomorrow's cars.

Today we will hear from a number of experts about the medium- and heavy-duty commercial truck market and its needs for the same innovative focus. Applications such as hybrid engines and battery-powered auxiliary systems promise a significant reduction in oil consumption and greenhouse gas emissions, but technological hurdles stand in the way of realizing those benefits.

I join with the Chairman in thanking Mr. Sensenbrenner for introducing this draft legislation that would steer federal dollars toward research, development, and demonstration in the areas of commercial truck hybrid technologies. I would be interested to hear from our witnesses as to whether current oil prices are enough incentive for heavy truck companies to invest in these technologies, or if there is a necessary role for the Federal Government to assist in overcoming these technological hurdles.

Thank you again, Mr. Chairman. I look forward to hearing from our witnesses on their perspectives in this, on their perspectives in this legislation and suggestions as to ways we might improve it.

[The prepared statement of Mr. Inglis follows:]

PREPARED STATEMENT OF REPRESENTATIVE BOB INGLIS

Thank you for holding this hearing, Mr. Chairman.

Transportation needs innovation. The transportation sector is our primary consumer of oil, and exhales more carbon dioxide emissions than any other source. The more we pay at the pump each week, the easier it is to realize the obvious benefits of alternatives to oil. It seems that rising oil prices rouse our attention to ways we could "do energy" a different way. This hearing is a case in point.

In previous hearings of this subcommittee, we've talked about reinventing the car. We've heard the economic, environmental, and national security benefits that will come from pursuing hybrid, battery, and hydrogen technologies to power tomorrow's cars.

Today, we'll hear from several experts that the medium- and heavy-duty commercial truck market needs the same innovative focus. Applications such as hybrid engines and battery-powered auxiliary systems promise a significant reduction in oil consumption and greenhouse gas emissions, but technological hurdles stand in the way of realizing those benefits.

I'd also like to thank Mr. Sensenbrenner for introducing draft legislation that would steer federal dollars toward research, development, and demonstration in the area of commercial truck hybrid technologies. I'd be interested to hear from our witnesses as to whether current oil prices are enough incentive for heavy truck companies to invest in these technologies, or if there's still a necessary role for the Federal Government to assist in overcoming these technological hurdles.

Thank you again, Mr. Chairman. I look forward to hearing from our witnesses on their perspectives of this legislation and any suggestions they may have to improve it.

Chairman LAMPSON. Thank you, Mr. Inglis.

And now I would like to recognize Mr. Sensenbrenner for a statement.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman.

New taxes are not the only solution to climate change. We need to focus our economy as we work to reduce our emissions. We can over regulate our businesses, cripple our economic development, and watch as China and India race past us, sputtering greenhouse gases along the way. Or Congress can create incentives that encourage the development of new technologies that will reduce our emissions, foster economic development, and allow U.S. manufacturers to export their energy-saving technologies worldwide.

A honking motorcade of trucks around the Capitol last month flashed signs that read, "When Trucks Stop, America Stops." Commercial traffic is truly vital to the American economy, and the fuel costs for trucks directly affects costs for all Americans. The additional price of their fuel raises the price of our food, health care, manufacturing, retail, waste removal, and other goods and services. And while our economy would not survive without them, trucks consume huge quantities of oil, which raises the cost of their businesses and raises our dependence on oil and injects greenhouse gases into the environment.

The answer is not to burden these businesses already strained by high fuel costs with additional taxes for the CO_2 they release. Instead, we need to encourage the development and introduction of technologies that will reduce their fuel consumption.

The technologies we need already exist. Everybody has seen hybrid cars. This technology, which combines gas and electric motors for a powerful and efficient engine, is even more practical in trucks. Even though there are fewer trucks on the road, trucks use more fuel.

Utility trucks, for example, typically drive short distances to and from a work site, but sit idle for hours while on site. A plug-in hybrid truck would use less fuel getting to and from the site and would operate without any fuel on the site. Ultimately, a plug-in hybrid engine in a utility truck could use up to 60 percent less fuel.

Delivery trucks constantly stop and go. Hybrid engines excel at this type of driving because the engine can essentially turn off during short accelerations, while coasting and while it is at a stop.

Developing these technologies will have benefits beyond fuel savings. By making our trucks more efficient, we will make our goods and services more affordable and then become leaders in these new technologies. Like America, Asia is faced with rising fuel costs. Their trucking fleets, like ours, are currently powered by diesel. In Europe the price of diesel has risen to nearly $9 a gallon. This has led to a strike. Spanish truckers are currently holding a "snail protest," essentially blockading the highways of Spain and Southern France by inching along the road. Anti-protest demonstrators, fearing that food and other goods could become scarce, have rebelled violently by slashing truck tires and smashing their windshields. If America's companies are the first to develop and commercialize products such as the topic of the hearing today, not only can we avoid a similar fate, but we can export these technologies worldwide.

By helping American manufacturers research and commercialize new technologies, we can strengthen our economy, reduce our dependence on foreign oil, and lower our emissions. The legislation we will discuss today is a narrow example of how technology, and not taxes or carbon offset credits, can help solve our energy crisis. The legislation would accelerate research of plug-in hybrid technology in trucks by creating grants for manufacturers to build, test, and sell plug-in hybrid utility and delivery trucks. The Act would also encourage the Department of Energy to expand its research in advanced energy storage technologies to include heavy hybrid trucks as well as passenger vehicles. This bill will put plug-in hybrid trucks on the road and help advance research and accelerate commercialization of this important technology.

I thank the Chairman for holding this hearing and the witnesses for lending their expertise to this effort, and yield back the balance of my time.

[The prepared statement of Mr. Sensenbrenner follows:]

PREPARED STATEMENT OF REPRESENTATIVE F. JAMES SENSENBRENNER JR.

New taxes are not the only solution to climate change. We need to focus on our economy as we work to reduce our emissions. We can over-regulate our businesses, cripple our economic development, and watch as China and India race past us—sputtering greenhouse gases along the way—or Congress can create incentives that encourage the development of new technologies that will reduce our emissions, foster economic development, and allow U.S. manufacturers to export their energy-saving technologies worldwide.

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American economy, and the fuel costs for trucks directly affect costs for all Americans. The additional price of their fuel raises the price of our food, health care, manufacturing, retail, waste removal, and other the goods and services. While our economy would not survive without them, trucks consume huge quantities of oil, which raises the cost of their business, increases our dependence on oil, and injects greenhouse gases into our environment.

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By helping American manufacturers research and commercialize new technologies, we can strengthen our economy, reduce our dependence on foreign oil, and lower our emissions. The legislation we will to discuss today is a narrow example of how technology, not taxes, can solve our energy crisis. The legislation would accelerate research of plug-in hybrid technology in trucks by creating grants for manufacturers to build, test, and sell plug-in hybrid utility and delivery trucks. The Act would also encourage the Department of Energy to expand its research in advanced energy storage technologies to include heavy hybrid trucks as well as passenger vehicles. This bill will put plug-in hybrid trucks on the road and help advance research and accelerate commercialization of an important technology. I thank the Chairman for holding this hearing and the witnesses for lending their expertise to this effort.

Chairman LAMPSON. Thank you, Mr. Sensenbrenner.

I ask unanimous consent that all additional opening statements submitted by the Committee Members be included in the record.

Without objection, so ordered.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Mr. Chairman, I appreciate the Subcommittee giving attention to this matter, it is particularly salient topic as gas and diesel prices continue to rise every day.

Hybrid technology for passenger cars has received an increasing amount of media and consumer attention recently as gas prices continue to soar. As alternative fuel technologies advance for passenger vehicles, I am pleased that this committee has turned its attention to the status of renewable technologies for medium- and heavy-duty trucks.

There are many benefits to hybrid technologies for heavy-duty trucks, and variety of electric vehicles systems currently exist to serve in various capacities. The cross-country shipping industry, the military, utility companies and the construction industry can all benefit from the expansion of hybrid technologies. A manufacturer in my district in Southern Illinois, BNSF Railway and Vehicle Projects LLC, are developing a switch locomotive powered by a hydrogen fuel cell. This technology can help these industries to not only to lower their carbon footprints, but to also reduce their expenses by decreasing the amount of gasoline for their fleets of medium- and heavy-duty trucks.

At this critical time when Congress will embark upon major climate change legislation in the near future, we must ensure that funding is dedicated to overcoming the existing challenges that face this developing technology. Although the Department of Energy once funded a program to develop and test early heavy hybrid technologies that yielded encouraging results, the Bush Administration has since terminated the funding.

As we will hear today, many utility companies currently use hybrid trucks in their fleet today. If additional funding is invested, the foundation of technology exists to launch hybrid technologies into the mass-consumer level. With the proper resources, the United States can take advantage of the opportunity to become a leader in hybrid technology.

Thank you, Mr. Chairman, for my time; I look forward to hearing from our witnesses today. I yield back.

Chairman LAMPSON. It is my pleasure to introduce our witnesses this morning. Terry Penney is the Technology Manager for Advanced Vehicle Technologies and the Renewable Fuels Science and Technology Directorate at the National Renewable Energy Laboratory. Mr. Eric Smith is the Chief Engineer for Medium-Duty Hybrid Electric Powertrains for the Eaton Corporation. Joseph Dalum is the Vice President of Dueco, and Ms. Jill Egbert is the Manager of the Clean Air Transportation Department at the Pacific Gas and Electric Company, PG&E. Mr. Richard Parish is the Senior Program Manager of the Hybrid Truck Users Forum at CALSTART.

You will each have five minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When you all complete your testimony, we will begin with our rounds of questions. Each Member will have five minutes to question the panel.

Mr. Penney, would you please begin.

STATEMENT OF MR. TERRY PENNEY, TECHNOLOGY MANAGER, ADVANCED VEHICLE TECHNOLOGIES, NATIONAL RENEWABLE ENERGY LABORATORY, GOLDEN, COLORADO

Mr. PENNEY. Thank you, Mr. Chairman, and other Members for this opportunity to talk about the status and potential of heavy hybrid trucks.

NREL has been working for the last 15 years with partners in government, other national labs, and industry on both light and heavy-duty hybrids. Despite the tremendous progress that has been made, I believe that targeted R&D and purchase incentives are still needed so these trucks can grow in volume and play a prominent role in the marketplace.

Primarily, because of escalating fuel prices and tougher emission standards, the cost in operating and producing heavy-duty vehicles are rising at alarming rates. But there are reasons to be optimistic. Despite the fact that more fuel is being used by our light-duty car fleet, and we are working hard on those vehicles too, we should not ignore advanced heavy truck technologies across many applications that can also significantly reduce their fuel use and subsequent emissions.

To frame the opportunity, first a little background. About 80 percent of all our goods are transported by truck, and last year Class one through Class eight trucks consumed about 40 billion gallons of diesel fuel. The good news, hybrid trucks in various forms from research prototypes to recent early commercialization products have demonstrated the potential to reduce fuel costs anywhere from a few percent to 50 to 60 percent.

Original equipment manufacturers, OEMs, and truck owners are learning that their exact savings depend on three things: the application, the duty cycle, and the way it is driven, and of course, the distance it travels between stop and go.

For example, a typical delivery truck using a hybrid drive system could save more than a thousand gallons of fuel per year in comparison to a conventional truck. We believe almost every truck application can benefit from hybrid drive of some sort and other system improvements.

In addition to NREL's fleet testing, we have shown that hybrids' overall operating and maintenance costs per mile can be lower, too, in part because of fewer brake replacements and less downtime, which help lower the cost differential between conventional and hybrid drive trains.

Let us quickly review the potential for hybrids and or perhaps plug-in hybrid truck applications by class, and if you have my testimony in front of you, take a look at page two and page three, where I describe the classes one through eight, and you will see that classes one through four are your typical minivans, utility vans, pickup trucks, five includes a shuttle or city delivery and a bucket truck. Class six is a beverage or a school bus. Class seven is refuse haulers, furniture delivery, city transit buses, for example, and of course, Class eight is dump trucks, cement trucks, and line haul semis.

Of course, military vehicles of all classes and sizes could also benefit from hybridization, and several have already been demonstrated as you are well aware.

I would like to draw your attention to the Class eight trucks. They use, and this is on page three, you will notice that they use as much diesel fuel as all other truck classes combined, and until recently many believed there was little hope in hybridizing line haul semis because they don't have much stop and go, which is classic of the hybrid cycle. However, even in this class, truck OEMs are finding opportunities for fuel savings, even if only in the single digits, because hybridization and other system improvements can yield tremendous savings.

Today hybrid trucks are just starting to hit the market in various service applications, most notably transit buses, though for most applications it is tough, it is a tough sell. This is probably because the cost premiums which result from limited current production quantities and the need for further improvement and establish the system reliability, economics, and performance of various truck components.

Along with continuing credits and incentives, we need to continue our R&D programs to improve the performance and economics of these hybrid systems. The National Academy of Sciences recently completed a detailed examination of the 21st Century Truck Partnership Projects in this area, and that report is expected to be delivered to the Department of Energy in the next few weeks. I would encourage you to review its findings.

There are approximately 18 million commercial vehicles on the road, every kind of vehicle represents a different set of demands, and these, in turn, determine vehicle size, configuration, and each with a different duty cycle. As a result, there are many unique powertrain solutions. A hybrid is not just a hybrid. Today there are a handful of demonstration hybrid trucks, many supported by federal and State cost-sharing programs and are shedding life on both opportunities and challenges, but production volumes are still very low and not very high since system costs from drive trains through energy storage systems to power electronics must be continued to be reduced.

So with these considerations in mind, what needs to be done? First, we must understand the unique duty cycle of the hybrid vehicle. Then we need to understand how these new powertrain topologies can boost miles per gallon or ton miles delivered. We must take an overall systems approach to greater efficiency. We also need to work on advanced combustion, heat recovery, energy storage technology, especially batteries and ultracapacitors, to improve the cost, performance, and life and thermal abuse tolerance. Finally, we need to improve the overall performance and costs associated with the power of electronics module and electric drive motor, improving performance, life, and reliability issues through advanced thermal control.

Despite a limited DOE budget, the DOE Vehicle Technology Program is actively engaged in pursuing many of these technical areas. With DOE's support of NREL, we employ heavy hybrid vehicle R&D testing, analysis to understand and solve many technical issues and overcome these barriers while working with OEMs and their suppliers.

For example, NREL's ReFUEL lab tests advanced fuels and double, and heavy-duty engines for advanced heavy hybrid vehicles and is home, unique testing, and measurement equipment. With industry partners we also conduct field evaluations of transit buses, trucks, idle-reduction technologies. We design test plans, gather on-site data, and publish our results. Education, getting the word out, helping industry and fleet owners learn about what actually works and what doesn't, has been a hallmark of our efforts.

The government's commitment to funding, finding solutions for supporting advanced R&D and government industry partnerships and by encouraging incentives is absolute key.

Thank you so much.

[The prepared statement of Mr. Penney follows:]

PREPARED STATEMENT OF TERRY PENNEY

Mr. Chairman, I want to thank you for providing this opportunity to talk about the status and potential of heavy-duty hybrid trucks in the United States, and the research and development and policy support that is needed to give them a more prominent role in the marketplace. As groups like the Hybrid Truck Users Forum have recently noted, hybrid trucks are right "on the cusp" of production in medium- and heavy-duty commercial markets, and there is much we can do to tip the balance in their favor, and in ours, in terms of achieving greater energy security and lessening our reliance on imported fuels.

I am the Technology Manager for Advanced Vehicle Technologies in the Renewable Fuels Science and Technology directorate at the National Renewable Energy Laboratory in Golden, Colorado. NREL is the U.S. Department of Energy's primary laboratory for R&D in renewable energy and energy efficiency technologies, and we are dedicated to helping the Nation develop a full portfolio of technologies that can meet our energy needs.

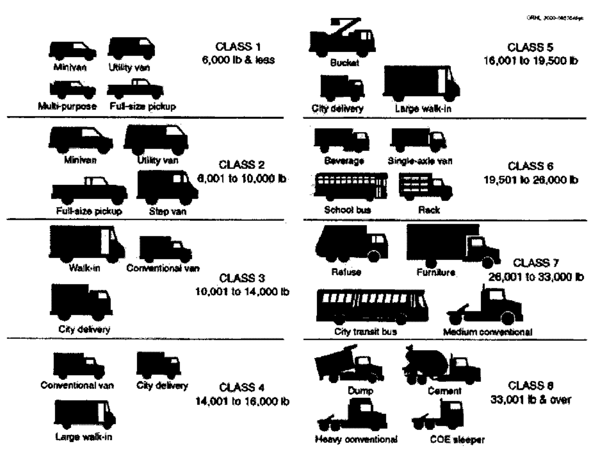
It is an honor to be here and to speak with you today. I want to commend the Committee for its interest in exploring ways to reduce the use of imported petroleum in the commercial sector, curb emissions associated with burning fossil fuels for transportation, and increase the competitiveness of U.S. manufacturers and truck fleets through greater use of hybrid trucks.

Despite the progress we have achieved in fuel efficiency and emissions reductions over recent years, the costs associated with producing and operating our heavy-duty fleets have risen at alarming rates. There exists today great potential from several heavy-duty hybrid truck technologies to significantly reduce fuel consumption and emissions. This should in turn improve the economic picture for U.S. truck manufacturers, suppliers, fleets, and customers alike.

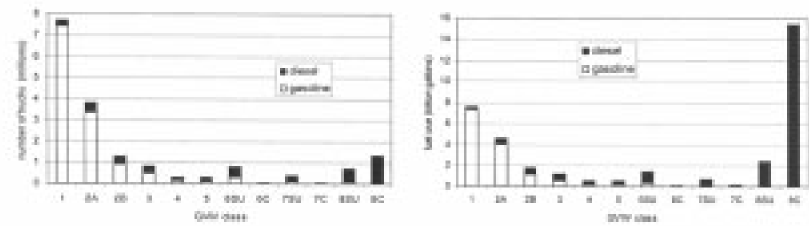
First, a little background. Approximately 80 percent of all the goods transported in the United States today are moved by truck. In all, the United States consumed about 140 billion gallons of gasoline and about 40 billion gallons of diesel fuel for on-road transportation in 2004, according to the Department of Energy. The U.S. now imports more than 60 percent of the crude oil it uses. Retail gasoline and diesel fuel prices have reached record highs in recent months, and the retail price of diesel is well over $4 per gallon in most parts of the Nation.

Given the current situation, we see considerable potential for hybrid trucks to reduce fuel use, and thus costs, from five percent at minimum, to as much as 50 percent to 60 percent at the high end. Although exact reductions depend on the actual use of the truck—and specifically, the way it's driven and the distance traveled between stops—there is virtually no truck application that cannot benefit from a hybrid drive train and related system improvements. Potential applications include shuttle and school buses, military vehicles, utility trucks, bucket trucks, beverage delivery and parcel delivery trucks, refuse haulers, and some large Class 8 vehicles. Because trucks generally use much more fuel per year than passenger vehicles, the overall savings potential is very significant (see illustrations that follow).

Plug-in hybrid trucks are on the horizon, as well. Plug-in hybrid systems could benefit not only industry and the environment, they perhaps could alter the nature of our utility grids, by providing stored energy and a form of mobile distributed energy generation. Before we can begin to realize these benefits widely, however, we must address some remaining issues surrounding hybrid and plug-in hybrid technologies.



