

EXAMINING FEDERAL VEHICLE TECHNOLOGY RESEARCH AND DEVELOPMENT PROGRAMS

HEARING BEFORE THE SUBCOMMITTEE ON ENERGY AND ENVIRONMENT COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

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**EXAMINING FEDERAL VEHICLE TECHNOLOGY
RESEARCH AND DEVELOPMENT PROGRAMS**

TUESDAY, MARCH 24, 2009

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

The Subcommittee met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Brian Baird [Chair of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

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Subcommittee on Energy and Environment

Hearing on

***Examining Federal Vehicle Technology Research and
Development Programs***

Tuesday, March 24, 2009
10:00a.m. - 12:00p.m.
2318 Rayburn House Office Building

Witness List

Mr. Thomas C. Baloga
*Vice President of Engineering
BMW of North America*

Mr. Steven Chalk
*Principal Deputy Assistant Secretary
Energy Efficiency and Renewable Energy, U.S. Department of Energy*

Dr. Kathryn Clay
*Director of Research
Alliance of Automobile Manufacturers*

Mr. Anthony Gressler
*Vice President of Government and Industry Relations
Valtra Powertrain North America Member*

Dr. John H. Johnson
*Presidential Professor
Michigan Technological University*

HEARING CHARTER

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

**Examining Federal Vehicle Technology
Research and Development Programs**

TUESDAY, MARCH 24, 2009
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Tuesday, March 24, the Subcommittee on Energy and Environment will hold a hearing to receive testimony on the Department of Energy's (DOE) Vehicle Technologies research and development programs. Witnesses will discuss the role of federal research programs in light- and heavy-duty vehicle technology development, as well as future directions for FreedomCAR and 21st Century Truck Partnerships at DOE, specifically, and proposals for programmatic changes to meet ever-changing market and public needs.

WITNESSES

- **Mr. Steven Chalk**—Principal Deputy Assistant Secretary, Energy Efficiency and Renewable Energy, U.S. Department of Energy
- **Dr. Kathryn Clay**—Director of Research, Alliance of Automobile Manufacturers
- **Mr. Anthony Gresler**—Vice President of Government and Industry Relations, Volvo Powertrain North America; Member, 21st Century Truck Partnership Executive Committee
- **Dr. John H. Johnson**—Presidential Professor of Mechanical Engineering, Michigan Technological University; Chair, National Academies Committee to Review the 21st Century Truck Partnership
- **Mr. Thomas C. Baloga**—Vice President of Engineering U.S., BMW of North America

BACKGROUND

For over two decades the Department of Energy has funded a wide range of research activities on passenger vehicles and heavy-duty trucks through its Vehicle Technologies program. The program's mission is to "Develop 'leap frog' technologies that will provide Americans with greater freedom of mobility and energy security, while lowering costs and reducing impacts on the environment." Most recently DOE has addressed these research needs through two public-private research programs: The 21st Century Truck Partnership (21CTP), which conducts R&D through collaborations with the heavy-duty trucking industry; and the FreedomCAR and the Hydrogen Fuel Initiative programs which examine the pre-competitive, high-risk research needed to develop technologies that will apply to a range of affordable cars and light trucks.

Over the last decade federal research priorities have shifted between passenger and heavy-duty vehicles, as well as diesel-hybrids, hydrogen-fueled, and battery-powered drive systems. While the programs have had some notable successes in transferring technologies to the marketplace, critics contend that previous administrations have adopted an inconsistent winner-take-all approach to vehicle research where one technology or platform receives the large bulk of funding, only to have funding cut before the programs can reasonably be expected to develop commercially viable technologies. They will argue that what is needed is long-term sustained funding on a broad range of areas from near-commercial technologies to exploratory research on systems with the potential to revolutionize transportation in the U.S. Striking the appropriate research balance and strengthening the federal commit-

ment in this area is especially critical at a time when both the automotive and trucking industries have very limited resources for research and development.