Truck classes (courtesy of Oak Ridge National Laboratory, modified from an illustration in the Commercial Carrier Journal, "Industry Trends and Statistics," July 1984)



The graph on the left shows the number of commercial trucks (Classes 1-8) in use; the graph on the right shows their fuel use (courtesy of Oak Ridge National Laboratory, 2006)

Heavy-Duty Hybrid Trucks: Some Major Issues

An article in the April 27, 2008, edition of the *New York Times* noted that commercial vehicles, particularly those making frequent stops, should be the "killer" application for hybrid technologies, because hybrids often work best in the kind of stop-and-go conditions that delivery trucks and refuse haulers experience. Despite this potential, there remain relatively few hybrid trucks on the road. The primary reasons for this are the costs of the hybrid systems, the limited commercial production to date, and the need to further improve the economics and performance of energy storage, power electronics, auxiliary loads and engine idling systems.

Light-duty hybrid-electric vehicles (HEVs), such as the Toyota Prius and Ford Escape Hybrid, have gained public attention and some market momentum in recent years. The added price of hybrid systems have been somewhat offset by tax policies at the federal and the State levels. It should be noted that light duty and heavy duty applications can be much different in overall design and individual components. The price premium for hybrid systems will be proportionally greater for large commercial vehicles, because of their size and complexities. These higher costs have slowed widespread acceptance of these technologies, potential fuel savings notwithstanding.

Hybrid technologies improve fuel economy, primarily by turning off the engine when idling, such as when coasting or at a stop. They use batteries and electric motors for short accelerations, recharge the batteries by recovering the energy used in braking, and use batteries for auxiliary loads such as cabin cooling. The combustion engines in HEVs can thus be smaller than those in conventional heavy vehicles. Our fleet testing has shown how overall maintenance and operating costs per mile can also be lower for hybrids, in part because of a decrease in brake replacement costs.

The energy storage system is the most critical component for hybridization and electric vehicles generally. The energy storage system must be affordable, safe, and durable enough to last through the major portion of the vehicle's life. Since vehicles operate at many different climates and temperatures, energy storage systems must be able to perform well at low temperatures and not quickly degrade at high temperatures. Current commercial light duty and heavy duty vehicles use Nickel Metal Hydride (NiMH) batteries, mostly from Japanese manufacturers. Research and development on advanced energy storage systems, such as lithium ion batteries and ultracapacitors, is expanding, with hybrid electric vehicle systems being seen as a primary use.

One major concern is the domestic production of batteries. Relying on a few foreign sources of battery production (Japan, Korea, China, and France) could increase costs and create new energy security concerns. Domestic production of energy storage materials and U.S.-based manufacturing of energy storage systems should be encouraged.

To increase market acceptance, energy storage systems must be improved to reduce their weight and size. Enhanced power and storage capacity are two other key goals of current R&D.

Improving a hybrid's power electronics system likewise is essential. In some vehicle systems, the power electronics module costs as much as the energy storage system. Boosting the performance and cutting the cost of this system will lead to more favorable economics for hybrid trucks.

Other issues include improving the efficiency and cost-effectiveness of idling reduction technologies. For long-haul trucks especially, there exists considerable opportunity to decrease the effects of aerodynamic drag on the vehicle, primarily through use of lightweight yet strong materials for the truck body, and development of heavy-duty tires with low rolling resistance. Government and industry groups working together through the 21st Century Truck Partnership (21 CT) have found that aerodynamic drag resistance, rolling resistance, drive-train losses, and auxiliary load losses represent fully 40 percent of the total fuel energy used to move a heavy-duty vehicle.

Potential for Fuel Savings and Emission Reductions

Commercial vehicles running on diesel fuel can easily tally 75,000 miles in a year and, at $4-plus per gallon, pay $1,000 for just one fill-up. Thus, a relatively modest increase in fuel efficiency—even five percent—can have a major financial impact over time. Urban hybrid trucks that make frequent stops and starts could see and up to 60 percent savings in fuels costs, depending on the way the truck is driven and which hybrid system is used. The Environmental Protection Agency (EPA) estimates that a typical delivery truck using a hybrid drive train system could save more than 1,000 gallons of fuel per year in comparison to the fuel used by a similar conventional truck.

Energy recovery is a major benefit of hybridization. By converting the vehicle's dynamic energy into electrical energy during braking, less fuel is spent overall. The benefits of energy recovery will be greatest for urban vehicles with repeated start-and-stop cycles. The hybrid's control system effectively allows for separation of the engine speed from the speed of auxiliary or ancillary devices, which offers many advantages.

Electrification of a truck's auxiliary systems, like heating, air conditioning and entertainment systems, allows the engine to be shut down instead of idling. Again, potential fuel savings is significant, as U.S. trucks idle an average of 1,830 hours per year.

In addition, modern long haul trucks are increasingly equipped with automated gearboxes to control the engine speed and save fuel. This has opened up the possibility of introducing "Eco-roll." When no engine power is needed, the gearbox goes into neutral and the engine runs on idle, saving one percent to two percent of fuel. With electrification, we can shut the engine off during coasting for an additional one percent savings. Blending the use of gasoline engine and electric systems allows for added fuel savings.

Another feature is the ability for low-speed moving of the vehicle in electric-only mode. This is useful when going in and out of docks, in harbors, in traffic jams, and so on. Considering projected increases for traffic congestion, this feature could be even more valuable in the future.

Future trucks need to be much more efficient than they are today. Electrification of a truck enables waste heat recovery systems, in which heat can be converted back to energy. Waste heat recovery systems are estimated to reduce fuel consumption about six percent to eight percent. Also, using an electric motor for torque assist can help downspeed the engine, or downsize it, with both alternatives saving fuel.

Fuel savings provide emission reductions as well. A recent study by the CALSTART partnership evaluated the increases in fuel economy and reductions in emissions obtained for a hybrid truck during four driving cycles, compared to a conventional vehicle. The study found that in one driving cycle of 70 miles, lasting 1.5 hours, the hybrid truck showed a 68 percent increase in fuel economy and a 58 percent reduction in hydrocarbons, on a gallons-per-mile basis. A 50 percent decrease in carbon monoxide, a 34 percent reduction in oxides of nitrogen and a 25 percent decrease in particulate matter were also reported. This is significant, because to meet current and upcoming EPA regulations, conventional trucks can lose as much as five to ten percent in fuel economy. This is a result of the use of fuel by advanced emission control systems and also from aggressive exhaust gas recovery strategies for lower oxide of nitrogen emissions. Hybrid trucks offer the potential to reduce the overall emission reduction requirements and therefore reduce the accompanying emission control fuel economy penalty.

Applications for Hybrid Technologies

Hybrid electric powertrains can be used in many, if not most, of the Nation's approximately 18 million commercial vehicles. Stop-and-go short-haul commercial vehicles are well-suited for systems that capture braking energy, assist the engine during frequent accelerations, and turn off the engine during coasting and stops. However, each kind of commercial vehicle presents a different set of demands, which in turn determine the vehicle size, configuration, and duty cycles. As a result, each type is likely to have a different hybrid power-train solution. For example, the duty cycle of a refuse hauler usually consists of a long drive to a neighborhood, followed by repeated short starts and stops and ending with a long drive to a waste site. Rather than using batteries, this application might be ideal for ultracapacitors—devices with enough power to move heavy loads over short distances—while the engine is used to and from the waste site.

Hybrid transit buses are in use today and have demonstrated an average 27 percent reduction in fuel use. Depending on the climate, about 25 percent of the fuel used for transit buses is for heating and cooling passengers. School buses can double the fuel economy with hybridization, but today cost twice the $70,000 price tag of a conventional bus. Postal delivery vehicles could benefit significantly from plug-in operation if they could use the engine to reach a neighborhood, then go to all-electric mode while making mailbox-to-mailbox stops.

Many commercial vehicles idle for extended periods during package deliveries, refuse collection, or to operate necessary equipment like fans, extension buckets, backhoes, and related equipment. Altogether, idling of commercial vehicles is estimated to consume more than two billion gallons of fuel annually, while producing unwanted emissions.

Long-haul trucks, which operate at fairly constant speeds, have challenges all their own. Long-haul trucks consume nearly 16 billion gallons of diesel fuel annually, with opportunities for increasing fuel economy in this truck class centering around development of more efficient engines, reduction of aerodynamic drag, and use of low-rolling-resistance tires. Biofuels may offer advantages as well. Another promising method of cutting fuel consumption and emissions is to use batteries, or plug in directly to electricity sources, at truck stops. Off-board service to the truck can provide heating and cooling, and electricity for lighting, entertainment and ancillary equipment during mandatory driver rest periods. Such needs today are largely met through idling of the truck's main engine.

In addition, long-haul trucks are being studied in order to determine the benefits of some form of hybridization as well, especially when their routes involve climbing and descending hills. Such applications could ultimately deliver huge fuel savings, despite their relatively small gains in efficiency.

Today's Market Issues

Promising developments are on the horizon for hybrid trucks, as early prototypes and demonstration vehicles shed new light on both opportunities and challenges.

For example, one delivery service is creating a fleet of 100 hybrid vans that will offer an estimated 57 percent improvement in fuel economy and significantly lower emissions. Other planned new delivery vans can travel up to 20 miles on electricity alone. At a recent Hybrid Truck Users Forum meeting, at least 15 truck manufacturers announced plans to build or demonstrate new vehicles. They will be used in refuse hauling, delivery, shuttle bus, school bus, bucket truck, heavy truck applications and more.

Industry and deployment groups are finding that the applications are quickly expanding for trucks built on a core hybrid chassis and then customized for particular uses. However, because the overall production volume of these trucks is still not high, they are available only at premium prices. This means that system costs, for drive-trains through energy storage systems to power electronics, must continue to be reduced. Consequently, support for continued R&D and for policy incentives remains vital.

Current Federal Programs and Policies

The Department of Energy's Vehicle Technologies Program supports the development of advanced combustion and engines design, durable and affordable advanced batteries covering the full range of vehicle applications, from start/stop to full-power hybrid electric, electric, and fuel cell vehicles. NREL's extensive testing and analysis capabilities are being used to understand and solve energy storage thermal issues in both light- and heavy-duty hybrid applications.

The Department of Energy is also the lead federal agency in the 21st Century Truck Partnership, established to develop the heavy-duty vehicles of the future. The partnership also includes the Departments of Defense and Transportation, the EPA, as well as numerous industry members. Groups such as CALSTART and the Hybrid Truck Users Forum are also doing much to support and promote the greater use and availability of hybrid commercial trucks.

Recently the National Academy of Sciences conducted a thorough review of the 21st Century Truck Partnership program. Their final report will be delivered to the Partnership in a few weeks. Their conclusions and recommendation should be valuable to the Committee as it evaluates the opportunities in heavy hybrids.

Along with automotive companies and their suppliers, NREL has been developing and evaluating new technologies that reduce climate control loads as well as analyzing and evaluating the thermal performance of advanced lithium-ion batteries and ultracapacitors for energy storage. NREL is conducting research to develop thermal control technologies that enable high power density solutions for reducing the overall cost of the power electronics system. Our research includes experimental and numerical modeling focused on developing advanced thermal interface materials, single-phase liquid, and two-phase jet and spray cooling technology, surface enhancements for advanced heat exchangers, air cooling, and thermal system integration.

NREL's Renewable Fuels and Lubricants (ReFUEL) Research Laboratory, a test facility for advanced fuels in heavy-duty engines and advanced heavy hybrid vehicles, houses unique testing and measurement equipment. These include a heavy-duty vehicle chassis dynamometer for testing hybrid trucks and buses, with a road load simulation capability from 8,000 pounds to 80,000 pounds; a heavy-duty engine transient test cell (up to 400 hp) for fuels research and development; and an emissions measurement capability sensitive enough to be compliant with federal certification procedures required in 2007. NREL has performed both electric and hydraulic hybrid vehicle test projects with manufacturers including Eaton/International, Oshkosh, and Allison GM, for hybrid buses, refuse haulers, and step vans.

In addition, DOE's Advanced Vehicle Testing activities benchmark and validate the performance of light-, medium-, and heavy-duty vehicles that feature one or more advanced technologies, including internal combustion engines burning advanced fuels, such as 100 percent hydrogen and hydrogen/compressed natural gas-blended fuels; hybrid electric, pure electric, and hydraulic drive systems; advanced batteries and engines; and advanced climate control, power electronic, and other ancillary systems. The NREL team has conducted medium- and heavy-duty vehicle evaluations, including evaluations of transit buses, trucks, and idle reduction technologies. Tasks include identifying fleets to evaluate, designing test plans, gathering on-site data, preparing technical reports, and communicating the results. This work is funded by the Department's Vehicle Technologies Program.

Numerous other partnership opportunities and incentives help manufacturers to develop and fleets to purchase hybrid trucks in the United States, at both the federal and the State level. The Environmental Defense Fund has compiled an online resource of tax credits and other incentives: *www.edf.org/page.cfm?tagID+1124*

Summary

This testimony shows that there is no single hybrid truck design or system that will meet all our commercial transportation needs. Different solutions are needed both to improve the fuel economy of heavy-duty vehicles and to reduce associated emissions. Specific technologies and systems for achieving those objectives in heavy-duty hybrid vehicles will differ, depending on the vehicle's application and duty cycle.

As we move toward a future in which advanced vehicle technologies play a larger role, we understand the corresponding need to create a U.S. manufacturing base for heavy-duty hybrids, and their components. Otherwise, we might be trading our dependence on imported petroleum for a dependence on imported batteries and other components, a potentially serious issue for U.S. competitiveness.

Thus, a portfolio of energy-saving and environmental solutions will serve to meet our nation's economic, energy, and transportation challenges as well as enhance our energy security. A strong federal R&D and policy role is essential to development of these solutions.

Thank you.

BIOGRAPHY FOR TERRY PENNEY

Terry Penney joined the National Renewable Energy Laboratory in 1979. Prior to joining NREL, he worked for Concentration, Heat and Momentum (CHAM) a consulting group headed by Prof. Brain Spalding based in London developing unique finite element computational codes for multi-phase heat and mass transfer problems. He also worked Von Karmen Facility at the Arnold Engineering Development Center in middle Tennessee where he worked on the Space Shuttle program. At NREL he has worked on Ocean Energy, Buildings research, Optical and Thermal Fluid Science. More recently, he launched the Hybrid Vehicle program in 1992, which grew into a $300M Partnership for New Generation Vehicles (PNGV) between the government and GM, Ford and DaimlerChyrsler. Currently he is NREL's Technology Manager for Advanced Vehicle and Fuel Technologies responsible for both alternative fuels and advanced vehicles projects in both light and heavy-duty hybrid platforms.

He has more than 50 technical publications to his credit, including energy-related articles in *Scientific American* and the *Encyclopedia Britannica.* Terry has worked on computational fluid dynamics problems for a variety of applications and has pushed math-based analysis, which has evolved simultaneous multi-physics based tools with optimization including six-sigma, optimization and virtual proving ground. He has 35 years experience in testing and analysis in aerodynamics, heated mass transfer components, and advanced thermodynamic cycles, including gas turbines. He is an SAE member, a Baldridge team competition examiner, National Science Bowl scientific judge and winner of the Van Morris Award for performance. His undergraduate degree was from Purdue University in Aeronautical Engineering and Engineering Science and his graduate work was at the University of Tennessee in Mechanical Engineering. He received the MRI President's Award in 1992 for exceptional performance and the Van Morris award in 1996 for inspired leadership and forging links to industry.

Chairman LAMPSON. Thank you, Mr. Penney.

Mr. Smith, you are recognized for five minutes.

STATEMENT OF MR. ERIC M. SMITH, CHIEF ENGINEER, MEDIUM DUTY HYBRID ELECTRIC POWERTRAINS, EATON CORPORATION

Mr. SMITH. Chairman Lampson, Ranking Member Inglis, thank you for the opportunity to appear today. My name is Eric Smith, and I am the Chief Engineer for Medium-Duty Hybrid Electric Powertrains for the Eaton Corporation. Eaton is headquartered in Cleveland, Ohio. We have over 79,000 employees worldwide, including over 28,000 employees in more than 40 states.

A little bit of background on the Eaton hybrid power system. Following years of successful development and extensive real-world testing, Eaton is currently offering production hybrid electric products for commercial vehicle applications, and our first hybrid hydraulic products will enter the market later this year. Eaton's hybrid electric power system is currently in production option in North America with Peterbilt, Kenworth, International, and Freightliner, and we are also working with leading European manufacturers such as DAF Trucks and Daimler Trucks.

Eaton was part of the U.S. Department of Commerce Clean Energy Trade Mission to China, and we are working currently to place over 200 hybrid electric buses in Guangzhou, China. Those should all be placed by the end of 2008.

The design and development effort for all of this work is happening at Eaton facilities in Michigan and Minnesota, and our hybrid systems are produced currently in Indiana and Iowa.

Eaton has invested in three separate hybrid power solutions for commercial vehicles. First, our hybrid electric vehicle. Eaton's production hybrid electric power system can provide significant fuel savings and reduce vehicle emissions. Hybrid power is particularly appealing in Classes five through eight vehicles. These are large trucks with weights exceeding 16,000 pounds, such as pick-up and delivery and utility trucks.

And as you can see on my graph that is displayed here, the fuel savings possible on the range of trucks we are discussing is not only from improved fuel economy while driving but also from reduction in engine idle or engine off operation at work sites.

Additionally, Eaton's hybrid electric power system is the only certified by the IRS for the medium- and heavy-duty hybrid tax credit that was enacted in the *Energy Policy Act of 2005.*

I would like to speak just briefly on the hybrid hydraulic vehicles. In addition to hybrid electrics that I have mentioned, Eaton is also working on development of hybrid hydraulic vehicles for applications such as refuse trucks and pick-up and delivery vehicles. We are working with the EPA and the Army to research and develop these vehicles.

Finally, a few comments on plug-in hybrid vehicles. In addition to the hybrid electric and hybrid hydraulic vehicles, plug-in hybrid technology in the early stages of development and demonstration for medium- and heavy-duty trucks. Eaton is pursuing a number of development and demonstration projects directly and with partners such as the Department of Energy. With this energy the focus must not be only on batteries but also on chargers and electrication of the accessories that will be critical to the success of this technology.

A few comments on battery system development challenges. The success of the hybrid market is tied to the development and commercialization of state-of-the-art lithium ion batteries. The develop, manufacturing, and assembly methodologies needed to allow for the wide range of vehicle sizes and unique configurations needed in the world of, I am sorry. The wide range of vehicle size and the unique configurations needed in the world of medium- and heavy-duty trucks.

Remember, the benefits of hybridization apply equally to cars and trucks, although implementation and use of commercial trucks has unique challenges because of the size of the systems, the operating environments, and the duty cycles.

Finally, the hybrid truck market and supporting technologies are still in the early stages of commercialization and long-term leadership will be hotly contested worldwide. U.S.-based companies are currently positioned to be world leaders in development and manufacture of hybrid systems, and we can provide the same benefits and solution for truck fleets around the globe, though we must keep pushing our research efforts forward.

As the Committee debates funding research and development for hybrid vehicles, we would urge that electric hybrids, hybrid hybrids, I am sorry, hydraulic hybrids, and plug-in hybrid systems for commercial vehicles be included in any such programs.

Once again, thank you for this opportunity to appear today in front of this committee as a representative of Eaton Corporation.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF ERIC M. SMITH

Chairman Lampson, Ranking Member Inglis, thank you for the opportunity to appear today. My name is Eric Smith and I am the Chief Engineer for Medium Duty Hybrid Electric Powertrains for the Eaton Corporation. Eaton is a diversified industrial manufacturer headquartered in Cleveland, Ohio. We have over 79,000 employees worldwide, including over 28,000 employees in over 100 locations in over 40 states. Our 2007 sales were over $13 billion, and we sold products in more than 125 countries.