Light-Duty Vehicles and the FreedomCAR Partnership

FreedomCAR has been focused primarily on R&D for hydrogen-powered passenger vehicles. Launched in 2003, the initiative aims to help industry make mass-market fuel cell and hydrogen combustion vehicles available at an affordable cost within 10 to 15 years. The program replaced the Clinton Administration initiative, the Partnership for a New Generation of Vehicles (PNGV), which was funded for 10 years with the goal of developing ultra-efficient diesel hybrid passenger vehicles with fuel mileage up to 80 miles per gallon. PNGV resulted in prototype vehicles that met the criteria, but was ultimately canceled in 2001 at the request of the industry partners represented as U.S. Council for Automotive Research (USCAR—Daimler Chrysler, Ford, and General Motors).

The FreedomCAR program was then established as a collaborative effort between DOE, energy companies and the USCAR partners, and the focus was shifted to longer-term research on hydrogen vehicles. While simultaneously pursuing their own proprietary research, the partners work together to develop hydrogen technology roadmaps, determine technical requirements and goals, and suggest R&D priorities for the federal program. Efforts are divided among six technical teams: fuel cells, advanced combustion and emissions control, systems engineering and analysis, electrochemical energy storage, material, and electrical and electronics. Generally, the partners aim to have reliable systems for future fuel cell power trains with costs comparable to conventional internal combustion engines and automatic transmission systems. If successful, advances in hydrogen technologies could ultimately mean significant reductions in greenhouse gas emissions, reduced fuel costs for consumers, and greatly decreased imports of foreign oil.

However, FreedomCAR has raised public debate over several issues including the proper role of the government in R&D with ultimate market applications, as well as the appropriate level of funding for such long-term research when there are more immediate needs in the vehicle sector. The Congressional Research Service found that some critics of the program believe that there are too many technical and economic hurdles to the development of affordable, practical hydrogen and fuel cell technology for automobiles, and that federal research should focus on more realistic goals. Proponents of hydrogen research contend that it will require many years of sustained funding to realize its potential for revolutionizing the transportation sector, and withdrawing support now would amount to the squandering of several years and billions of dollars in government and private research.

Between 2003 and 2008 the FreedomCAR and the hydrogen related research at DOE saw a steady increase in funding from \$184.6 million to \$338.5 million. However, for FY09, the Bush Administration's request for hydrogen related research within the Vehicle Technologies program dropped 30 percent below the FY08 appropriation, indicating that the program's focus would shift towards plug-in hybrid and alternative fuel vehicles technologies.

Medium- to Heavy-Duty Trucks, and the 21st Century Truck Partnership at DOE

Launched in 2000, the 21st Century Truck Partnership (21CTP) explores technology improvements in commercial and military trucks and buses. The aim of the program is to support R&D in five key areas: engine systems, heavy-duty hybrids, parasitic losses, idle reduction and safety. Other federal agencies in the 21st Century Truck Partnership include the Department of Defense, Department of Transportation, and the Environmental Protection Agency. The goal of 21CTP is to combine federal and industry resources to develop a balanced portfolio of heavy-duty truck research activities, coordinate their research activities where appropriate, and make effective use of the Nation's research universities and national laboratories. In addition to funding specific research projects, 21CTP also serves as a forum for information exchange across all government and industrial sectors related to heavy truck research.

Funding for the Partnership steadily increased from \$45.6 million in FY99 to \$86.6 million in FY02. However, despite the potential economic and environmental benefits of improvements in trucks and the considerable technical hurdles that remain, the 21st Century Truck Partnership started to see a decrease in its funding in FY03 and hit a low of \$29 million in FY08. Stakeholders in 21CTP contend that the Bush Administration's decision to shift the focus of federal research to the passenger vehicle market came at the expense of truck related research.

Since 2000 there have been a number of suggestions on how to improve the 21CTP. In 2008, the National Academy of Sciences (NAS) at the request of DOE released a report entitled, "*Review of the 21st Century Truck Partnership.*" In this report the Academies panel examined the overall adequacy and balance of the program, and made recommendations to improve the likelihood of 21CTP meeting its goals. There are a variety of recommendations related to the five main research areas and additional recommendations on the structure and management of the program. The Chair of this review panel will testify on the panel's findings and recommendations at the hearing.