Eaton has five main business groups that manufacture highly-engineered components:

- Hydraulics, which manufactures hydraulic components, hoses and connectors;

- Aerospace, which manufactures fuel systems, motion control systems, propulsion sub-systems and cockpit interface and circuit protection applications for commercial and military programs;
- Electrical, which manufactures residential and commercial power distribution equipment;
- Automotive, which manufactures engine valves, lifters and superchargers; and
- Truck, which manufactures transmissions and hybrid systems for heavy- and medium-duty trucks.

Eaton Hybrid Truck Power Systems

Following years of successful development and extensive real-world testing, Eaton has emerged as a market leader in the development and production of hybrid power systems for commercial vehicle fleets. Eaton is currently offering hybrid electric products for commercial vehicles applications and our hybrid hydraulic products will enter the market this year. Our hybrid power systems are being tested and used in the United States by companies such as FedEx, UPS, Coca-Cola and Pepsi Cola. Eaton's diesel-electric hybrid power system is currently engineered as a production option in North America for Peterbilt, Kenworth, International and Freightliner and we are working with leading European manufacturers like DAF Trucks and Daimler Trucks for potential introduction in Europe.

Eaton has invested in three separate hybrid power solutions for commercial vehicles:

- Hybrid Electric Vehicles (HEV)
- Hybrid Hydraulic Vehicles (HHV)
- Plug-In Hybrid Vehicles (PHEV)

Eaton believes that all of these technologies have a place in the truck market. We will continue to develop these technologies to create a portfolio of hybrid power systems for a wide variety of vehicles and applications.

Eaton's hybrid power systems can provide significant fuel savings and reduce vehicle emissions. Hybrid power is particularly appealing for Class 5/6 vehicles (Pick-up and Delivery), Class 7 vehicles (Utility), and Class 8 vehicles (Over the Road Trucks)—all large trucks with weights exceeding 16,000 pounds, especially in stop-and-go applications.

Hybrid power provides further savings through engine-off operations and power take-off operations at a work site. Whatever the application, hybrid power can provide significant fuel savings, increased functionality, quieter operation, and improved performance.

Currently, the U.S. stands poised to lead the world in hybrid power for trucks. Our Hybrid Drive Systems are being developed and engineered at our facilities in Michigan and Minnesota and then our systems are produced in Indiana and Iowa.

Eaton is the first Tier One Supplier of Truck components to produce for sale HEV systems to the Truck OEM market. We are the only hybrid power system to be certified by the IRS for the medium- and heavy-duty hybrid tax credit that was enacted in the *Energy Policy Act of 2005*.

Our medium-duty hybrid electric vehicles are achieving between 20 percent and 70 percent fuel economy gains depending upon the truck application.

Early this year, Eaton Corporation agreed to sell 207 diesel-electric hybrid power systems to Guangzhou Armada Development Corporation to be installed in new buses for operation in the city of Guangzhou, China. This purchase adds to the initial sales of 30 Eaton hybrid-powered buses announced in January as part of the U.S. Department of Commerce Clean Energy Trade Mission to China.

It is Eaton's largest single hybrid power systems order to date. Additionally, Eaton Corporation recently received orders from United Parcel Service for 200 units while Coca Cola Enterprises ordered 120 hybrid units. These sales make Eaton Corporation the world leader in hybrid power sales in the commercial truck market.

Hybrid Electric Vehicles (HEV)

To produce Eaton's patented parallel hybrid electric system; we couple a vehicle's diesel engine with an electric motor/generator, power electronics and batteries.

Hybrid electric systems have much higher energy storage capacity, and generally have low to moderate power capabilities compared to hydraulic hybrids. Hybrid electric systems can provide engine off PTO capability for applications needing work site hydraulic operations and an auxiliary electric power source from the vehicle. This is valuable in vehicles whose workday takes them off the highway and to a job site, where the truck's power is used to operate other tools and equipment.

Hybrid electric vehicles also require an unprecedented level of integration and partnership between truck makers, engine manufacturers and suppliers of the drivetrain and major electrical components. Eaton's strategy includes early and significant collaboration with truck OEMs, engine manufacturers and key technology and component suppliers.

The hybrid electric system maintains conventional drivetrain architecture—such as Eaton's Fuller® UltraShift® automated transmissions—while adding the ability to augment engine torque with electrical torque. The system recovers energy normally lost during braking and stores the energy in batteries. When electric torque is blended with engine torque, the stored energy is used to improve fuel economy and vehicle performance for a given speed or used to operate the vehicle with electric power only.

This integrated system delivers a number of benefits, including:

- Up to 60 percent reduction in fuel consumption
- Up to 87 percent reduction in idle times
- Reduced maintenance and lower life cycle costs
- Reduced emissions
- Quieter operations and better acceleration

The system can also be designed to provide energy for use during engine-off work site operations. As an additional benefit of the parallel architecture, should the hybrid system go off-line, conventional engine-powered operation continues.

Hydraulic Hybrid Vehicles (HHV)—Parallel and Series

In a parallel hybrid hydraulic system, the conventional vehicle powertrain is supplemented by the addition of the hydraulic system. The system is best suited for vehicles that operate in stop-and-go duty cycles, including refuse vehicles, pickup and delivery vehicles, and buses, where fuel economy improvements between 20 percent and 30 percent are typical. Eaton plans to commercialize its parallel hybrid hydraulic system in refuse trucks in 2008. Other applications will soon follow.

In a series hybrid hydraulic system, the conventional vehicle driveline is replaced by the hybrid system. The conventional transmission and driveline are replaced by the hybrid hydraulic powertrain and energy is transferred from the engine to the drive wheels through fluid power. The system is suited to a broader number of applications than parallel hydraulic hybrids, though—as with all hybrids—benefits will be highest in vehicles that operate in stop-and-go duty cycles.

Eaton is working with the Environmental Protection Agency (EPA), under a Cooperative Research and Development agreement, to develop a series hydraulic hybrid power system that combines a high-efficiency diesel engine and a unique hydraulic propulsion system to replace the conventional drivetrain and transmission.

The series hybrid engine continually operates at its "sweet spot" of fuel consumption facilitated by the continuously variable transmission (CVT) functionality of the series hybrid system and by regenerative braking. The vehicle uses hydraulic pump/motors and hydraulic storage tanks to recover and store energy, similar to what is done with electric motors and batteries in hybrid electric vehicles.

These vehicles can achieve a fuel economy improvement between 50 and 70 percent by:

- braking energy that normally is wasted is recovered and reused;
- the engine is operated more efficiently; and
- the engine can be shut off when not needed, such as when stopped or decelerating.

Currently, Eaton is engaged in a program supported by the U.S. Army to militarize this drive train to provide power and fuel efficiency to military vehicle drive trains.

Plug-In Hybrid Electric Vehicles (PHEV)

Eaton is currently working with the Electric Power and Research Institute (EPRI) to develop commercial PHEV trucks. However, plug-in Hybrid technology is in the very early stages of development for heavy duty trucks.

PHEV vehicles require a notably higher energy storage capability then current medium or light duty production systems in order to maximize benefits of plug in capability. Higher energy storage battery systems facilitate the on vehicle energy storage necessary to move towards full electric vehicle capability (critical for zero emission and noise restriction areas). This would also require work on electrifying the accessories inside the vehicle (e.g., steering, brakes, HVAC).

In addition, we are working with members of the Hybrid Truck Users Forum (HTUF) such as Southern California Edison, Pacific Gas and Electric, and Florida Power and Light to develop a PHEV for use in utility truck applications. We are also working with Navistar on a proposal for a Department of Energy funded PHEV truck project.

Needed Enabling Technologies

Successful deployment of hybrid vehicles is dependent on the availability of high power output and high energy storage devices. Today, the Lithium Ion battery represents the most promising technology for hybrid electric vehicles. However, these types of batteries significantly increase the complexity and cost of the system. Additionally, robust battery management systems are needed to ensure safe and reliable operation.

Managing the charge and discharge process within the battery pack to optimize service life and reliability, as well as monitoring, predicting, diagnosing and mitigating potentially unsafe conditions, are challenges that must be overcome. The use of high voltage DC batteries (400–600 volts) in vehicles poses a set of challenges not normally seen on commercial vehicles.

For Hydraulic Hybrid Vehicles, the Accumulator provides the same energy storage function as a battery. Today's accumulator technology is adequate for certain applications. But to achieve widespread adoption of hybrids, an increase in the energy storage capacity is needed.

Challenges and Opportunities

The U.S. is far behind in the development and commercialization of state-of-the-art, "plug and play" lithium ion battery systems for HEV and PHEV applications that are affordable, reliable and safe. The assembly and manufacturing methodologies need to be modular and flexible, in order to cater to a range of vehicle size and configuration needed in the world of medium- and heavy-duty trucks. Unfortunately, there isn't a one-size-fits-all solution for trucks.

The benefits of hybridization apply equally to cars and trucks, although implementation and use in commercial trucks is significantly more complex. For example, the battery packs are larger, often must be located on the exterior of trucks (exposed to the elements) and the duty cycles are much more demanding, since commercial vehicles are typically driven for 12–16 hours a day versus cars that are normally used for commuting and hence driven only a few hours a day.

Phasing in the next generation lithium ion batteries to make PHEVs a reality will require significantly more effort. Any significant effort towards accelerating the market appeal and penetration of hybrid vehicles in the U.S. by developing state-of-the-art technologies and systems will provide huge impetus to the endeavor towards energy conservation and pollution reduction.

A major threat to the widespread adoption of hybrid vehicles (particularly the PHEVs) is the high cost of implementation of the fairly large battery systems needed, as well as the reliability and life of the energy storage systems. Developing a flexible and robust system to leverage multiple cell suppliers and reach the necessary economies of scale will go a long way toward reducing implementation costs. (Dr. Giorgio Rizzoni, Center for Automotive Research, The Ohio State University)

Conclusion

The hybrid truck market is in its infancy and the jury is still out as to who will lead the world in this space. Investment in Research and Development will help reduce our dependence on foreign oil, help truck fleets big and small mitigate the cost of fuel and reduce emission here at home. In fact, these are the types of technologies that can lead to a leadership position for the United States in the manufacture of hybrid truck technologies. We can provide these same benefits and solutions to truck fleets around the globe.

As the Committee debates funding research and development for hybrid vehicles, we would urge that electric hybrid, hydraulic hybrid, and plug-in hybrid systems be included in such a program. Battery and accumulator technologies need to be developed specifically for commercial vehicles because their size, weight, duty cycle and energy storage requirement are unique from those storage systems being developed for passenger vehicles. It only makes sense to include commercial trucks in the mix. With proper investment, the United States could lead the world in these new and exciting technologies.

BIOGRAPHY FOR ERIC M. SMITH

Employment History

2005 to Current:

Eaton Corporation in the Truck Group, current role Chief Engineer—Hybrid Medium Duty Product Engineering. Responsible for development and bring to production the medium duty electric hybrid system. Current in post launch phase of the program.

2001–2005:

Ballard Power Systems—Powertrain Engineering Manager responsible for design and development of the electric powertrain used in the Ford and Daimler pre-production fuel cell vehicles.

1989–2001:

Ford Motor Company—Various positions in manufacturing, testing and product development all within the Transmission group.

Education

Bachelor of Science—Metallurgical Engineering, Michigan Technological University

Personal

Have lived the majority of my life in Michigan, currently living in Kalamazoo, MI with wife and three daughters.

Chairman LAMPSON. Thank you very much, Mr. Smith.

Mr. Dalum, you are recognized for five minutes.

STATEMENT OF MR. JOSEPH T. DALUM, VICE PRESIDENT, DUECO

Mr. DALUM. Good morning, Chairman Lampson, Ranking Member Inglis, and distinguished Members of the Subcommittee. Thank you for inviting me here today. Also, thank you for the opportunity to offer the views of Dueco and for soliciting the views of others on hybrid technologies for medium- to heavy-duty commercial trucks.

My name is Joe Dalum, and I am Vice President of Dueco. Dueco, headquartered in Waukesha, Wisconsin, is one of the largest final stage manufacturers of utility trucks in the country. We produce aerial devices, digger derricks, and cranes that are sold to electric utilities for the maintenance of their transmission and distribution power lines. Dueco also provides equipment and services for the telecommunications market, other industries, and the government.

In 2006, Dueco began to assess alternative hybrid vehicle technologies. Those activities led to a collaborative development program between Dueco and Odyne Corporation. Odyne is a developer of plug-in hybrid electric vehicle powertrains for Class six, seven, and eight vehicles. Our efforts resulted in the introduction of the utility industry's first pre-production plug-in hybrid medium-duty truck in the fall of 2007.

While you have already received my more extensive written testimony, this morning I will focus on our development of a plug-in hybrid medium-duty truck. There are several factors that favor the development and deployment of hybrid and plug-in hybrid trucks: rising fuel prices, increased pressure for environmentally-friendly and green operations with lower carbon emissions, a national priority to reduce foreign oil dependency, and increased maintenance costs.

In our company's opinion, plug-in hybrid technology for medium- and heavy-duty trucks is particularly well suited to addressing those challenges. In my written testimony you will find a more detailed explanation of the factors that support that position.

I will now discuss our experience with the plug-in medium-duty truck. A photo of a plug-in medium, heavy-duty truck is shown on the screen. This type of truck is typically used by utilities for the maintenance and installation of power lines. It is unique in that a very large battery system of approximately 35 kilowatt hours, more than 15 times larger than one used in a conventional hybrid, provides power to help propel the vehicle, along with the diesel engine.

The battery system also provides power for equipment on and off the truck. When the truck returns to the garage, domestically-generated grid power recharges the battery system, offsetting the need for petroleum. The size of the battery system and the ability to recharge using grid power differentiates the plug-in hybrid system from a conventional hybrid. Using the large grid rechargeable battery system reduces fuel consumption and emissions during driving and provides for an all-electric stationary mode. The system completely eliminates fuel consumption and emissions at the job site for a typical day, while also reducing noise.

Fuel savings and corresponding reduction in greenhouse gas emissions are dependent upon the application. The current vehicle reduces fuel consumption by an estimated 1,400 gallons of fuel per vehicle per year for a typical utility application. I am confident additional research can further improve fuel savings.

In my opinion there will be a time in the future when affordable plug-in hybrid systems for a medium or heavy-duty truck provides 100 percent electrical operation for a limited driving range, completely eliminating fuel consumption and reducing emissions when recharged by clean electricity produced through renewable or non-emitting domestic energy sources.

There are several technical hurdles to the deployment of plug-in hybrid trucks. Battery system costs and performance challenges, non-optimal powertrain architecture, questions about utility infrastructure for charging large fleets of trucks with high capacity battery systems, and a lack of information about specific medium- and heavy-duty applications need to be overcome.

Dueco encourages the Federal Government to develop programs that help to specifically fund research into the development of plug-in hybrid systems for medium- and heavy-duty trucks used in specific applications that are open to final-stage manufacturers and other entities. Assistance with testing, certification, the creation of tax incentives for customers, and modification of government purchasing policies to favor the acquisition of more fuel-efficient trucks using plug-in hybrid technology can also accelerate development and deployment.

Commercial fleets consume large amounts of fuel; developing more efficient trucks that utilize domestically-sourced power from the Nation's energy grid would have several benefits. The development of this technology in the United States would provide opportunities for job creation, export opportunities, reduce the cost of businesses competing in a global market, reduce greenhouse gas emissions and emissions of other pollutants, reduce dependency on foreign oil, reduce noise within our cities, and potentially improve productivity for certain applications, such as crews who could perform work at night in residential areas.

This is potentially a historic opportunity to develop the technology needed for the electrification of medium- and heavy-duty trucks. I would ask for your support of the proposed legislation that would help to accelerate research into plug-in hybrid technology for medium- and heavy-duty trucks and encourage the development of partnerships between manufacturers and utilities.

Thank you.

[The prepared statement of Mr. Dalum follows:]

PREPARED STATEMENT OF JOSEPH T. DALUM

Introduction

Good morning Chairman Lampson, Ranking Member, Inglis and distinguished Members of the Subcommittee on Science and Technology. Thank you for inviting me here today. Also thank you for the opportunity to offer the views of DUECO and for soliciting the views of others on hybrid technologies for medium to heavy duty commercial trucks.

My name is Joe Dalum, and I am Vice President of DUECO. Headquartered in Waukesha, Wisconsin, DUECO is one of the largest final stage manufactures of utility trucks in the country, with facilities also located in South Dakota, Minnesota, Indiana, Ohio and Pennsylvania. We produce aerial devices, digger derricks and cranes that are sold to electric utilities for the maintenance of their transmission and distribution power lines in a 15-state region and are also used by utilities throughout the country through UELC, our rental and leasing company, with direct facilities in Florida, Texas and California. DUECO also provides equipment and services for the telecommunications, contractor, electric cooperative, municipality, gas utility and tree care markets.

In 2006, DUECO began to assess alternative hybrid vehicle technologies. Those activities lead to a collaborative development program between DUECO and Odyne Corporation. Odyne Corporation is a developer of Plug-In Hybrid Electric Vehicle (PHEV) power trains for Class 6, 7 and 8 vehicles. Our efforts resulted in the introduction of the utility industry's first commercial plug-in hybrid medium duty truck in the Fall of 2007.

Background

Medium- and heavy-duty trucks, used by the utility industry are typically built in multiple stages. During the first stage an original equipment manufacturer builds an incomplete vehicle, commonly known as a chassis. The vehicle is then often completed by a final stage manufacturer. Final stage manufacturers typically evaluate the intended application of the vehicle, perform engineering analysis, and then install an appropriate body, equipment and interface components with chassis systems in a manufacturing operation.

Hybrid drive systems may be installed by an original equipment manufacturer or by another entity during an intermediate or final stage of manufacturing process. DUECO installs the plug-in hybrid drive system and interfaces the system with the chassis and installed equipment during the latter stage of manufacturing.

Hybrid drive systems may be installed only on newly manufactured truck chassis or some designs may facilitate either an installation on a new chassis or a retrofit on an existing chassis for certain applications. The plug-in hybrid system developed by DUECO and Odyne can be either installed during the manufacturing process of a new truck or it can be installed as a retro-fit on an existing chassis. Retrofit applications must be carefully engineered, installation of a system on an existing truck requires sufficient payload, packaging space and specific chassis data communications interfaces.

Trucks used by utilities typically drive to a job site and then conduct stationary operations. In a conventional truck, the diesel or gas powered engine provides the sole source of propulsion for the vehicle and is also used to power truck mounted equipment, such as an aerial device, digger derrick, crane, compressor, winch or other equipment. While at the job site, the vehicle may idle for many hours to provide power for the equipment and provide heat or air conditioning in the cab. A medium duty truck may average approximately eight mpg while being driven and while at idle will typically consume approximately one gallon per hour.

A plug-in hybrid electric vehicle (PHEV) is a hybrid vehicle with batteries that can be recharged by plugging into our nation's electric power grid. It shares the characteristics of both conventional hybrid electric vehicles and battery electric vehicles, having an internal combustion engine and batteries for power.

Hybrid systems used in larger trucks, greater than Class 4, have typically utilized two basic design configurations—a series design or a parallel design.