Electric hybridization is one area of focus for 21CTP. The power demands on trucks are as varied as the applications, and significant technical hurdles remain in hybridization. There is no one-size-fits-all solution for the entire sector. For example, through the course of an average drive cycle the charging and discharging of a hybrid system on a refuse truck, with its frequent starts and stops, dumpster lifting, and trash compaction, will be considerably different than that of a utility truck which may sit idling in one place for several hours in order to operate the bucket lifting boom and other equipment. Hybridization of long-haul tractor trailer rigs (Class 8) may prove even more challenging since they seldom brake during a drive cycle, providing few opportunities for battery systems to recharge through regenerative braking.

While the total number of heavy trucks is small compared to passenger vehicles, their fuel consumption and emissions justifies the high costs of development of hybrid models and other advanced truck technologies. 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.

Given the additional funding for vehicle technologies under the *American Recovery and Investment Act*, and growing public awareness of the need for new vehicle technologies, it is important that DOE programs be continually assessed for their ability to meet the changing needs of the transportation sector. Witnesses at the hearing will address both the strengths and weaknesses of the public-private research programs, as well as provide suggestions for how the programs can be enhanced to ensure the most appropriate use of taxpayer funds in this sector.

Chair BAIRD. Well, welcome to our hearing today. I am very grateful for our distinguished panel of witnesses, for those in the audience, and my good friends and colleagues on the panel.

This is a topic I find incredibly fascinating and absolutely essential to solving our energy consumption and global overheating and ocean acidification problems. We are always going to be in some fashion moving ourselves about the planet in vehicles, and the question is how can we do this in the most energy-efficient and environmentally-responsible way. And our panelists today can enlighten us on this.

I will start with a brief editorial observation that maybe not everyone will agree with, but I find it compelling, and it is that some years ago the United States, I think, had made some important strides on energy efficient vehicles, particularly the Chevy Corvair, and it was a front-wheel-drive, high-mileage vehicle, and rather ironically it was killed by Ralph Nader. And the damage that did to fuel efficiency in this country is immeasurable, and hence the damage it did to the environment because we labeled small cars, fuel-efficient cars unsafe at any speed, and that has left a legacy of, I think, inefficient vehicles that has contributed to global warming and overheating. And hopefully we can move forward with more responsible efforts to change how we drive and what we drive and what our mileage is.

Our hearing today deals with DOE's program, and DOE has supported a diverse portfolio of research in vehicle technologies for many years. The goal of the programs is to develop technologies that will maintain the freedom of mobility that vehicles provide while improving our energy security and reducing impacts on the environment. The program sponsors collaborative research on passenger vehicles through the FreedomCAR Partnership, and on heavy-duty trucks through the 21st Century Truck Partnership.

While these partnerships have had a number of successes, it is important to recognize when a shift in priorities needs to take place. As stewards of the taxpayers' dollars it is our responsibility to continually assess these programs and ensure that research activities are relevant to the industry's needs for commercially-viable technologies and appropriate to the government's role in exploratory research in areas that industry partners would not be able to pursue on their own.

This hearing today should shed light on some of these confusing and sometimes conflicting priorities. Many stakeholders argue that the Vehicle Technology Program at DOE has been a victim of drastic swings in priority between Administrations. The Clinton Administration sought to develop highly-efficient diesel hybrid passenger cars along with technologies for cleaner and more efficient trucks. The Bush Administration chose to focus instead on long-term research on hydrogen passenger vehicles and infrastructure and to reduce the funding for the heavy-duty truck research. Now as the new Administration develops its own policies, I hope we will avoid again putting all our eggs in one technology basket.

While we must be targeted in our federal R&D programs, a single-minded approach can ignore the importance of balancing a diverse portfolio with sustained funding for long-term research. Last year the National Academies of Science reviewed both the

FreedomCAR and the 21st Century Truck Programs and made a number of recommendations for programmatic changes, some of which we will hear today.

Given the recommendations of these two reports and the constantly changing landscape in the vehicle sector, the Committee is interested in hearing the witnesses' views on what the near-term priorities and future direction should be for the Vehicle Technologies Program at DOE.

With that I look forward to working with you all in exploring ways in which federal programs can be improved to support a robust vehicle manufacturing industry and to better serve public needs in advanced passenger vehicles and heavy-duty truck technology development.

I now would recognize my distinguished colleague and friend from South Carolina, our Ranking Member, Mr. Inglis, for his opening statement.

[The prepared statement of Chair Baird follows:]

PREPARED STATEMENT OF CHAIR BRIAN BAIRD

I want to welcome Members of the Subcommittee and our distinguished panelists to today's hearing examining the vehicle technology research and development programs at the Department of Energy (DOE).

With concerns about our over-reliance on foreign oil, the fluctuating costs of fuels, and the impact of the transportation sector on air quality and carbon emissions, it is imperative that we continually push the envelope in passenger and commercial vehicle technologies.

DOE has supported a diverse portfolio of research in vehicle technologies for many years. The goal of these programs is to develop technologies that will maintain the freedom of mobility that vehicles provide, while improving our energy security and reducing their impacts on the environment. The program sponsors collaborative research on passenger vehicles through the FreedomCAR Partnership, and on heavy-duty trucks through the 21st Century Truck Partnership.

While these partnerships have had a number of successes, it is important to recognize when a shift in priorities needs to take place. As stewards of the taxpayers' dollars it is our responsibility to continually assess these programs and ensure that research activities are both relevant to the industry's needs for commercially-viable technologies, and appropriate to the government's role in exploratory research in areas that industry partners would not be able to pursue on their own. This hearing today should shed some light on these often confusing, and sometimes conflicting, priorities.

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Now, as the new administration develops its own policies, I hope that we will avoid again putting all of our eggs in one technology basket. While we must be targeted in our federal R&D programs, this single-minded approach ignores the importance of balancing a diverse portfolio with sustained funding for longer-term research.

Last year the National Academies of Science reviewed both the FreedomCAR and 21st Century Truck programs, and made a number of recommendations for programmatic changes, some of which we will hear today. Given the recommendations of these two reports, and the constantly changing landscape in the vehicles sector, the Committee is interested in hearing the witnesses' views on what the near-term priorities and future directions should be for the Vehicle Technologies Program at DOE.

With that, I look forward to working with you all in exploring ways in which federal programs can be improved to support a robust vehicle manufacturing industry and to better serve public needs in advanced passenger vehicle and heavy-duty truck technology development.

I now yield to my distinguished colleague from South Carolina, our Ranking Member, Mr. Inglis for his opening statement.

Mr. INGLIS. Thank you, Mr. Chair.

Transportation clearly needs innovation. The transportation sector is our primary consumer of oil and is the second largest emitter of carbon dioxide in the country. So the Federal Government should continue its efforts to provide vehicle technology research and development. Transitioning from today's dependence on oil to tomorrow's clean energy economy holds enormous potential for our economy, environment, and national security.

I am particularly excited about having our friend, Thomas Baloga, from—Vice President of Engineering from BMW North America. Mr. Chair, I have got to point out that that is big for us in South Carolina, the fact that we have BMW there. In the upstate of South Carolina, BMW and the International Center for Automotive Research are working together to reinvent the car with innovation in various things like hydrogen combustion, battery research and development, and it is particularly exciting for us.

I should also point out that were it not really for BMW South Carolina would not have a claim on the transportation innovation future. We are immensely grateful for the \$6 billion that BMW has invested in South Carolina, 750 million of which is coming out of the ground right now in an expansion to produce, bring the production of the X-3 to Greer, South Carolina, along with the X-5 and the brand new X-6.