Series design configurations typically use an internal combustion engine (heat engine) with a generator to produce electricity for both the battery pack and the electric motor. There is typically no direct mechanical power connection between the internal combustion engine and the wheels in an electric series design. Series design hybrids often have the benefit of having a no-idle system, include an engine-driven generator that enables optimum engine performance, typically lack a transmission (on some models), and accommodate a variety of options for mounting the engine and other components. However, series design hybrids also generally include a larger, heavier battery; have a greater demand on the engine to maintain the battery charge; and include inefficiencies due to the multiple energy conversions.

Parallel design configurations have a direct mechanical connection between the internal combustion engine and the wheels in addition to an electric or hydraulic motor to drive the wheels. Parallel design hybrids have the benefit of being capable of increased power due to simultaneous use of the engine and electric motor or hydraulic motor, having a smaller engine with improved fuel economy while avoiding compromised acceleration power, and increasing efficiency by having minimal reduction or conversion or power when the internal combustion engine is directly coupled to the driveshaft, typically through a transmission. However, parallel design hybrids typically lack a no-idle system and may have non-optimal engine operation (e.g., low rpm or high transient loads) under certain circumstances. Existing systems on trucks of Class 4 or higher have traditionally not had a system that combines the benefits of a series system and a parallel system.

DUECO has produced plug-in hybrid electric trucks, hybrid electric trucks and conventionally powered trucks for the utility industry.

The need for plug-in hybrid and conventional hybrid trucks:

There are several factors that favor the development and use of hybrid and plug-in hybrid trucks:

- Rising fuel prices.
- Increased pressure for environmentally friendly and green operations with lower carbon emissions.
- A national priority to reduce foreign oil dependency.
- Increased maintenance costs.

Differences between plug-in hybrid electric trucks and hybrid electric trucks:

The following compares some of the benefits of a plug-in hybrid to that of a conventional hybrid. The primary difference between the plug-in hybrid and the conventional hybrid is the size of the battery system and the ability to recharge the battery system from the domestic power grid.

While a plug-in hybrid truck offers some of the same benefits as a conventional hybrid truck, plug-in hybrids offer advantages in several areas:

- Reduced fuel consumption
    - A plug-in hybrid system has a large battery system that operates in a charge depleting mode. The energy from the battery is typically used to help propel the vehicle and operate equipment. Energy required to recharge the battery is ideally provided by the power grid or from regenerative braking, displacing the use of petroleum. A vehicle with a large enough battery system could potentially eliminate fuel consumption by operating in an all electric driving mode for a limited distance and operating in an all electric stationary mode. All electric trucks are available in Europe, while there are disadvantages such as limited range; electric trucks demonstrate that the technology is available for emission free operation.
    - A conventional hybrid typically uses power from the diesel and gas engine to recharge the battery or may be recharged from regenerative braking. Since much of the energy in the battery system results from recharging through the engine, fuel consumption may be higher.

- Reduced emissions, potentially eliminates emissions at the job site.
  - A plug-in hybrid typically reduces fuel consumption and corresponding CO_2 emissions during urban driving and has a large battery system that can allow the engine to stay off the entire day at the job site. The large battery system is used to power truck mounted equipment such as an aerial device or electrically powered air conditioning system. Electricity to recharge the battery system may be generated by sources with lower emissions; some utilities generate a sizable portion of power from non-emitting sources. As an example, PG&E generates over 50 percent of their energy from renewable sources.
  - A conventional hybrid due to a smaller battery system often may need to restart the engine at the job site to recharge the battery and may not have enough energy in the battery system to power large loads, such as an electrically driven air conditioner, with the engine off. When the engine is started periodically for short durations in the field to recharge the smaller battery system, emission systems may not be at optimal effectiveness, potentially resulting in greater emissions of harmful pollutants.
- Lower noise levels during stationary operations.
  - The engine typically stays off with a plug-in hybrid, resulting in lower noise levels. A conventional hybrid may require the engine to restart to charge the batteries.
- Uses low cost, domestically produced energy from the Nation's electric grid.
  - Off-sets fuel consumption by displacing petroleum with electricity. Ability to recharge at off-peak hours.
- Maintains a charge or is recharged at any time with conventional engine.
  - While a plug-in hybrid is typically designed to deplete the charge in the battery system and recharge through the grid, the system can be designed to maintain a minimum state of charge in the battery system by recharging through the engine if needed. This allows extended operations in the field during situations where it is impossible to recharge through the grid. In other words, while it is desirable to recharge a plug-in hybrid through the grid, it is not necessary to plug it in. Charging using the engine is similar to how a conventional hybrid recharges.
- Improved vehicle acceleration.
  - Electric motors provide additional power and torque to the drive train of the truck. The larger battery system of a plug-in hybrid provides more energy for extended use of the electric motor. The smaller battery system of a conventional hybrid may become depleted more quickly, reducing available power when needed for climbing grades or other demanding situations.
- Standby power capability: option for 9 kW or more exportable power for applications such as job site power tools, lighting and temporary restoration of power to facilities.
  - The large battery system of a plug-in hybrid offers the ability to export power from the vehicle for external uses. In the more distant future it may be possible to export power from the vehicle to the grid (Vehicle to Grid, or V2G) to reduce peak loads on grid generation systems. The smaller battery system in a conventional hybrid typically does not have enough energy for export without turning on the engine to provide additional power.
- Reduced maintenance costs.
  - Utility vehicles often are serviced based upon hours of engine operation. A plug-in hybrid truck has reduced hours of engine operation, potentially extending maintenance intervals.

Benefits of Electricity as a Fuel:

A plug-in hybrid electric truck uses electricity to supplement or replace the use of fossil fuels. There are several benefits to using electricity as a fuel.

- Feed Stock diversity promotes stability
  - ○ Hydro, Wind, Bio-Mass, Natural Gas, Coal, Nuclear

- A portion of our nation's existing generation fuel mix is currently CO_2 free.
  - Example: approximately 56 percent of PG&E's energy portfolio is CO_2 free
- Recent and ongoing legislation promotes cleaner generation mix over time
  - Renewable Portfolio Standard (RPS) legislation enacted in 21 states
- Low fuel cost and minimal additional infrastructure required
  - Preferential rates for off-peak consumption
- Projected future renewable energy sources tend to be an off-peak energy resource
  - Wind can often produce more energy at night

Plug-in Hybrid Electric Truck, bucket truck application:

A plug-in hybrid electric medium duty bucket truck is shown above. This type of truck is typically used by utilities of maintenance and installation of power lines. The truck has many of the benefits listed previously. Specifically this vehicle has the following features:

- Hybrid launch assist and regenerative braking
- All Electric Operation at a job site for a typical day
- 35 kWh Energy storage (note: a traditional hybrid may have two kWh of energy storage)
  - Electrically powered hydraulic system moves Aerial lift & outriggers, this function is also known as E–PTO
  - Electrically powered air conditioning
- 110/220VAC Electric shore power nine kW, more optional
- Interfaces with an Allison transmission, the system may also interface with other transmissions (testing with other transmissions has not been completed)
- Modular design with standard components
- Enhanced reliability with redundant power for critical operations
- Advanced diagnostics & data acquisition available, ability to monitor vehicle via satellite
- Very versatile design:
  - Basic system design can be used on for a variety of truck weight Classes: 5, 6, 7, 8 (19,500 - > 33,000 GVWR). Testing of the system on Class 5 and Class 7 trucks has begun, testing on Class 6 and Class 8 is planned within the next year.

- Basic design can be used on a variety of chassis configurations: 2x4, 4x4, tandem. Testing has begun on the two-wheel drive application, testing on the tandem will begin within the next year. Testing on the 4x4 has not been scheduled.
- System should be able to interface with multiple power trains from multiple chassis manufacturers. Testing has begun on GMC and International units and on chassis with gas and diesel engines.

- Ability to tow trailer.
- No special diagnostic software.
- Enhances stability of vehicle for aerial device applications.
- Utilities can power their fleet with their own fuel: Electricity

Fuel savings are dependent upon the application. The current vehicle reduces fuel consumption during driving in urban areas by approximately 10–15 percent. The vehicle will typically save 100 percent of fuel consumption during stationary operations at a job site, resulting in approximately one gallon per hour reduction. There is little to no fuel savings during higher speed highway driving.

Anticipated fuel savings for a plug-in hybrid in comparison to a conventional truck depend upon many factors such as the type of system architecture, size of battery and field application. The following is an estimate for two types of plug-in systems, one with parallel system architecture and one with series system architecture. The sample application is a 20-mile drive, a five-hour idling period, and an additional 20-mile drive.

Parallel system with plug-in battery system compared to a conventional truck:

Stated Assumptions:

Conventional chassis: approximately eight mpg fuel efficiency during driving and approximately one gallon per hour fuel consumption during idle.

Parallel system with plug-in: approximately 12 percent decrease in fuel consumption for a plug-in hybrid during driving and 0 gallons per hour fuel consumption during idle.

Estimated fuel savings: 56 percent reduction in fuel consumption, or approximately 1,400 gallons of fuel saved per year, based upon 250 work days per year.

Series system with plug-in battery system compared to a conventional truck:

Stated Assumptions:

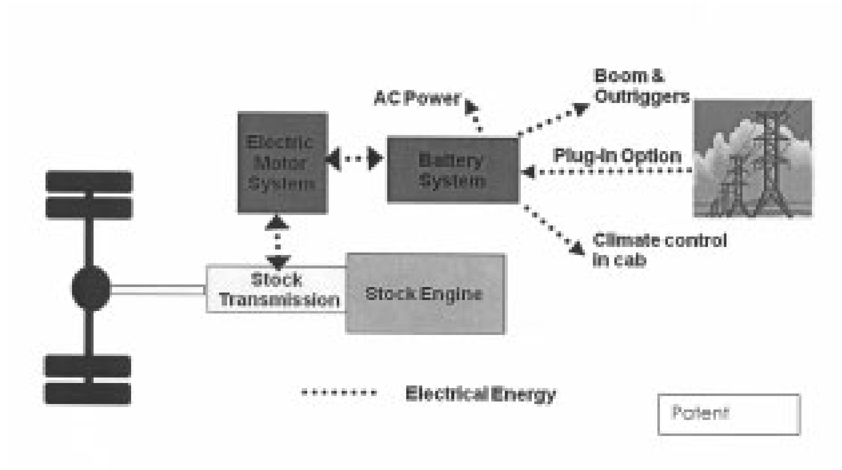
Conventional chassis: approximately eight mpg fuel efficiency during driving and approximately one gallon per hour fuel consumption during idle.

Series system with plug-in: 50 percent decrease in fuel consumption for a plug-in hybrid during driving and 0 gallons per hour fuel consumption during idle.

Estimated fuel savings: 75 percent reduction in fuel consumption, or approximately 1,875 gallons of fuel saved per year, based upon 250 work days per year.

Due to the large amount of savings, medium- and heavy-duty trucks with plug-in hybrid technology may be able to reach an attractive return-on-investment more quickly than other vehicles.

A diagram of a plug-in hybrid electric system for a truck is shown below. Electrical energy is used to increase efficiency while driving through hybrid launch assist and regenerative braking. Electrical energy also powers equipment loads at a job site, potentially eliminating the need to run the engine.



Major technical hurdles for deployment of plug-in hybrid trucks:

There are several technical hurdles for the deployment of plug-in hybrid trucks.

Battery system technology:

Existing battery technology either tends to offer battery systems that are relatively low cost, but heavy, large and of limited life or are relatively expensive, but much lighter, smaller and with potentially longer life. While certain applications of trucks may be able to carry lower cost, heavier battery systems, it is generally desirable to minimize battery system weight, size and cost. Development of cost effective larger advanced battery systems, potentially with energy storage in excess of 35 kWh, or even in excess of 100 kWh, would improve the performance and reduce the operating cost of plug-in hybrid trucks.

In order to accelerate deployment of plug-in hybrid trucks using existing technology, it may be desirable to design battery systems that are modular, that allow for newer technology battery systems to be placed on existing vehicles when the original battery system no longer performs to acceptable standards.

System architecture:

Existing hybrid systems for trucks tend to utilize system architectures that are similar in many ways to that of existing truck power trains. The internal combustion engine typically remains operating while the vehicle is driven to power auxiliary loads such as power steering systems, brake systems and HVAC systems. Keeping the engine running while stationary or in low speed stop and go traffic increases fuel consumption. Some vehicles also do not have a clutch in between the internal combustion engine and the transmission. While such systems utilize an automatic transmission, it may be desirable to create a method to uncouple from the transmission from the engine for improved regenerative braking or an all-electric drive mode.

In order to improve fuel economy further, different system architectures that are designed for high volume production in which the internal combustion engine can remain off during driving need to be developed. The development of electrically driven sub-systems such as braking, power steering, HVAC and others need to be brought to high volume production for medium- and heavy-duty trucks.

Existing parallel hybrid electric vehicle systems for trucks also tend to use relatively small electric drive components with relatively low power output, compared to the power provided by the internal combustions engine. Larger electric motors and higher capacity battery systems may allow smaller engines to be used that operate at higher efficiency without a reduction in vehicle performance, or allow the vehicle to be driven entirely by electric propulsion. Future system architectures could also combine the benefits of plug-in hybrid technology, which requires battery systems with high energy densities, with that of hydraulic hybrids that have high power densities. The combined plug-in electric hybrid system with hydraulic hybrid components could offer high horsepower during acceleration and recapture more energy during braking while providing enough energy for sustained operation with the engine off.

Alternative power train architectures, such as a combined series/parallel hybrid system with plug-in battery system are also recommended for consideration. A combined series/parallel system would allow the vehicle to operate in an all electric mode, a series hybrid configuration or a parallel hybrid configuration, depending upon which is most advantageous given operating requirements.

Utility infrastructure:

While studies tend to indicate that there is sufficient capacity in the Nation's energy grid at off-peak periods to provide power for charging a large number of plug-in vehicles, there has been little testing on the effects of charging a large number of commercial plug-in hybrid trucks. A commercial fleet of 1000 vehicles, each with a 35 kWh battery system, could require approximately 25,000 kWh (or 25 MWh) of power to recharge overnight. Assessment and testing on the effects of charging a large number of plug-in hybrid trucks is suggested.

Research into specific medium- and heavy-duty applications:

Plug-in hybrid technology for medium- and heavy-duty trucks may reduce fuel consumption and emissions in a wide variety of applications. Besides aerial utility trucks and delivery trucks, other truck applications such as those that use cranes, compressors, welding equipment, or are used in gas utility maintenance, refrigeration, rescue, refuse and construction may benefit from plug-in hybrid technology.

Specific information about the energy required for various mobile and stationary applications is typically not available. In order to optimize the design of a plug-in hybrid medium or heavy duty truck, it is recommended that data be collected on actual fleet utilization, including miles driven, time at idle, power requirements, fuel consumption and other operational factors. The development of plug-in hybrid systems for vehicles that operate at especially low efficiency should be a priority and testing should be undertaken to validate improved efficiency and reliability.

DUECO's experience with government technology development programs and how the federal role can be enhanced:

Federal technology development programs focused on plug-in hybrid systems for medium- and heavy-duty trucks have been very limited. DUECO has not obtained federal assistance in this area, with the exception of possible general research tax credits. Most of the funding in this area has focused on the development of plug-in technology for automobiles or has been focused on large original equipment manufacturers. The medium- and heavy-duty truck industry is unique in that many of its products are often manufactured in multiple stages and brought to market by companies that are not directly affiliated with the original equipment manufacturer.

DUECO encourages the Federal Government to develop programs that help to specifically fund research into the development of plug-in hybrid systems for medium- and heavy-duty trucks used in specific applications and that are open to final stage manufacturers and other entities. Assistance with testing, certification, the creation of tax incentives for customers, and modification of government purchasing policies to favor the acquisition of more fuel efficient trucks using plug-in hybrid technology can also accelerate development and deployment.

Commercial fleets consume large amounts of fuel, developing more efficient trucks that utilize domestically sourced power from the Nation's energy grid would have several benefits.

The development of this technology in the United States would provide opportunities for job creation, export opportunities, reduce the costs for businesses competing in a global market, reduce greenhouse gas emissions and emissions of other pollutants, reduce dependency on foreign oil, reduce noise within our cities and potentially improve productivity for certain applications, such as electric crews who could perform work at night in residential areas.

This is potentially a historic opportunity to develop the technology needed for the electrification of medium- and heavy-duty trucks. I would ask for your support of the proposed legislation that would help to accelerate research into plug-in hybrid technology for medium- and heavy-duty trucks and encourage the development of partnerships between manufacturers and utilities.

BIOGRAPHY FOR JOSEPH T. DALUM

Mr. Dalum obtained a BS in Mechanical Engineering from the University of Notre Dame in 1986 and a Master's of Business Administration from the Kellogg School of Management, Northwestern University, in 2003. He has over 20 years of experience in the automotive and truck industries.

As Vice President of DUECO, Joe has management responsibility for hybrid programs and several business segments. He has technical experience in the design and manufacture of aerial bucket and digger derrick trucks for the utility industry and has managed the engineering group within DUECO. Joe also works with key accounts and helps to direct business and investment strategy for DUECO. He serves on the Board of Directors of DUECO and its affiliates.

Prior to joining DUECO in 1999 as Engineering Manager, Mr. Dalum developed automotive products and systems for over 10 years. He has experience in managing projects and bringing new technology from initial concept into high volume production. Joe has been granted eight U.S. patents in the area of automotive technology. He has worked on a variety of domestic and international programs with vehicle manufacturers including General Motors (both domestic and foreign subsidiaries), Suzuki, Isuzu, and Fiat to design new components into their vehicles.

Chairman LAMPSON. Thank you, Mr. Dalum.

Ms. Egbert, you are recognized for five minutes.

STATEMENT OF MS. JILL M. EGBERT, MANAGER, CLEAN AIR TRANSPORTATION, PACIFIC GAS & ELECTRIC COMPANY

Ms. EGBERT. Good morning, Chairman Lampson, Ranking Member Inglis, and Members of the Committee. I am very pleased to appear before you this morning on behalf of Pacific Gas and Electric Company to offer my views on the important role of medium- and heavy-duty hybrid and plug-in electric hybrid vehicles.

Pacific Gas and Electric Company, headquartered in San Francisco, California, is one of the largest natural gas and electric power utility companies in the United States. The company provides natural gas and electric service to approximately 15 million people in northern and central California.

For nearly two decades PG&E has also actively worked to advance alternative transportation technologies, including natural gas and electric vehicles. We are particularly enthusiastic about the incorporation of hybrid and plug-in electric hybrid medium- and heavy-duty trucks into our fleet. We have already seen tremendous financial and environmental benefits from doing so.

The two most common uses for integrating hybrid and plug-in hybrid electric trucks into our fleet are for our so-called trouble trucks and more familiar, bucket trucks. PG&E's trouble trucks are used by our first responders when an outage or other situation is initially reported. These trucks operate within a wide range of mileage parameters, ranging from a few miles if operated within the city of San Francisco, to covering long distances if operating in more remote parts of our service territory. This range of operation makes hybrids an ideal solution for our company and our industry.

For most repair work the utility industry standard is to dispatch large diesel-powered bucket trucks. These trucks are then required to idle for long periods of time to complete many necessary repairs, consuming one gallon of diesel per hour of idle time. The idling is necessary to maneuver the bucket used to hoist servicemen to perform repairs.