So because we have this wonderful blessing of BMW in the upstate of South Carolina, we have a claim to part of the innovation future, and we are particularly excited about partnering in any way we can with the Federal Government and agencies and others interested in this process to find ways to break this addiction to oil, to truly innovate our way out of our current fix.

So, thank you, again, Mr. Chair, for holding this hearing. I look forward to hearing our witnesses and how we can continue to develop and encourage the partnership between federal R&D support and the vehicle industry.

[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 is the second largest emitter of carbon dioxide in the country. The Federal Government must continue to support efforts in vehicle technology research and development. Transitioning from today's dependence on oil to tomorrow's clean energy economy holds enormous potential to for our economy, environment, and national security.

I'm delighted to have Mr. Thomas Baloga here this morning, Vice President of Engineering at BMW North America, located in the Fourth District of South Carolina. In the Upstate, BMW and the International Center for Automotive Research are working together to reinvent the car with innovation in hydrogen combustion and battery research and development.

Meanwhile, in the present, BMW employs about 5,000 at the plant and its suppliers employ over 17,000 in our region. Without BMW, we wouldn't have a claim on the transportation innovation future in South Carolina, and we are immensely grateful for the \$6.0 billion they have invested in SC—\$750 million of which is coming out of the ground new in an expansion to produce the new X-3 alongside the X-5 and X-6.

Thank you again for holding this hearing, Mr. Chairman. I look forward to hearing from our witnesses about how we can continue to encourage the partnership between federal R&D support and the vehicle industry.

Chair BAIRD. Thank you, Mr. Inglis. I appreciate your good words, and we also have with us Mr. Tonko and Dr. Ehlers. I also want to acknowledge the presence of former Member of Congress, Dave McCurdy. Dave, good to see you again, and thank you for being here.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good Morning. Thank you, Mr. Chairman, for holding today's hearing to discuss the role of federal research programs in light- and heavy-duty vehicle technology development.

As a supporter of advanced energy research and a senior Member of the Transportation and Infrastructure Committee, I applaud the Department of Energy for their far-reaching efforts to promote the development of new, clean, cost-efficient vehicle technologies for passenger cars and for medium- to heavy-duty trucks. FreedomCAR and the 21st Century Truck Partnership are innovative public-private partnerships that focus on creating a roadmap for the expansion of hydrogen and hybrid vehicles of any size. They provide unique forums for the public sector and the private sector to come together, share ideas, and discuss emerging technologies. Many of the new vehicle technologies are in their earliest stages, and the long-term focus of these partnerships will ensure that the best new ideas move from the drafting board to our garages, lowering our energy costs and protecting our environment.

I am interested to hear from our witnesses about the challenges and opportunities facing development of both light-duty vehicle and medium- to heavy-duty truck research. Over the past fiscal years, funding for vehicular research and development has favored light-duty vehicles and passenger cars. However, some research suggests that investment in the development of more efficient medium- to heavy-duty vehicles could have a larger impact on the environment. I support the development of new technologies in both fields, and I am interested to hear how the Department of Energy and industry representatives view the funding division and how the Science and Technology Committee can work with both industries to meet the changing needs of the transportation sector.

The Obama Administration has made it clear that science and technological advancement will be a top priority for the United States. I can think of no better place to begin our renewed focus on energy efficiency than on our roadways and in our cars.

I welcome our panel of witnesses, and I look forward to their testimony.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON

Good morning, Mr. Chairman and Ranking Member.

Today's Energy Subcommittee hearing on vehicle technology research will be beneficial for developing forward-thinking science policy.

As a Member of the House Committee on Transportation and Infrastructure, I have a keen interest in any policies affecting vehicles.

My home State of Texas, the second largest state in the Union, has the most State highway miles in the country. There are more than 79,000 miles of highways in Texas.

Improvements in fuel efficiency for cars and trucks will have a major impact there.

It is my hope that today's witnesses will discuss, in greater detail, the role of federal research programs in light- and heavy-duty vehicle technology development.

The Department of Energy will play a major role in funding research to develop cars and trucks that are more fuel efficient.