In 2007, PG&E became one of 14 utilities across North America to deploy one of 24 diesel electric hybrid bucket trucks developed by the International Truck and Eaton Companies. PG&E's field trial for this new truck is currently ongoing in San Francisco, and preliminary results indicate that diesel electric hybrid bucket trucks reduce fuel consumption by 40 to 60 percent, reduce emissions by 50 to 90 percent, provide on-board power generating capacity to power up to five average-sized homes while service is being restored, improve operational and scheduling flexibility, and reduce maintenance costs.

In addition to incorporating these and other new vehicle and truck technologies into our fleet, PG&E has actively participated in DOE-sponsored workshops by providing a utility company perspective on the benefits and potential of all types of plug-in hybrid vehicles.

Even as new technology demonstration options are becoming available to PG&E at an increasing pace, there remains significant barriers to our ability to more fully deploy the hybrid and plug-in hybrid electric medium- and heavy-duty trucks, the most significant being financial barriers. Currently the up-front cost of a hybrid bucket truck is 50 percent higher than a conventional bucket truck. In other words, we could purchase three conventional bucket trucks for every two hybrids we purchase.

Although the lifetime fuel and maintenance savings help make the investment more attractive and the environmental benefits are a key part of our business objectives, the up-front costs are still daunting. In order to accelerate the procurement of hybrid trucks into utility fleets, we believe some financial incentive will be needed in either the form of grants or tax credits. These financial incentives would spur demands from PG&E and other utilities around the Nation that will allow truck and power system manufacturers to ultimately bring down their unit costs.

At a time of historically high diesel prices, increasing concerns over climate change, and energy security, the time is right to accelerate research, development, and deployment of hybrid and plug-in hybrid electric truck technologies. With thousands of utilities nationwide, the market for medium- and heavy-duty hybrid and plug-in hybrid electric trucks is very significant. PG&E commends the Subcommittee's inquiry into this important market, and we are hopeful that with effective government leadership the right incentives will be implemented to help reduce the financial barriers that currently exist and that discourage widespread, rapid deployment of clean hybrid commercial truck technology.

On behalf of Pacific Gas and Electric Company, I want to thank you for the opportunity to appear before the Subcommittee today. Thank you.

[The prepared statement of Ms. Egbert follows:]

Prepared Statement of Jill M. Egbert

Chairman Lampson, Ranking Member Inglis, and Members of the Committee, I am very pleased to appear before you this morning on behalf of Pacific Gas and Electric Company to offer my views on the important role of medium- and heavy-duty hybrid and plug-in electric hybrid trucks in utility fleets. At a time of historically high diesel fuel prices, increasing concerns over climate change and U.S. energy security, I commend the Committee for its leadership in addressing this important topic.

Pacific Gas and Electric Company, headquartered in San Francisco, California, is one of the largest natural gas and electric power utility companies in the United States. The company provides natural gas and electric service to approximately 15 million people throughout a 70,000-square-mile service area in northern and central California. PG&E proudly delivers some of the Nation's cleanest energy to our customers. On average, more than half of the electricity we deliver to customers comes from sources that emit no carbon dioxide, or CO_2, and an increasing amount comes from renewable sources of energy.

For nearly two decades, PG&E has also actively worked to advance alternative transportation technologies, including natural gas and electric vehicles. More recently, the Company has added diesel-electric hybrid, plug-in hybrid electric and fuel cell powered vehicles to its fleet. PG&E's clean air transportation strategy is integrated throughout our fleet and the fleets of many of our customers as well. This is a key pillar of PG&E's overall emissions reduction and environmental stewardship strategy—no less important than procuring clean sources of energy or protecting wildlife habitats.

PG&E operates the largest natural gas alternative fueled utility fleet in the Nation. Our fleet includes more than 1,200 natural gas fueled vehicles, of which more than 100 are classified as medium- and heavy-duty vehicles. The majority of these vehicles run on cleaner burning compressed natural gas. Over the past ten years, PG&E's fleet displaced over 3.4 million gallons of diesel and gasoline with natural gas which translates to over 6,000 avoided tons of CO_2 emissions. When combining our fleet with those of more than 300 of our customers whom we have helped with incorporating alternative fueled vehicles into their own fleets, the amount of diesel and gasoline displaced grows to more than 47 million gallons and 174,000 tons of avoided CO_2 emissions over the last three year period alone.[1]

We are particularly enthusiastic about the incorporation of hybrid and plug-in electric hybrid, medium- and heavy-duty trucks, or PHET's, into our fleet. We have already seen tremendous financial and environmental benefits from doing so. Our goal in assessing and applying new vehicle power technologies is to demonstrate their practical application in our fleet, and gain the experience necessary to provide our fleet management with alternatives to conventionally fueled vehicles. With each demonstration vehicle and truck we consider a number of factors, including initial capital cost, operating and long-term fuel costs, ability to meet greenhouse gas emissions reduction goals, reliability and serviceability, operational flexibility, fuel consumption reduction, tailpipe emission reductions consistent with California and federal regulations, noise pollution reduction and operator safety.

The two most common uses for integrating hybrid and PHET trucks into our fleet are for our so-called "trouble trucks," and the more familiar "bucket trucks." PG&E's "trouble trucks" are used by our first responders when an outage or other situation is initially reported, and are dispatched to assess a problem, and occasionally perform minor repairs lasting under two hours. These trucks operate within a wide range of mileage parameters, ranging from a few miles if operated locally within the City of San Francisco to covering long distances if operating in more remote parts of our service territory. This range of operation makes hybrids, such as the Ford F550 SuperDuty hybrid truck an ideal solution for our company and our industry. These types of vehicles provide significant benefits which include improved fuel efficiency, lower fuel costs, and lower refueling time as compared to our conventional trouble trucks. PG&E is currently working with Ford to develop an all plug-in electric version of the F550 SuperDuty truck.

For most repair work, the utility industry standard is to dispatch large diesel-powered bucket trucks. These trucks are then required to idle for long periods of time to complete many of the necessary repairs which forces a fuel consumption rate of approximately one gallon of diesel per hour of idle time. The idling is necessary to power the hydraulic arm, which is powered by the engine, to maneuver the bucket used to hoist servicemen who perform repairs.

In 2007, PG&E became one of 14 utilities across North America to deploy one of 24 diesel-electric hybrid bucket trucks developed by the International Truck and Eaton Companies. PG&E's field trial for this new truck is currently ongoing in San Francisco with an on-board telematics system that sends continuous performance and operations data which measures efficiency against that of a conventional diesel truck being used in the same application and in the same general geographic location. Preliminary results indicate that diesel-electric hybrid bucket trucks:

- Reduce fuel consumption by 40–60 percent.

[1] These figures represent a full "well-to-wheel" analysis, which takes into account energy use and emissions at every state of the process, from the moment the fuel is produced at the well to the moment the wheels are moved. Estimates compare the avoided emissions from PG&E's CNG vehicles to petroleum usage based on the methodology outlined in Full Fuel cycle Assessment (CEC–600–2007–003, June 2007), which uses the Argonne National Laboratory's GREET emissions model modified to California inputs.

- Reduce emissions by 50–90 percent by operating the utility bucket in electric-only mode without the engine running. A typical utility truck's engine runs eight or more hours a day.
- Provide on-board power generating capacity of 25 kilowatts of standby power—enough to power up to five average-size homes while service is being restored.
- Improve operational and scheduling flexibility, and customer satisfaction by operating quietly, particularly when working at night in noise-sensitive areas.
- Reduce maintenance costs due to less engine use and brake wear due to regenerative braking capacity that charges the battery.

PG&E has also procured two pre-production heavy duty Peterbilt hybrid trucks which will have two buckets per truck, designed specifically for live wire work.

In addition to incorporating these and other new vehicle and truck technologies into our fleet, we also participate actively in industry and government sponsored initiatives aimed at defining standards and requirements for new hybrid and PHET technology. PG&E has actively participated in DOE sponsored workshops by providing a utility company perspective on the benefits and potential of all types of plug-in hybrid electric vehicles and the potential impacts on the electric power grid of significant penetrations of such vehicles.

Even as new technology demonstration options are becoming available to PG&E at an increasing pace, there remain significant barriers to our ability to more fully deploy the hybrid and PHET medium- and heavy-duty trucks—the most significant being financial barriers. Currently, the up-front cost of a hybrid bucket truck is 50 percent higher than a conventional bucket truck. In other words, we could purchase three conventional bucket trucks for every two hybrids we purchase. Though the lifetime fuel and maintenance savings help make the investment more attractive, and the environmental benefits are a key part of our business objectives, the up-front costs are still daunting. In order to accelerate the procurement of hybrid trucks into utility fleets, therefore, we believe some financial incentive will be needed in either the form of grants or tax credits. These financial incentives would spur demand from PG&E and other utilities around the Nation that will allow truck and power system manufacturers to expand operations and production, achieve economies of scale, and ultimately bring down the unit costs.

At a time of historically high diesel prices, increasing concerns over climate change and energy security, the time is right to accelerate the research, development and deployment of hybrid and plug-in hybrid electric truck technologies. With thousands of utilities nationwide, each deploying a fleet of trucks daily to points far and wide within their service territory, the market for medium- and heavy-duty hybrid and plug-in hybrid electric trucks is significant. PG&E commends the Subcommittee's inquiry into this important market and we are hopeful that with effective government leadership, the right incentives will be implemented to help reduce the financial barriers that currently exist and that discourage widespread, rapid deployment of clean, hybrid commercial truck technology.

On behalf of PG&E, I want to thank you for the opportunity to appear before the Subcommittee today.

Thank you.

BIOGRAPHY FOR JILL M. EGBERT

Jill is the Manager of Pacific Gas and Electric Company's Clean Air Transportation department. She has worked for PG&E for over 25 years in a number of capacities, including governmental affairs, customer service, service planning and community relations. She chairs the Greater Sacramento Regional Clean Air Coalition, sits on the Board of Directors for the California Natural Gas Vehicle Coalition (CNGVC) and the Electric Drive Transportation Association (EDTA). Jill has a BS in Business Management.

Chairman LAMPSON. Thank you very much.

Mr. Parish, you are recognized for five minutes.

STATEMENT OF MR. RICHARD C. PARISH, SENIOR PROGRAM MANAGER, CALSTART HYBRID TRUCK USERS FORUM (HTUF), DENVER, COLORADO

Mr. PARISH. Thank you very much. I would like to thank the Subcommittee for inviting CALSTART here today to present our viewpoint on heavy hybrid technology. We feel like we serve a very important role in implementing this technology into the general public and then also providing a means to focus the activity and the interest of the different fleets in producing these types of technologies for use in the fleet activities.

I would like to draw your attention to my presentation charts that are on the screen. The CALSTART activity is based, it is a non-profit organization, a consortium of not only industry but also fleet providers, that is very interested in improving the industry, the transportation industry, and moving it forward in terms of decreasing the amount of fuel used and decreasing the amount of emissions that are produced by the commercial industries.

HTUF, the Hybrid Truck Users Forum, is actually a subset of the CALSTART activity and is a user-driven process in which we represent the fleets and try to bridge the gap between the technology development activity and the actual commercialization of these vehicles. HTUF intends to bring working groups together of fleets that are quite interested in a variety of different applications. Our first activity that we put together was in the utility bucket truck activity, which PG&E took part in, and we simulated the different requirements from the various fleets to identify a common set of requirements that the truck manufacturers could then respond to.

So what we did was get the hybrid truck technology off the ground. There had been some development of heavy hybrids in the Department of Energy as well as U.S. Army National Automotive Center, and the Federal Transit Administration, but there was no real pull from the fleet side to actually get these vehicles into service.

So what the Hybrid Truck Users Forum did was aggregate the requirements to provide a focal point for the industry to then start producing these vehicles. We did this in a joint activity with U.S. Army National Automotive Center. They are very supportive of this particular activity, because the Army is very interested in seeing the hybrid technology being implemented and being put out on the street so they can see a reduction in the cost of these vehicles rather than footing the cost of developing this type of technology on their own. They would like to see it become commercially viable and therefore, more cost effective in putting in the military vehicles.

So we have been very active in terms of this first particular working group that we put together. We have looked at other working groups and are in the process of implementing those as well.

You should be aware that hybrid trucks and medium- and heavy-duty trucks are very different than the light-duty vehicles. We have seen a great implementation of light-duty vehicles, hybrid vehicles, in the public sector. There is good acceptance there now, but we feel like because of that acceptance that the government should now start focusing on medium- and heavy-duty sectors to start making some real technology improvements and implementation of these new vehicle concepts.

On this timeline you see where there is a real range in implementation of these particular vehicles. On the far right we are already in early production as identified by Mr. Smith from Eaton

Corporation. We are in early production of these bucket truck vehicles from International using the Eaton drive train, and that is very encouraging, but these vehicles are still rather expensive. There are other vehicles that are being implemented in terms of the refuse vehicles, parcel delivery, also shuttle bus type of vehicles that are going to be entering early production here in the next few years, but still the technology is not there to implement some of the benefits that we see in the light-duty world. In particular, I think it was pointed out that light-duty vehicles have the ability to shut off their engines when they are at a stop, engine off at idle capability. Right now we do not have that capability in medium- and heavy-duty trucks because we do not have the electrically-driven accessories that are required. So much development is required in getting that type of technology in place.

So we are seeing just the first versions of these vehicles emerging at this point in time, and much technology development is still really needed to make these viable.

And was as pointed out earlier, hybrid technology is starting to be incorporated in Class eight over-the-road vehicles, and are now being looked at in drage vehicles for the ports, particularly ports of LA and the ports of Long Beach. And these are very promising types of technologies, but until we get the appropriate support for the technology, development, as well as the implementation of these vehicles, and then some incentives to help reduce the up-front costs, they will be lagging in terms of their implementation.

So as identified, the trucks are different from passenger cars, even though the technology has been well developed for passenger cars, and we see it starting to emerge, trucks are a different order of magnitude in terms of their weight, class, and the scale of the systems that need to be put in place, as well as the durability that is required for these vehicles. So there is a whole new segment of development activity that needs to take place here.

We feel that industry and the fleets could benefit from support for ongoing R&D. There was some preliminary R&D efforts involved at the Department of Energy under the Heavy Hybrid Program managed by the National Renewable Energy Lab, but that funding has been reduced and is now coming to a close. And but without the full benefit of coming to fruition for these new technologies. So we would like to see some further support for that type of R&D effort.

And we would also like to see that there be some purchase incentives. As was also pointed out the initial costs of these vehicles is fairly high. The cost of the fuel at this point in time, even though it is high, does not quite cover the total cost of the differential cost of the hybrid vehicle. So what we are seeing is some additional funding needed up-front to help cover that differential.

So we would also like to see a commitment by the government over a long-term, five- to ten-year program, to really implement these technologies, not only hybridization, but also more efficient truck technologies into the commercial fleets.

I would like to thank you very much for the opportunity to talk with you today and hopefully we have a good discussion.

[The prepared statement of Mr. Parish follows:]

PREPARED STATEMENT OF RICHARD C. PARISH

CALSTART thanks the House Committee on Science and Technology, Energy and Environment Subcommittee and its members for the opportunity to testify and share our knowledge with you on the important issue of hybrid and more efficient medium- and heavy-duty vehicles. This is a critical area of emerging capability for the U.S., both in terms of reducing fuel—and cutting costs—for users, as well as reducing urban pollution and global warming emissions. It is also an important competitive leadership issue for U.S. manufacturers building leading-edge products here and for export to the international market.

CALSTART and its Hybrid Truck Users Forum (HTUF), together with its industry, fleet and public partners, are working together to speed hybrid and advanced truck commercialization and have identified the key benefits and barriers to progress which we welcome the chance to explain. We think there is an opportunity for smart, targeted investments and partnerships between industry and government to speed these new capabilities to market.

Our testimony will follow this outline: A brief introduction to CALSTART; the Role & Goals of HTUF; the Importance of Hybrids; the State of the Industry; Gaps and Barriers; Next Steps; Future Vision.

What is CALSTART?

CALSTART is North America's leading advanced transportation technologies consortium. It is a fuel and technology neutral, participant-supported non-profit organization of more than 150 companies and agencies, dedicated to expanding and supporting a high-tech transportation industry that cleans the air, creates economic opportunity and reduces imported oil use and greenhouse gas emissions.

CALSTART serves as an unbiased, strategic broker to spur advanced transportation technologies, fuels, systems and the companies that make them. It works across four areas to expand and support this industry: operating technology development and demonstration programs with industry partners; consulting to ports, fleets and others on implementation of new fuels, vehicles and technologies; providing services to industry members to expand their capabilities; and supporting and guiding the creation of policies that increase the efficiency and reduce the emissions of U.S. transportation.

CALSTART plays a leading national role in facilitating the development of advanced propulsion systems and alternative fuels in the heavy-duty vehicle and transit industry. It helped create the capability for heavy-duty hybrid drive systems in transit buses in program partnerships with DARPA, and now leads efforts in advanced commercial vehicle hybrids, fuels cells, hydrogen and biofuels. Founded in 1992, CALSTART is headquartered in California but operates nationally and internationally in its programs.

Role and Goals of the Hybrid Truck Users Forum (HTUF)

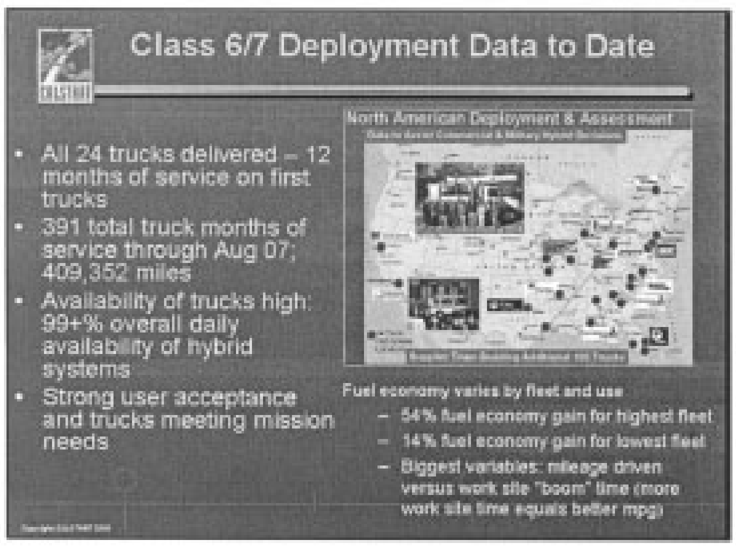
The Hybrid Truck Users Forum (HTUF) is a national program made up of first-mover fleets and major truck and system makers to speed the commercialization of medium- and heavy-duty hybrid vehicles and to build a competitive, sustainable medium- and heavy-duty hybrid vehicle market. HTUF is operated by CALSTART in a unique partnership with the U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC)—National Automotive Center (NAC).[1] Additional program support has been provided by the Hewlett Foundation, with some project funding from the Department of Transportation and the Department of Energy. HTUF has proven to be a highly successful program to jump-start the commercial hybrid truck industry in North America. Its track record of success, and the results in terms of industry development and product launches, has benefited truck makers and suppliers as well as military planners keen on supporting a dual-use commercial manufacturing capability for advanced trucks. HTUF is credited with removing one to two years from the product development cycle.