While market prices for oil and gas may change, one thing is certain: there is a limited world supply of these items.

We, as a nation, must invest in fuel technology innovation. The President has signaled a strong interest in energy research.

I thank the Chairman for inviting industry leaders to testify on the potential impacts of various policy scenarios.

It is certainly our intention to help, not hinder, vehicle manufacturers to innovate to meet future demands.

Heavy load-bearing trucks demand lots of power to transport freight across the country. I see this as a significant challenge to the truck industry, especially as fuel prices have been volatile.

Considering the additional funding for vehicle technologies under the *American Recovery and Investment Act*, it is important that Department of Energy programs be continually assessed for their ability to meet the changing needs of the transportation sector.

Mr. Chairman, support for fuel efficiency technology is support for a more fuel-independent nation.

This committee has tremendous potential to blaze a trail. We must lead the way to incentivize innovation in vehicle research.

Thank you, Mr. Chairman. I yield back the balance of my time.

Chair BAIRD. With that I will introduce the witnesses. Your seating arrangement is slightly different than the order you will speak, and so I will introduce you in the order you will speak and then we will proceed.

Mr. Steven Chalk is the Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy at the U.S. Department of Energy. Mr. Chalk, glad you are here. I understand you are in some pain from a back injury, so we will be as accommodating as we possibly can be, and we appreciate very much your being with us.

Dr. Kathryn Clay, Director of Research at the Alliance of Automobile Manufacturers and a former staff member for this committee. Dr. Clay, it is great to see you again. Thank you for being here.

Dr. John Johnson is President and Professor, Presidential Professor of Mechanical Engineering at Michigan Technological University. Dr. Johnson also chaired the National Academy's panel reviewing the 21st Century Truck Partnership. Dr. Ehlers has some affection for Michigan. If he wishes to add any comments, I would welcome that at this point. Dr. Ehlers.

Mr. EHLERS. Thank you, Mr. Chair. I am very pleased that Dr. Johnson is able to be here.

Many people in the lower 48 don't know a great deal about Michigan Technological University, but it is an outstanding university located in the frozen north of Michigan, and I think that you are down to about four feet of snow now apparently. But it is a great advantage. After they snowshoe to the university in the morning, they are pretty well locked in all day doing research, and they have produced some really tremendous results there. It is an outstanding university, and we are very blessed to have Dr. Johnson with us today. And thank you for being here.

Chair BAIRD. Thank you, Dr. Ehlers.

Mr. Anthony Greszler is the Vice President of Government and Industry Relations at Volvo Powertrain North America. He also serves on the Executive Committee, the 21st Century Truck Partnership.

And last but by no means least, Mr. Thomas Baloga, who is Vice President of Engineering for BMW, which my friend Mr. Inglis already acknowledged.

As our witnesses know, 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 have completed your spoken

testimony, we will begin with questions with each Member having five minutes to question the panel, and, again, any colleagues who want to offer comments for the record, those will be accepted.

We will start with Mr. Chalk. Mr. Chalk, please proceed.

STATEMENT OF MR. STEVEN CHALK, PRINCIPAL DEPUTY ASSISTANT SECRETARY, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. CHALK. Thank you, Chair Baird and Ranking Member Inglis, Members of the Committee. Thanks for the opportunity to appear before you today to discuss the Department of Energy's Vehicle Technologies Program activities.

Vehicles are pivotal in meeting some of the most significant challenges our nation faces today: dependence on foreign oil and climate change. The transportation sector counts for more than two-thirds of our U.S. oil usage, so advances in transportation technology must play a major role in reducing our oil dependence and improving energy security.

It is also central to combating global warming, as improvements in efficiency of vehicles and advances in alternative fuels will reduce greenhouse gas emissions.

Additionally, vehicle technologies affect consumer pocketbooks. For every one percent improvement we have in fuel economy across the Nation's fleet, consumers can save more than two billion gallons of fuel annually.