HTUF was designed to fill what was clearly a gap between technology development and products moving into the market. What was needed was a nimble, fast-track process for commercialization. HTUF's model for action focuses on truck users to create market "pull" (demand) around their needs for saving fuel, reducing emissions and noise and better performance. HTUF now works with more than 80 national fleets representing more than one million vehicles on the road, and all major

[1] The NAC is the Army's outreach arm to the commercial transportation industry, and is charged with both understanding the capabilities of the commercial vehicle industry and working to increase the capabilities of the industry to build advanced vehicles and technologies that can support emerging Army and military needs.

truck makers and system suppliers. HTUF has identified the most promising early uses of hybrid technology (such as refuse, delivery and utility trucks), is working with fleet users of these vehicles to determine their common needs, and then is organizing these committed users to purchase and use commercially-built hybrids that meet these requirements. For the commercial industry, this has significantly accelerated their time to market by allowing them to focus on the most promising first markets. Product improvement is also much faster because customers share information and needs in real time with suppliers during assessment and development.

There is an additional benefit in the model—reducing cost and time for the military user. By developing a commercial manufacturing base and market for similarly sized and functioning systems, eventual costs to military users are reduced. The time to source and deploy future military systems is reduced, as well. By partnering in early commercial deployments, the military is able to assess performance, designs and architecture at extremely low cost. And by being active in the performance requirements, future military capabilities, such as silent watch, are designed into commercial systems from the start.



HTUF fleets have already launched or completed several fast track projects. Fourteen initial fleets ordered, deployed and assessed 24 utility hybrid trucks in a national pilot program, demonstrating up to 50 percent fuel economy improvements and exceptional reliability. This effort led directly to a follow up order of more than 100 trucks and has now helped launch early hybrid production in this class of medium-duty trucks. HTUF fleet working groups in the parcel, refuse and small bus categories are launching similar pilot efforts to spread hybrid truck applications. A new working group—in full-size, Class 8 long haul trucks, plans to deploy some hybrid "big-rigs" by late 2008. As a result of the HTUF process, the commercial industry is now rapidly developing early heavy-duty hybrid products in several different market applications. First assembly line production has now started and additional product launches are pending.

Importance of Hybrids

Hybrid technology is a transformative technology for transportation. Future vehicles need to reduce urban pollution while also cutting fuel use. Few technologies can do both: hybrid can, increasing efficiency while also reducing emissions. Not only can it provide immediate benefits today, in terms of reduced fuel consumption, reduced criteria emissions and reduced greenhouse gas emissions, it also is an enabling architecture for future reductions and improvements. Once hybridized, vehicles can become more effective platforms for additional improvements, including the use of electrified, more efficient components, the use of downsized and optimized engines and combustion schemes, and enabling a transition to greater engine-off operation with enhanced energy storage. The stored energy can come from cleaner fuel sources—such as electricity—in plug-in variants. For the military, hybrids provide not just reduced consumption—which means a reduced supply chain and longer endurance—but also advanced capabilities. Military vehicles desperately need increased electrical power in deployed vehicles, and military users desire greater power generation in the field: both are inherent capabilities of a hybrid electric system. Military planners also seek engine-off "silent watch" functionality, which is the ability to support vehicle functions from stored energy without using the noisy—and detectable—engine. Hybrids deployed in assessment by HTUF and the NAC have already proven-out this stealth function. Advanced versions can allow "stealth" driving, as well—vehicle movement for limited distances without the engine starting.

State of the Industry

Hybrid truck technology has made significant strides in the last several years and is now on the "cusp" of commercialization. However, unlike passenger cars, where hybrid technology has been in production for a decade, first hybrid production is only now just starting in the truck industry. Integrating hybrid technology into truck platforms presents different challenges than in passenger cars, requiring different strategies, packaging and weight concerns, system designs and component sizing. The market drivers and purchase criteria are completely different in the commercial vehicle market than in the consumer market. Therefore, it is fair to think of hybrid trucks as being ten years behind the auto industry and also needing very different research, development and market acceptance tools to support them.

So far, unlike the automotive industry, the leaders in medium- and heavy-duty hybrids are U.S.-based manufacturers. This is a significant advantage to the Nation. However, that leadership is not assured. More than six truck makers and ten system makers are now developing heavy hybrid prototypes or pre-production products in first applications, but the effort has not yet achieved critical mass and is at an important point in its evolution. To break out, these first efforts must succeed and expand. One of the key early barriers to success is that production volumes are low, so prices remain high.

On target with HTUF's intermediate goals, the first U.S. truck maker entered early assembly line production of hybrids in October 2007. International Truck and Engine Corporation, using an Eaton Corporation hybrid electric drive system, launched the DuraStar hybrid truck. It is now available in limited quantities from all its dealers in North America. The company can build up to one thousand trucks its first year. This capability was assisted directly from HTUF's efforts. Two other truck makers, Peterbilt and Kenworth, have announced early production plans for 2008, including hydraulic and electric hybrid offerings using Eaton systems, and Peterbilt is developing a Class 8 long-haul hybrid truck. Azure Dynamics will start producing a hybrid chassis with Ford in 2008. Freightliner has recently announced it will join International, Kenworth and Peterbilt in the medium hybrid truck market. Volvo/Mack has announced a hybrid truck capability in the 2009/2010 timeframe. Other companies are show-casing capabilities and prototypes, including Dueco with an Odyne plug-in hybrid utility truck, Oshkosh with an electric refuse collection truck, Crane Carrier with both an electric hybrid featuring an ISE driveline and a hydraulic hybrid featuring a Bosch Rexroth driveline. BAE, Allison, Parker Hannifin, Hybra-Drive, Permo-Drive, Enova Systems and ArvinMeritor are other examples of suppliers with active development efforts, some of which already produce hybrid systems for transit or other applications.

Initially there was skepticism by some whether hybrid technology would have a broad enough application to all trucks. Certainly initially, it is clear there are some first "beachhead" markets and applications for hybrids, such as refuse, urban and regional delivery, utility and similar work truck applications. However, these early markets are just the beginning, not the end pint, for hybrids. HTUF and partner testing are showing that hybrid technology delivers greater fuel economy in almost every duty cycle. The key early issue is to place hybrid vehicles where they will have the highest initial payback. However, as system costs come down with increased volume, improved system design and integration and new technologies, hybrid drivelines will steadily be applied in more and more market segments. Indeed, the next breakthrough in hybrid technology appears to be Class 8 long haul trucks, the highest fuel using truck class. Five truck-makers have public or private programs to develop this capability, currently led by Peterbilt-Eaton. Hybrid systems may contribute three to four percent fuel economy improvements alone; combined with their built-in ability to provide idle reduction savings, this could approach six to eight percent improvements. Hybrid technology actually shows the future capability of addressing a significant percentage of the truck fleet, building out of first markets in heavy urban work trucks.

Gaps and Barriers

Hybridizing the truck driveline is a key stepping-stone to future advanced capabilities in both hybrid and conventional trucks. If we are to reduce petroleum use (and address climate change) it is one of the key technologies to achieve that. Yet truck and system makers need public sector support and partnerships to bring these important technologies forward as quickly as the Nation needs them. The industry is resource constrained: as much as 80 percent of the engineering talent at the truck and engine makers has been focused, rightly, on the emission reduction requirements of 2007 and 2010. To support a parallel and fast-track effort in hybrids, critical as it is, is more than the industry can do alone. Industry needs government partnership and shared risk and investment to make it happen as fast as it is needed.

The core early barriers to fleet adoption are clearly high unit cost mostly due to low manufacturing volumes and the lack of a robust component marketplace. Assistance to help fleets cross this first market incremental price barrier would be extremely helpful. However, fleets also need additional in-use performance data and validation to help justify their capital investment in these new systems, and assistance to aggregate their demand with other fleets to speed purchases. Together with this is industry's need for additional development and testing of new components, better system integration and advanced capabilities. In essence, hybrid trucks are at the emergent stage of technology; the performance shown by early vehicles is just the beginning of what future hybrid and advanced capabilities can be.

Given these observations, CALSTART/HTUF has identified with its industry and fleet partners the core needs for continuing momentum in hybrids, and they fall along the stages of development:

- **Need for continued funding of research and development in core hybrid and advanced systems (R&D—development stage)**
- **Need for continued funding and partnership in fleet support/pre-production demonstration and pilot projects to assess and validate hy-**

brid performance and reliability (Demonstration/Validation—pre-production stage)

- **Need for fleet purchase assistance in the early market stage to speed introduction and rapidly increase manufacturing volume (Purchase Incentives—early market stage).**

In terms of R&D, the core technology development needs now are for improved system integration and manufacturability, reduced energy storage costs specific to commercial vehicle designs, electrified components (to enable even greater fuel economy gains in all trucks, and more capable hybrids in particular), optimized and downsized engines, advanced combustion schemes, power generation, light-weight materials, and advanced control systems.

It's important to understand that there are still technical barriers for trucks and buses that are not the same for passenger cars. For instance, there is no commercially-available electrically-driven air conditioning, steering pump or other components yet in the truck world. There are expensive prototypes, but no systems that can hold up to heavy-duty vehicle duty cycles. This is a core area of need, because their availability not only enables more-effective hybrids, they make for more efficient conventional trucks as well. Optimized engines are another good example. Specifically because a hybrid drive system allows the main engine to work differently, and usually to work less or work in a narrower power range, cleaner and more efficient engine designs are possible, such as Homogenous Charge Compression Ignition (HCCI). Such engines are more difficult to use if they must cover the full range of a conventional truck's power needs, but may be possible when functioning in a more limited power range coupled to a hybrid system.

The medium- and heavy-duty industry would greatly benefit from support across all three of the stages identified above to more rapidly improve the fuel efficiency of the heavy truck sector, which has the highest per vehicle fuel use, and therefore the highest pay-back potential for investment. Yet investment has been sorely lacking for the commercial vehicle platforms, or applied in a less than focused way.

It is worth noting that Department of Energy projects to help develop and test early heavy hybrid technologies, managed by the National Renewable Energy Lab (NREL), were very useful and moved specific technologies forward that are in products we are now seeing today in transit hybrid buses and medium hybrid trucks. Unfortunately, most of that funding and commitment has ended.

Similarly, significant progress was made to drive the core hybrid driveline functionality via early Department of Transportation–Federal Transit Administration and Defense Advanced Research Projects Agency (DARPA) funding in the 1990s. These were exceptionally innovative programs.

Missing from all these efforts was not only a longer-term duration, but support and strategies that moved technology along all the stages of development.

The commercial vehicle segment has not been a high enough priority for funding. It has also been assumed that investments made in passenger cars are sufficient to support commercial vehicle needs. The truth is, there are important differences between commercial and consumer—truck and car—hybrid vehicles in terms of duty cycles, system architectures, market needs and business cases. A portfolio of smart, targeted funding over a multi-year period and covering all the stages identified above and aimed at the needs of the commercial industry would have significant impacts.

The Army has been a great partner and leader, supports this effort and has directed internal funds to it, but resources to completely support the needs and develop new capabilities are limited by the Army's immediate priorities. Additional broader support is needed to accelerate the effort and achieve critical next steps to develop a national heavy hybrid capability.

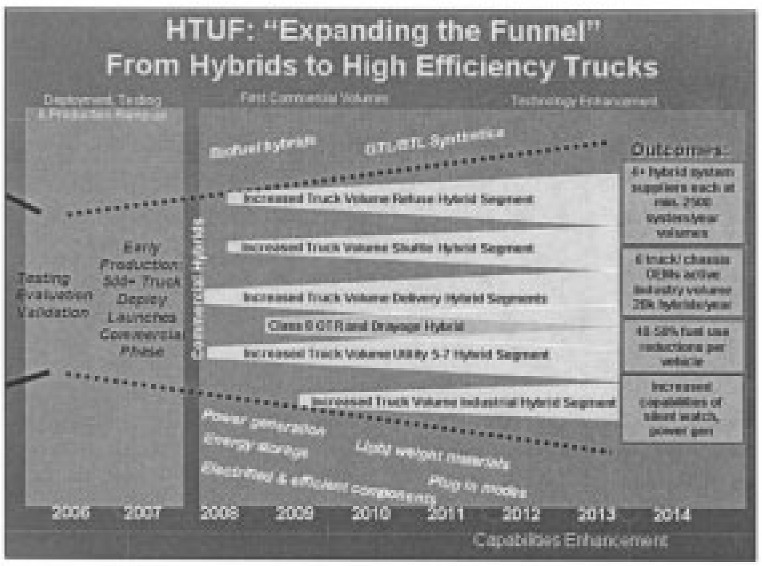
Next Steps

HTUF itself, together with its partners, are currently focused on a multi-year strategy that envisions creating a sustainable hybrid and high efficiency truck market over the next seven years, and working to develop the support to achieve this vision. Hybrids are the first and critical component of the move to high efficiency trucks. To achieve this will require building both market volumes in early applications, and adding new capabilities to both hybrid and conventional trucks over this time frame. To do this effectively will require government partnerships and risk sharing with the industry and fleets.

To succeed will require a robust, self-sustaining hybrid truck market, with offerings across multiple platform sizes and applications. To achieve these goals HTUF needs to continue to recruit and educate fleets in the targeted segments, and ensure that pre-production and early production commitments are achieved in these segments over the next several years. This will also entail opening new segments as price points allow, such as industrial/non-road vehicles and drayage trucks.

Hybrid alone will provide such benefits in many but not all duty cycles. It will require enhanced capabilities to achieve these levels, including optimized engines, improved energy storage, light-weight material use, more efficient components, better aerodynamics in long haul applications, plug-in hybrid modes, and other strategies. Such enhancements enable the increased capabilities of quiet, engine-off operation and the ability of some trucks to be mobile power generators for emergency and work needs.

Importantly, these same improvements that increase the capabilities of hybrids also increase the fuel efficiency of conventional trucks. This concurrent move of hybrids into Class 8 heavy segments and the focus on improving core truck components is the leverage point to much more broadly impact the truck industry. By targeting users demanding increased fuel efficiency, working with regulatory agencies to develop accepted metrics for hybrid fuel efficiency and expanding the suite of enabling and enhancing technologies for hybrids, we will provide the platform and the pathway for measuring, delivering and expanding improved fuel efficiency in all trucks.



Future Vision

The government has a rightful and needed role to play at each stage of hybrid and high efficiency truck and technology development, and it is likely a different role at each point. If government agencies were to commit to moving forward medium- and heavy-duty hybrid and high efficiency trucks following an integrated plan and an "investment" strategy for the use of funding, that would be extremely useful and cost-effective for the industry.

In light of the growing market penetration and public acceptance of hybrid drivetrain technology in light-duty vehicles, the government can now direct a concerted focus on the medium- and heavy-duty sectors to further advance the technology benefits.

It is important to note that assistance is needed now. The industry is at a critical stage and on the threshold of a successful launch. However, this launch can also be viewed more broadly as the first stage of a transformation of transportation technology. What is required is a commitment to a major program, on a par with light-duty efforts, to move medium- and heavy-duty vehicle technology to the next level. Therefore, looking forward in the broadest sense, CALSTART could envision a high profile program built on these parameters:

- First, a commitment to target, support and fund over a multi-year period the steps required to achieve commercialization outlined earlier: R&D; Fleet Support and Pre-production Demonstration; and Purchase Incentives. To get maximum effect, an integrated strategy encompassing all three is needed.
- Second, government's role and risk should be different at each stage, as is acknowledged already in most programs. However, a portfolio approach as to how much funding to apply to each stage, and a commitment to do so consistently over several years, would be most beneficial to the market. It would focus industry technology investments and engineering resource allocation as well as signal to private investors where to extend their investment into innovation in new technology. Such signals can often leverage as much private resource as direct governmental funding.
    - Research and development might rightly make up 15–20 percent of such a total government partnership portfolio, with pre-production demonstration, testing and validation an additional five to ten percent. We can see the need for purchase incentives, based on a sliding scale determined by truck size and level of increased efficiency, and declining over time, making up as much as 70–75 percent of this overall portfolio.
- Third, it is highly important that research, development and demonstration activities be designed and operated to encourage competition, innovation and new players. Past efforts in some agencies have been closed to any but a handful of manufacturers and suppliers, a constraint unlikely to speed new approaches. Additionally, a commitment to spur action and achieve aggressive outcomes would add energy to the program. We can envision a ten year commitment to achieve 40–50 percent fuel economy gains as an average across all new trucks as a starting point for discussion.
- Fourth, such a program structure would ideally take place over a minimum of five years and be led by an agency or partnership that sees the value of and desires action to occur. Given the likely growing concerns with reducing foreign oil imports for energy security, the need for greater fuel efficiency to save truck operators money and secure jobs, and the need for significant carbon reductions in the future, a ten year program would be ideal as a clarion call to and a signal of commitment and action.
- Fifth, the level of investment should be commensurate with the needs and the challenge. California has recently enacted a high tech and fuel investment program (Assembly Bill 118) that will invest $200M per year over seven years in new transportation technology and fuels. Given this precedent in only one state, we would recommend at least a comparable federal effort, but targeting hybrid and high-efficiency medium- and heavy-duty vehicles over ten years. This can serve as a framework for the effort needed to ensure U.S. manufacturing technology leadership and meeting its energy security and greenhouse gas emissions goals. Based on the investment portfolio proposed, this could mean $40–$60M per year for R&D and fleet support/pre-production deployments, and $140M per year for purchase incentives. This balance can also be modified to "front load" the investment in the early years and decline over time, from $400M/year down to $50M in the final year. Purchase incentives can also be structured to decline over time.

Such program commitments and integrated strategies are difficult to coordinate across different agencies, as demonstrated by the limited success of some previous efforts. However, it is possible that motivated agencies can be determined to carry out segments of the total strategy. The Department of Transportation already has responsibility for setting truck fuel economy standards; its Federal Transit Administration has helped spur hybrid bus acceptance; the Environmental Protection Agency is establishing truck fuel economy testing protocols; the Department of Energy's NREL has managed R&D and testing for heavy hybrids; The Department of Defense's NAC has invested in both targeted hybrid R&D and in pre-production pilot demonstrations. A coordinated approach is critical, as is a strong and willing commitment to lead. The DOD's NAC is a good example of an agency taking a focused, outcome-oriented approach and achieving measurable results. Such characteristics have been the hallmark of past successful efforts in which we have experience.

Again, thanks to the Committee, staff and Members for the opportunity to provide this testimony and share the progress to date we have seen in medium- and heavy-duty hybrids, and the significant benefit we could create for our industry and nation with a focused and strategic commitment to move change in this field.

BIOGRAPHY FOR RICHARD C. PARISH

EDUCATION:

University of Texas–Austin, 1980—MS, Mechanical Engineering
Thesis: Performance Analysis of the Gateway Solar Energy Project
University of Texas–Austin, 1971—BA, Anthropology; Math minor

REGISTRATION:

Professional Engineer, State of Colorado

EXPERIENCE:

5/06–Present—WestStart-CALSTART; Denver, Colorado

T3Senior Program Manager (May 2006 to present)

Leading the Hybrid Truck Users Forum (HTUF) program activity to assist in the commercialization of medium- and heavy-duty hybrid vehicles. Specific responsibilities include: leading the Hybrid Refuse Truck, Class 8, and Parcel Delivery Working Groups; overseeing the Shuttle Bus and Utility/Specialty Truck Working Groups; and organizing and implementing the annual HTUF National Meeting.

2/92–4/06—NATIONAL RENEWABLE ENERGY LABORATORY (NREL), Golden, Colorado

Senior Project Leader—Transportation Systems (Jan. 2000 to Apr. 2006)

Led three Department of Energy (DOE) funded tasks: 1) Gaseous Fuels; 2) Advanced Heavy Hybrid Propulsion Systems; 3) Power Electronics Systems. Developed medium- and heavy-duty natural gas engines and hybrid electric technologies and vehicles through in-house and subcontracted efforts with engine and vehicle manufacturers. Managed $6.2M annual budget. Previously initiated and managed a project to provide technical assistance (Tiger Teams) to Clean Cities organizations attempting to implement alternative fuel vehicles. Simultaneously led the Advanced Vehicle Testing Activity for test and evaluation of emerging, alternative fuel vehicle technologies. Participated in the California Fuel Cell Partnership, Fuel Cell Bus and Light-Duty Vehicle Working Groups.

Senior Project Leader—Federal Energy Management Program (Sept. 1996 to Dec. 1999)

Implemented DOE Federal Energy Management Program (FEMP) projects to conserve energy and incorporate renewable energy technologies in federal facilities. Assisted the Environmental Protection Agency (EPA) in establishing an Energy Savings Performance Contract (ESPC) to upgrade and create a renewable energy showcase for their Ann Arbor, Michigan facility HVAC system. Assisted NASA Headquarters Energy Manager in developing an ESPC and renewable energy program for their field offices. Worked closely with a subcontractor expert in building energy evaluation to perform preliminary evaluations of various federal facilities to implement renewable energy and energy efficient systems.

Senior Project Leader—Thermal Systems (Feb. 1992 to Aug. 1996)

Led the development of a variable-conductance,vacuum insulation system to be used for the thermal control of high-temperature advanced batteries in electric vehicles. Managed budget, schedule, technical personnel, research constraints, and performance to technical requirements to maintain the project on track. Managed laboratory test activities, evaluating test procedures and results, to accomplish multiple, parallel test goals. Interfaced with the primary customers, the U.S. Advanced Battery Consortium (USABC), which was composed of auto and battery manufacturers, to refine project requirements and goals. Managed the project to implement these in a timely and efficient manner. Performance under the original $3.5M cooperative research and development agreement (CRADA) resulted in a $600K supplemental contract with the USABC, which was managed concurrently with the original project.

Active participant in the NREL2000 activity to streamline operational processes within the laboratory. Led a sub-team focused on improving the operations and reducing costs within the NREL Facilities Office.

10/80–1/92—NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA), Houston, Texas

Space Station Thermal Systems Integration Manager (Sept. 1990 to Jan. 1992 and Dec. 1988 to Sept. 1989)

Responsible for the coordination and integration of the Space Station Thermal Control System (TCS) design between the participating NASA centers and International Partners. Charged with managing the TCS Architecture Control Document, which served as the system definition and design requirements document. Actively served as the Chairman of the TCS Working Group composed of NASA and International Partner thermal system experts, conducting Working Group meetings, resolving interface issues, creating action plans, and coordinating the goals of the Group. Thermal System prime point-of-contact for the NASA Space Station Program and Project Offices.

Planet Surface System, Systems Engineer (Sept. 1989 to Sept. 1990)

Performed as lead engineer in the development of planet-surface system concepts and element designs. Responsible for coordinating and managing line organization support to the Planet Surface System (PSS) Office. Served as alternate to the PSS Manager at agency-wide Program Review Boards. Frequently acted in the stead of the PSS Manager in his absence. Responsible for organizing and directing the PSS Technical Status Review Board with the goal of interaction and communication between the various NASA centers' engineering and project office organizations.

Space Station Heat Acquisition and Transport Subsystem Manager (Jan. 1988 to Dec. 1988)

Responsible for the design, development, test, and evaluation of critical Space Station thermal control subsystem hardware. Developed system design requirements, test requirements, test plans, and hardware performance criteria for candidate active thermal control systems.

Thermal Transport System Development Contract Manager (Jan. 1984 to Dec. 1988)

Acted as contract technical manager for development contracts focusing on technology advances in two-phase (liquid/vapor) spacecraft thermal transport systems as well as specific hardware components of the systems, such as contact and integral heat exchangers and rotating fluid couplers. Total contract value was approximately $5 million. Development efforts included design and implementation of reduced gravity flight tests.

Microgravity Research Principal Investigator (Jun. 1984 to Jan. 1988)

Established requirements and preliminary designs for experiments to investigate the behavior of liquid/vapor fluid in the microgravity environment. Coordinated research efforts with thermal technology development activity.

Thermal Analysis Development (Jan. 1984 to Oct. 1985)

Initiated the development of "next generation" thermal analysis programs for utilization with two-phase thermal control systems. Provided analytical support for preliminary design of Space Station thermal tools.

Shuttle Vehicle Thermal Model Development (Oct. 1980–Dec. 1983)

Generated and correlated detailed thermal models of portions of the Shuttle vehicle using SINDA and TRASYS analysis tools. Provided real-time mission support and post-flight data analysis.

DISCUSSION

THE FEDERAL GOVERNMENT'S ROLE IN PROMOTING HEAVY HYBRID TECHNOLOGIES

Chairman LAMPSON. Thank you, Mr. Parish.

At this point we will open our first round of questions, and the Chair will recognize himself for five minutes.

Mr. Penney, let me ask of you, what, at what point in the development do you feel that it is appropriate for DOE involvement to begin to drop off? And secondly, should we focus only on the most basic research, or do we have a responsibility to see that technologies get to the market, and where are they weakest?

Mr. PENNEY. That is a good question. The opportunity from my perspective I enjoy seeing systems level approach. When we work on components, which is essential and required, you sometimes don't, when you put all the pieces together, you learn new things, and I tried to emphasize in my testimony that a systems approach is absolutely critical.

Now, the Department of Energy has classically funded on the component level for energy storage, power electronics, thermal controls, and issues like that. They have drawn the line because they feel that industry's responsibility is to put that system level together. As was pointed out by Mr. Parish, we did have a few projects with Oshkosh truck, with Eaton, and Allison Bus transit fleets. The system level performance really taught us new things that we didn't learn from just component-type activities. And all of these companies benefited greatly by that education, and they would not be there today had it not been for that federal support.

PRICING

Chairman LAMPSON. Thank you. Mr. Smith, what is the price premium for an Eaton hybrid truck compared to a conventional model, and what accounts for the difference?

Mr. SMITH. Well, the difference is accounted for because of the added componentry that we need to add. There is, in a parallel system like we provide, there is a motor generator that is in the system, there is a power electronics inverter that takes energy from the batteries and feeds it to the motor or in the condition where you are acting as a generator such as regenerative braking, you are taking power back from the generator and feeding it into the batteries to recharge.

So the price premium that you are paying is for all of the additional components, plus all of the controls that make all of these individual components work together, you know, efficiently and safely.

As far as the price premium, that is actually an OEM decision to the customer since we sell to OEMs and then the OEMs sell directly to the customers, but as Ms. Egbert mentioned, you know, the 50 percent premium currently on a hybrid vehicle is probably very close to what we are seeing out in the market today for a hybrid vehicle.

THE 21ST CENTURY TRUCK PARTNERSHIP

Chairman LAMPSON. Has the 21st Century Truck Partnership been a success? And should it continue? And I would like for all of you to comment on that, and add a second part to it. How could the program be structured better to speed hybrid technology in medium and heavy truck, heavy-duty trucks?

And do you want to start, Mr. Smith?

Mr. SMITH. Yeah. It is actually not a topic that I am well informed on, and I can respond in writing at a later date to give a full response from the Eaton perspective.

Chairman LAMPSON. Anyone want to comment on those two things?

Please, Mr. Parish.

Mr. PARISH. Yes. I think the 21st Century Truck Program ideally was very well conceived, and I think it started out with good promise, because we did have the involvement of a variety of different federal agencies in that particular activity, and it looked like it was going to be very constructive.

However, as it turned out, I think it had limited success, because there was a lack of a real vision and adequate funding for the activity. I think as we have observed the 21 CT activity now is kind of a gathering of interested parties that, you know, they are interested to see if anything is going to happen from the federal level, but from what we have seen so far nothing has really been initiated, and there has been no real program activity that resulted as a result of the 21 CT Program.

So I would say that, yes, as it is conceived it is a very viable and very worthwhile type of activity, but I think it needs to be revisioned in terms of how it is led and make sure that there is an agency that is very motivated to make it a success. And our association with U.S. National Automotive Center has proven that they have the ability to——

Chairman LAMPSON. Mr. Penney, do you want to comment?

Mr. PENNEY. Yes. I am NREL's lab rep for 21 CT. In fact, I canceled my trip today, they are having a 21 CT meeting at Volvo Corporation in Greensboro, and I think the issue as was pointed out, there needs to be a flagship project, and I think getting together and sharing the education that I talked about in the 21 Century Truck Partnership has been very useful. We generally have at least monthly phone calls, people share what is happening, what is new, what are the issues that need to be worked on, but as Richard had pointed out, the funding from DOE has been focused more on the light duty because of the displacement of oil savings on the large number of light-duty vehicles as opposed to the heavy-duty vehicles.

But I think we have talked in the 21 Century Truck Partnership with all the members of a flagship project such as a super truck, putting all these technologies together, aerodynamics, idle reduction, hybridization, start, stop, you know, these things as one big package it would be nice to have a moon shot for a truck, so to speak, especially on the Class eight applications, which, in fact, could save a lot of oil.

Chairman LAMPSON. Thank you. I yield to Mr. Inglis for five minutes.

SCIENTIFIC AND ECONOMIC BARRIERS TO DEPLOYMENT

Mr. INGLIS. Thank you, Mr. Chairman.

First of all, Mr. Smith, thank you for having, Eaton having a facility in Greenville, South Carolina. We are very happy to have you there, and I will give you an opportunity to give a plug if you want to about what you do there, especially if it relates to this or even if it doesn't. But figure out a way to work that into an answer, would you? Do an advertisement for Greenville, South Carolina.

So I am sort of wondering here whether we are doing science or economics. If it is science that is holding us back through the deployment of these technologies or if it is economics. The issue with economics is you can approach it a couple of different ways. One is you can do grants and tax credits and regulate things, or you can unleash the power of the market. If you unleash the power of the market, it seems to me the first step is to stop having free externalities associated with incumbent technology, which is diesel.

If you attach the price to that, you internalize the externals to that product, then that 50 percent premium becomes a much smaller premium. Right? Because then the freebie in the air that currently is, benefits the incumbent technology, which is diesel, shrinks. And as it shrinks hybrids and every other kind of alternative suddenly becomes economically viable. Maybe not so suddenly but it becomes economically viable.

So which are we talking about here? Are we talking science that is holding us back, or are we talking economics that is holding us back?

Anybody want to tackle that?

Mr. DALUM. In my opinion it is both. I think there are some very short-term benefits that could be gained in this area, in my view, in plug-in technology, but those benefits are somewhat limited by not performing enough research. The research in my view could improve the performance over what is available today. I am referring to different powertrain designs which use smaller engines, larger electric motors, different battery technology that I have not seen available in a large capacity advanced battery for a truck.

So I think it is a little bit of both. I think we could move very quickly if we had some research for specific applications and incentives, and then secondly, perhaps some research devoted to more longer-term advancement of the technology.

Mr. INGLIS. And what you are selling today, is the electricity used to charge the battery which then runs the powertrain or is it like the Chevy Volt is going to do? That is the concept of the Volt. Right?

Mr. DALUM. It is a parallel system, which means that the diesel engine is always operating when the vehicle is moving, and that is because as Mr. Parish had talked about, in the industry right now there is not a commercially-available, high-volume, electrification of certain subcomponents like the HVAC system, power steering, brakes, and so forth.

So the engine is always running, and the electric motor provides supplemental propulsion. Okay? So there are limits to its efficiency gains because the engine is always running. The battery that we use is a very large battery. It is a heavy battery, but it has been around for a long time, and that is why we chose it, because it is well understood technology. But it depletes. That means that you charge it up at night, and you want the battery to deplete, and then when you are done after the day, you charge it up at night.

That being said, this vehicle never, you never have to charge the vehicle up, because the system will monitor the state of charge of the battery, and the engine will turn on if it has to, but we try to, you know, reduce that so that you can use grid power to recharge the battery.

Mr. INGLIS. Right.

Mr. DALUM. I hope that answers your question. It is using both diesel and the battery system to provide propulsion.

Mr. INGLIS. Is there an advantage to going to a system that uses only electricity for propulsion?

Mr. DALUM. In my view there is in certain areas, and I am talking more about stop and go driving in urban areas. And perhaps in what I would call mission that has a, or a job that has a short duration travel to a job destination, that might be able to be performed under 100 percent electric operation for a limited range. And then when you are at the job site, operate off the battery power, and then return to the garage after the work is completed and charge up overnight using power from the grid.

Right now the battery power that we have is not sufficient really, though, for that kind of application. I think more research needs to be done to provide that kind of power.

Mr. INGLIS. Mr. Smith, that commercial.

Mr. SMITH. Yes. Yes, sir. Or even an electrical group down in your area.

Mr. INGLIS. Good.

Mr. SMITH. But if I could just comment on what Mr. Dalum said. I think I would agree. It is a little bit of both science and economics. You know, to your question, you know, would it be better just to be all electric, I think that is a question, though, that you can't meet all of the needs because of the very wide range of applications that we are—and clearly a heavy-duty Class eight truck you would never be able to get enough storage capacity on a vehicle to do what it needs to do. Some of these work trucks travel far enough distances in any given day that, again, you couldn't store it.

But there are pick-up and delivery trucks like potentially a Fed Ex, a UPS truck, depending on their duty cycle and where they run, you might be able to get into a situation where you could run that way. But the, you know, the hybrid and having the ability to regen and recharge batteries on the vehicle I think will always be a significant portion of the market, and you will need that.

Chairman LAMPSON. Thank you, Mr. Smith. I am sure the Greenville Chamber of Commerce will be most appreciative of your comments.

I now recognize Mr. McNerney for five minutes.

BATTERY TECHNOLOGY AND DISPOSAL

Mr. MCNERNEY. Thank you, Mr. Chairman. I want to thank the panel. It has been a very interesting hearing, and it is an area that a tremendous opportunity for our country. I particularly want to thank Mr. Parish for coming from CALSTART. CALSTART is working very hard to reduce emissions in the San Joaquin Valley, which is one of the worst air pollution regions in the country. So thank you, Mr. Parish, and Ms. Egbert for coming from PG&E, my home utility company. I think your comments on reducing emissions by 50 to 70 percent is very important, and that is something we need to keep in mind.

Stockton, which is the largest city in my district, has now the highest gas prices in the country surprisingly, considering that it also has the highest foreclosure rates, and I have seen or we have seen a lot of hybrid technology on the highways with regard to private vehicles, but companies like BNSF are developing high-speed rail, not high speed but rail hybrid technology. So there is a lot happening, and it is very exciting to see it.

My first question is about the battery technology. There are four things that I am concerned about. That is the cost of the technology, of course, the reliability, the life, and the disposal requirements for batteries. Is that something that they recycled?

Could Mr. Smith or Mr. Dalum take that question?

Mr. SMITH. Yeah. I can comment on it. The, you know, the Eaton system currently is based on lithium ion batteries, and yes, those are fully recyclable and can be handled safely in an end-of-life condition. I mean, it is, there are several current sources in the U.S. where we can take batteries for appropriate disposal.

Mr. MCNERNEY. I spent much of my career in the manufacturing industry, and there is a law that the, every time you double your manufacturing volume, your cost goes down maybe 10 percent or 15 percent. Do you expect that sort of law to apply? In other words, as we go up the manufacturing volume, are we going to see the costs go down accordingly? Or is there some inherent cost barriers that we are going to be facing with hybrids?

Mr. SMITH. I, we definitely believe that, that, you know, we are currently, the price premium we are, our customers are paying today is driven mainly by volume issues. As we can increase the volume of the components, we expect significant price decreases. It is all based, it is what you said. As we can drive up the volumes and get into high volume, lower cost manufacturing processes, the cost will come out.

Mr. MCNERNEY. Is the battery technology improving in a way that will be parallel with the cost reductions or be contributing to the cost reductions?

Mr. SMITH. Yeah. What we see today, and again, Eaton Corporation has chosen or chose very early on to pursue lithium ion batteries as the appropriate technology for this, for these vehicles, and there is a lot of lithium ion batteries for hand tools, but they are smaller cells, lower energy capacity. Those systems are already in very high volume, manufacturing facilities, but the size that you need for vehicles hasn't made that transition yet. There is not, you know, there is not the market demand driving that increase yet, so we are on that road, but we are not to the point where we can justify spending the money that you need into the manufacturing facilities to increase the volume production and then ultimately get the lower cost.

Mr. MCNERNEY. Mr. Penney, do you have comments on the battery technology?

Mr. PENNEY. Absolutely. I was in Tampa at the International Battery Conference a couple of weeks ago, and as was said, the cell size are like C and D size batteries, and even for the GM–Volt that was mentioned, you know, you are talking thousands of batteries and thousands of interconnects, and every time you have an interconnect, there is that potential for that string or module to go bad.

Furthermore, as you package more and more batteries together for these heavy-truck applications, you have got to worry about thermal issues. Thermal management of batteries is something that we at NREL have focused on, are very important.

And then finally there is the control. The Prius, for example, was mentioned. The state of charge in the Prius, you only use about a quarter of that battery because the state of charge swing goes from about 85 percent to 65 percent or 50 percent. So that is only a third of the capacity. On many of these duty cycles and especially lithium, you can go from 90 to 10, 90 to 10.

And for a refuse example, they cycle that battery a thousand times a day or that ultra cap. A battery can last maybe several thousand cycles, several million cycles depending on that state of charge swing, the temperature, and actually the life. And the point is that all of these factors are unknown, and it is extremely difficult for these manufacturers to take the risk to say that this vehicle will last "X" number of miles and put a warranty on it. That warranty cost and that backing of that component is a very, very risky business at this point in time.

Mr. MCNERNEY. Thank you, Mr. Penney. My time has expired.

Chairman LAMPSON. Thank you, sir.

The gentlelady from Illinois, Ms. Biggert, you are recognized for five minutes.

DEPARTMENT OF DEFENSE HYBRID EFFORTS

Ms. BIGGERT. Thank you, Mr. Chairman. I am one of those people that was around in the '70s, sitting in the gas lines with three little kids in the back, thinking I was never going to get a full tank of gas again. And at that time everybody thought that, and then suddenly all of this, the crisis ended, and we forgot about it. The cars went back to being the SUVs and the heavy trucks and everything.

And I don't think that that is going to happen again. I think that we really see that the world has changed and that we have got to reduce our dependence on foreign oil and gas and whatever.

But my concern is that, you know, we waited so long, and we are still waiting, I think. We have got the hybrid car. I have one, and yet the hybrid plug-in to me seems to be something that really is going to, you know, I think revolutionize the industry of both cars and trucks.

But trying to, you know, get the battery small enough and to last long seems to be taking quite a bit of time, and I think that if we are going to have the grid, then we have to have the nuclear power, which is going to create the electricity rather than some other type of energy.

My question is then how are, well, maybe start with Mr. Penney, is NREL working with the Army or other, any other branch of the military in the development of the hybrid truck technologies in bringing down the costs of the hybrid trucks?

Mr. PENNEY. Probably the intersection is through, as was mentioned, the 21st Century Truck Partnership. We get most of our funding, as you know, from the Department of Energy. We get no funding from DOD or TACOM.

Ms. BIGGERT. Is, there was somebody else that mentioned the military that—Mr. Parish.

Mr. PARISH. Yes. CALSTART works with the military and gets some funding from the military to operate the Hybrid Truck Users Forum Program. Obviously, we do feel like there does need to be further development in the battery area, specifically for medium- and heavy-duty trucks. Right now trucks rely on battery packs that were predominantly designed for light-duty vehicles. Even some of the buses that we see up in the northwest and the Seattle area actually have Prius battery packs on them. These hybrid electric buses.

And so what is really neat is some specific design of these battery packs for the medium- and heavy-duty operation, and then a standardization of that battery pack so we can see the costs of the battery pack come down and be available to a wide variety of manufacturers.

Ms. BIGGERT. Well, the military has been working on finding lighter-weight material or metals for reducing the weight of tanks and trucks and whatever. Is the industry looking at that also, like say titanium?

Mr. PARISH. Yes. As a matter of fact, one of our participants in CALSTART, Alcoa, is very interested in trying to identify new markets for aluminum in light-weighting of vehicles, and I think we are going to start to see that emerge more importantly here as fuel economy becomes more important for medium- and heavy-duty trucks.

Ms. BIGGERT. Will that dramatically reduce the, if we reduce the weight, then the battery will last longer and would that aid in the development of the batteries?

Mr. PARISH. Well, it is kind of an integrated problem. We have to approach it from a variety of different perspectives in order to get the total benefit that we are looking for. So reducing weight in heavy-duty vehicles, as well as increasing the efficiency of the battery packs, increasing the efficiency in the electrification of the auxiliary systems is very necessary.

And then appropriate application of hybridization to the duty cycles of the vehicles is very important because it, there is a wide variety in the way these vehicles are applied, and so you get a wide variety of benefit from the hybrid system as a result of the duty cycle of these vehicles. So it is, there is a broad spectrum of technologies that need to be investigated in order to be integrated appropriately.

And also, downsizing and optimizing of the engines. Right now hybrid trucks typically use diesel engines, however, the fleets are now very interested fleets, such as Fed Ex and UPS, are very interested in seeing gasoline engines.

Ms. BIGGERT. How, you mentioned UPS and I might mention that I do have an International truck in my district, and UPS has a big facility not too far from us, since everybody is claiming something in their state, but with that, how, about how big is a fleet of the UPS with the hybrid trucks versus regular trucks?

Does anybody know that as we have been talking about them? Well, I will ask them later then.

Mr. PARISH. Well, they have just started incorporating hybrid trucks. I believe they have maybe on the order of 200 hybrid electric vehicles at this point in time. UPS is also investigating hydraulic hybrid vehicles, and one of our working groups is focused on bringing hydraulic hybrid vehicles to the parcel delivery segment. So they are just being implemented. They are being tested, but they need some improvements to really hit full stride.

Ms. BIGGERT. Thank you. I yield back.

Chairman LAMPSON. Thank you. Mr. Sensenbrenner, you are recognized for five minutes.

COMPETITIVE GRANTS

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman.

First of all, I will claim Mr. Dalum as a constituent since everybody is putting their oar in the water here. And I also was around when we had the gasoline crisis of 1979, and 1980. It was kind of my baptism of fire as a Member of Congress because they had this over-complicated allocation system, and since I represented an area where the population was growing, the allocations were not enough, and the problems were more acute. And President Carter actually announced he was having the Bureau of Engraving and Printing print up gas rationing coupons. We saw pictures of them in the newspaper. Well, Mr. Carter didn't make it through the next election. President Reagan got rid of the allocation system. The gas lines ended, people were able to have full tanks, the price went down, and I don't know if they threw the gas rationing coupons in the trash or not, but we haven't seen them, and that was about 30 years ago.

Now, that has convinced me that technology is the way to get out of the pickle that we are in rather than government regulation or taxes and more red tape and more Congressional casework for our employees.

Now, the bill that I have circulated around here establishes five grants for the development of plug-in hybrid trucks. In your written testimony, Mr. Penney, you state that there is no single hybrid truck designer system that will meet all of our transportation needs. And I guess my question I would like to ask of all five of you in the remainder of the five minutes that I have is, are five separate grants enough to be able to have a specific technology developed so that one of these technologies would end up being suitable for the various types of trucks that are on the road?

And since you brought the issue up, Mr. Penney, you can go first.

Mr. PENNEY. Thank you. You know, if you break down trucks into various vocations as the class system tries to do, as I mentioned, each class, each vocation needs a different duty cycle, just establishing and identifying and understanding that duty cycle is very difficult. And there probably are more, circling more than five. I think we identified maybe a dozen vocations which you would have to focus in on.

Mr. SENSENBRENNER. Okay. That is asking a little too much, and the Sensenbrenner rule of legislation is he who sticks snout in trough too far runs risk of getting head chopped off. So I guess that the competitiveness in the five grants is probably necessary.

How about you, Mr. Smith?

Mr. SMITH. Yeah. I guess I would say that, you know, is five the right number? I guess I am not sure. I think really what we need to look at is identifying the most likely paths to success or the areas where we are furthest behind or we have the largest challenges.

Mr. SENSENBRENNER. But doesn't the competitive nature that is contained in the bill take care of that?

Mr. SMITH. I guess I am not sure. I need to review it a little bit further so that I could comment on that.

Mr. SENSENBRENNER. Competitive grants work very well. Most of the scientific grants that the Federal Government hands out, whether it is in basic science or biomedical research.

Mr. Dalum.

Mr. DALUM. I think it is an excellent start. The five grants in my opinion would allow a variety of different applications to be submitted, and I am talking about technologies that might be, as discussed here, for delivery trucks, utility trucks. There are other applications I think that could be submitted that could benefit from plug-in hybrid technology, and those could also be part of that. So I think it is a very good start.

Mr. SENSENBRENNER. Ms. Egbert.

Ms. EGBERT. I would agree. I think it is a very good start as well. To start to get some of these technologies on the road and putting them into real world applications I think will bring us a long way.

Mr. SENSENBRENNER. Mr. Parish.

Mr. PARISH. Well, from CALSTART's perspective I think we would prefer to see a more general type of a funding activity in looking at medium- and heavy-duty hybrids specifically or generally improving that general technology with plug-ins being a subset of that general technology. So we feel that there is development work that needs to be done, but if we focus strictly on the plug-in aspect, that will just look at a very limited portion of the whole spectrum of the activity that needs to be approached.

So, you know, our feeling is that we would really like to see something more generalized than specifically plug-in.

Mr. SENSENBRENNER. Thank you. My time is expired.

Chairman LAMPSON. I yield myself as Chairman five minutes, and I yield to Mr. Sensenbrenner for him to continue his questioning if you would like, Mr. Sensenbrenner.

Mr. SENSENBRENNER. No. I am done.

HYBRIDIZING OFF-ROAD WORK EQUIPMENT

Chairman LAMPSON. All done? Thank you very much. Then I will, then let me ask any of you who would care to or all of you if you want, are you aware of work being done to hybridize other sectors such as heavy off-road work equipment, stationary power sources or other applications?

Mr. Parish.

Mr. PARISH. Yes. As a matter of fact, CALSTART has just initiated a working group focused on commercial construction equipment. That is also being sponsored by the U.S. National Automotive Center, U.S. Army National Automotive Center, because they are very interested in seeing obviously a fuel use by their construction equipment being reduced.

So what we have done is started some activity in bringing together the industry and the manufacturers, as well as the users of this off-road equipment to see if we can stimulate some additional activity in hybridization. We have already seen Volvo initiate a front-end wheeled loader that is hybridized, and we expect other, particularly U.S. manufacturers start to enter that as well. John Deere as well as Caterpillar have both expressed a great interest in off-road equipment hybridization.

Chairman LAMPSON. The Port of Long Beach, I understand, has demonstration hybrid tugboats.

Mr. SENSENBRENNER. Yes, and they also are hybridizing the crane lifts for the containers. So we see hybridization starting to enter in a variety of different modes.

Chairman LAMPSON. The primary thing that we are going to have to accomplish to facilitate all of that is going to be the battery.

Mr. PARISH. The battery.

Chairman LAMPSON. The link to the battery.

Mr. PARISH. And the auxiliary systems. You know, we can't just look at one aspect as Mr. Penney pointed out. If you look at just one component of the system, then you may not get the full story. You really need to look at the whole system affects and look at the variety of different things that are feeding into that system operation. So it is not only the battery but it is an optimized engine that operates on the hybrid system.

Right now the engines tend to be a little bit too large for the systems they are actually running, so you have to optimize those a little bit better, plus the control. And then also the electrical auxiliaries. If you could get electrical auxiliary systems or hydraulically operated auxiliary systems, then that would improve even more the efficiency gains.

Chairman LAMPSON. How long away are we from looking right now, and what is it going to take for us for this function of money that we have to throw at this to get faster results, get our in-gain more quickly?

Mr. PARISH. Well, I think so. I think the first vehicles we have seen out there by Eaton and International, which PG&E is using and a variety of other utilities are using, have shown the benefit of the hybridization.

However, in order for the next generation to come out, you know, we saw the first generation of Priuses back in '98, and then when we saw the second generation of Priuses, which really mushroomed because of the improvements in the design, we expect to see something similar in the medium- and heavy-duty truck category, where this first iteration that has come out, you know, that it is a great improvement over the conventional vehicle; however, there needs to be a second iteration, and in order to accomplish that second iteration, there has to be significant improvement in a variety of different technologies.

Chairman LAMPSON. And industry is just not willing or capable to do enough of that by themselves without government help?

Mr. PARISH. I think they have seen a downturn in their sales they did last year as a result of the pre-buy for the 2007 emissions regulations. They are going to see another big pre-buy for 2010 emissions regulations. So right now they are currently in a very low slump. I think this last year they were in a very low slump in sales, and so as a result of that they were probably unable to spend the dollars that they wanted on research for hybridization, and now they are also spending quite a few dollars on getting ready for the 2010, emissions regulations.

So, you know, that is what we are seeing is they are, rightly they are focused on trying to improve their products for the emissions regulations, but because of that they don't have adequate funding, I feel, to do the research necessary to bring hybrids along.

Chairman LAMPSON. I would like to pursue that some more but let me switch.

Just looking at the extensive membership list of CALSTART, it would seem that the industry efforts are fairly well integrated when it comes to new technologies. How integrated is the heavy-truck industry compared to that for passenger vehicles, and how is it different?

Mr. SMITH. If I could comment, I think there is a fairly significant difference, because if you look at the passenger car industry, it is mainly vertically integrated. There is, you know, a high level of oversight, design responsibility, integration responsibility that is all maintained within the companies, the Fords, the Toyotas, you know, whoever it is.

In the medium-duty, heavy-duty market it is quite a bit different, where I think there is a view that they are buying components that go on the system. They are buying a transmission or a hybrid system that needs to integrate within the existing chassis with as little disruption to the chassis as possible. And I think the systems you see out there, I know the Eaton system we intentionally try to make it as non-obtrusive to the engine and the chassis as possible.

So there is some real challenges there because of the lack of, you know, heavy integration or high level of integration in the vehicle.

Mr. DALUM. I would like to add that the vehicles that we are discussing are really, at least in the case of the utility truck, are built in multiple stages, and what that means is that an Eaton here may provide componentry to International, Ford, GM, or another chassis manufacturer. That chassis is then provided to another company. That company buys that and integrates their equipment on top of the chassis and finishes the manufacturing process and then brings it to market.

So unlike some other passenger cars, you have got various entities along the whole development chain here in going to market. So it is not as integrated as a passenger car.

Chairman LAMPSON. Mr. Parish.

Mr. PARISH. Yes. One more additional comment. What we found when we put the International Eaton bucket trucks out, those were the first hybrid trucks that were really on the road for commercial use. We found that there was some discord between the providers as was identified, International, Eaton, and the actual arm manufacturer in terms of who was responsible for what if there was a problem.

So unlike in a light-duty vehicle, a Ford or a Chevrolet, where they are totally responsible for the vehicle, then because of the integration issues with a truck, it becomes then necessary to work out who is responsible for the operation of the different aspects of the vehicle.

So this is one area where some, you know, further development activity needs to go on in terms to make everybody comfortable with the product that they are offering and in terms of establishing who has ultimate responsibility.

Chairman LAMPSON. Thank you very much.

Mr. Inglis, you are recognized for five minutes.

MORE ON SCIENTIFIC AND ECONOMIC BARRIERS TO DEPLOYMENT

Mr. INGLIS. Thank you, Mr. Chairman.

You know, when it comes to basic science, grants seem to make a lot of sense. National Science Foundation, for example, does basic science, and there are no commercialization opportunities immediately apparent in a lot of that basic science, and therefore, the government makes it happen by grants.

When it comes to applied technology like we are discussing here, I sort of break out in hives at the mention of grants, because that means grant writers and grant readers, it means regulations and regulators, it means an awful lot of productive energy being spent pursuing just a little tad of money.

It seems there are some other ways to get there more quickly. One of them is tax credits, which if you think about it, is a very efficient way to deliver a stimulus because then you don't have writers and readers and regulators and regulations.

But I wonder really what we are talking about here is mostly getting to the place where the incumbent technology is recognized for all the filth that it is. And if you do that, then suddenly everything else becomes more attractive, and then you have this incredible rush of creativity and innovation and jobs being created as we go out to take on that incumbent technology, which, by the way, is fueled by some people who don't like us very much.

And so I just wondered whether anybody sees it that way or if you want to make a spirited defense of a grant kind of system for applied technologies. I remember opposing in this committee, I didn't want to because I like her very much, but Ms. Giffords had a bill involving the installation of solar panels, training people to install solar panels, and the, I opposed that, and I lost on a vote about 20 to three or something.

But it is the application of this principle. Do you really want to do applied work through grants, or do you want to use a more efficient way of getting the market to respond?

Mr. Parish, do you want to respond to that?

Mr. PARISH. Yes. And typically what we see, and I agree with in that we need to identify what the real value of externalities are, because I think that would indeed help these alternative strategies become more viable. If we could monetize those externalities that would make it even more viable.

However, what we see in the typical development cycle or R&D cycle for new technologies is that the government funds the front end R&D activity to get the basic science, to develop the technology, and that funding starts dropping off until it hits a valley of death basically. So the industry is sitting there with a technology they don't have the funds to bring that technology to market, and so that is one of the things that Hybrid Truck Users

Forum does is tries to aggregate the pull, the demand for that particular technology to get it out of the OEM and get it on the road.

Now, we couldn't have done that without the support of the U.S. Army National Automotive Center, which provided us funding to not only run the working groups but also to provide some up-front buy-down funding. And what we have also learned, so we feel that the government participation in trying to bridge that chasm is very important because without that government funding to help bridge that chasm, the technology could very well just disappear and not be incorporated at all.

Mr. INGLIS. And we are here not talking about, it is not a question of basic science here. Right? If we were talking the batteries and better battery efficiencies and things like that, that would be more basic science. As it is what we are talking about is the application of that to particular uses, right, in issues like warranties which Mr. Penney, I think, mentioned. As I understand it, in the case of the Volt, that is a real issue is the pricing of the Volt will be affected by the warranty that they have got to issue.

And so working that out, I mean, just really became more of the nature of economics and risk kind of allocation rather than science. The science of better batteries might really change a lot of what we are talking about. Right?

Mr. PARISH. Right. There is a considerable amount of money being spent by the Department of Energy through the Department of Energy on battery development, but it is particularly focused on light-duty batteries. We feel that demonstration programs are a very important aspect of this activity, and the government has been involved in light-duty fuel cell demonstration programs in particular, and we feel like this is also necessary for the medium- and heavy-duty sector as well.

So it is really a three-pronged approach that we would like to propose is research and development, which talks about the science, what is really necessary to bring these advanced components into being. Number two is demonstration programs so we can actually get the vehicles on the road and get people interested in seeing how they operate and seeing how they actually operate in service, and then number three, incentives to make the purchase. And what we found from the 2005 Energy Bill is that tax incentives do work for some segments, but not all segments. What we have seen is that for those who cannot take advantage of the tax incentives, they were able to be taken by the seller of the vehicle, however, that savings was not passed along to the buyer of the vehicle. So it didn't fulfill the role it was needed to at that point in time.

So we would like to see something that would be more of a rebate or something along the lines that would make sure that the end-buyer, the end-user did, in fact, see the reduction in the cost.

Mr. INGLIS. Thank you, Mr. Chairman.

Chairman LAMPSON. Ms. Biggert, you are recognized for five minutes.

ROLE FOR THE DOE NATIONAL LABORATORIES

Ms. BIGGERT. Thank you, Mr. Chairman. I am concerned that we do need, that there is still basic research that needs to be done, and we haven't completed that, and that is, I am concerned with a question that I asked Mr. Penney before. And still is what is preventing the DOE and the Department of Defense from collaborating, and I think that the public and the private sector would benefit from a collaborative R&D effort.

But my next question then is, is there a role for universities and national labs to play in the competitive grant program created by the Sensenbrenner bill, maybe as research partners, and as I look at the bill, it talks about the five grants, and then it talks about partners, which include other entities including manufacturers and electric utility companies. But I think that there certainly is a role for the labs and for the universities, which really the grant program would then pull the technology out of the labs and get the technologies into the marketplace if we were to look at that.

I would like, if anybody would like to respond to that.

Mr. PENNEY. Certainly. As Mr. Inglis pointed out, you know, we need to work together, but at the same time I don't want to waste my energy writing proposals for Eaton to send its proposal to get a thing, and then someone else comes to me, and I want our staff and our capability to be available to everybody, and I don't want to waste the energy and the money to have to use our staff writing proposals through competitive grants. Personally. For the lab point of view. We like to make ourselves available to all companies, and it is an open source, open knowledge, education, and work through a competitive process, through non-disclosures, et cetera.

Ms. BIGGERT. I don't think I was thinking of the lab as actually writing the grants or anything. It would be still the—but to be maybe a research partner that they would work with.

Mr. PENNEY. Right, but there has to be a flow of money, and part of the disincentive for Eaton, most of these grants or most of the programs are cost-shared, 50 percent cost-shared. We can't cost share. We can't use government money to, you know, cost share government money funding. So as a result it puts a burden, an extra burden on an Eaton or an International or a truck company to work with us or select us because they have to come up with our cost share. So that disincentive needs to be taken away.

Ms. BIGGERT. Mr. Dalum.

Mr. DALUM. Yes. In my opinion the universities and national labs can play a role in this. I am talking about testing, modeling, other types of activities that could help promote and improve the technology.

Ms. BIGGERT. I know that Argonne Lab does have the Freedom Car that they do the testing for a lot.

Mr. DALUM. Right. And there are other universities I am aware of in Wisconsin that are working the hydraulics and other technologies that could be applied perhaps with research into this application.

Ms. BIGGERT. Would anybody like to comment on the coordination between the DOE and DOD?

Mr. Parish.

Mr. PARISH. Yes. I think that has been attempted in 21st century truck and I think as I had stated previously, the vision of that particular activity was very good, and I think it was a good forum by which there could have been a greater amount of interaction.

However, in actual practice it didn't turn out quite that way, but I think that given another try at it, you know, there is a possibility that we could make that happen. I think perhaps with more visionary leadership and stronger leadership for the 21 CT that would, in fact, happen.

Plus, if we had some real funding that the—a consortium could work with to start identifying what real projects were viable, do some competitive grants for different aspects of the program, I think that would be very worthwhile. You could have different agencies looking at different aspects of the whole problem.

Ms. BIGGERT. Thank you. I yield back.

Chairman LAMPSON. I want to thank everyone for taking the time to appear before us today, this committee.

Under the rules of the Committee, the record will be held open for two weeks for Members to submit additional statements and any additional questions that they might have for the witnesses.

This hearing is now adjourned. Thank you.

[Whereupon, at 11:37 a.m., the Subcommittee was adjourned.]

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