DOE's Vehicle Technology Program addresses the Nation's petroleum dependency on two fronts: improved efficiency of the vehicles we drive and through fuel substitution, including biofuels, electricity, and hydrogen. The Department leads a cooperative effort among energy companies, utilities, and vehicle manufacturers to develop the next generation of automotive technology. Our entire program is reviewed every other year by the National Academy, the National Research Foundation, who give us the recommendations. We work those into the program to improve the program.

We have historically had a robust light-duty vehicle program and are evaluating options for innovative programs that recognize the growing importance of heavy-duty vehicles within our budget. Medium- and heavy-duty vehicles warrant increased attention because of their growing fuel use, and it is pivotal to the Nation's economy.

The EIA projects that heavy-truck consumption is going to increase 23 percent between today and 2020, while overall transportation use is forecasted to stay relatively flat. So the influence of heavy-duty vehicles on oil dependence and greenhouse gas emissions is, therefore, likely to play a greater and greater role.

So heavy-duty vehicles are essential also to the well-being of the business community, with 70 percent of freight tonnage transported by truck. So when diesel prices go up, the trucking industry, many businesses struggle. The additional cost is then passed on to the consumer, since everything we buy from groceries to appliances to clothing comes to the store in a truck.

So, fortunately, the heavy-duty vehicle industry adapts to technological advances relatively quickly. While it might take 15 years for technology to reach a maximum penetration in new cars and light

trucks, and you mentioned front-wheel drive took about that long to penetrate the market, the timetable is closer to about three years for the heavy-duty fleet.

So this quick adoption of technology of heavy-duty vehicle fleet operators means rapid opportunities for job creation, improved energy security, and lower carbon emissions. Some of the Department's successes in the light-duty vehicles can migrate up or over to the heavy-duty sector, such as the batteries we are developing, the power electronics, or hybridization of heavy trucks.

In the future there is a lot of potential for light-duty, plug-in hybrid vehicles, or PHEVs as we might call them. They can stretch a passenger vehicle mileage up to over 100 miles per gallon on a gasoline basis and displace petroleum by substituting electricity from the grid for gasoline. And since PHEV owners might typically charge their vehicles at night, this would limit the impact to the electrical grid and allow consumers to take advantage of off-peak electricity rates. In a study done by the Pacific Northwest Lab showed that over or about 70 percent of our current light-duty vehicle fleet could be replaced with PHEDs without significant impact to the electrical grid.

The Department's heavy-duty vehicle R&D focuses on advanced combustion and increased engine efficiency, including waste heat recovery, optimizing engines for urban and highway hybrid applications, encouraging the use of renewable diesel fuel, and reducing powertrain losses. The DOE has contributed to important advances in heavy-duty engine efficiency. The program had a goal of 42 percent or the baseline efficiency, I should say, was about 42 percent for heavy trucks. We had a stretch goal of 50 percent, and two of the partners we worked with demonstrated over 47 percent. So I think there was some success there, although we do recognize the Academy's recommendation to demonstrate that in a full heavy-duty vehicle.

When the NRC reviewed the partnership last year, they recommended that we do a more systems-designed approach, and we are taking that under consideration as we re-plan the program.

The next steps towards making significant technological advances will be to look at the system as a whole. So in the heavy-duty vehicle we will look at the powertrain, the fuels, materials, aerodynamics, hybridization, idle reduction. All these capabilities must be engineered together to reach the most efficient vehicle energy balance.

So during this period of economic challenge it is critical that we forge an even stronger R&D alliance with industry to develop the next generation of world class, clean, efficient vehicles for both personal and commercial transportation.

So thank you again for the opportunity to appear before you today, and I would be happy to answer any questions that you all may have.

[The prepared statement of Mr. Chalk follows:]

PREPARED STATEMENT OF STEVEN CHALK

Chairman Baird, Ranking Member Inglis, Members of the Committee, thank you for the opportunity to appear before you today to discuss the U.S. Department of Energy's (DOE) Vehicle Technologies Program activities. Reducing U.S. dependence

on oil is one of the most significant ways in which our Nation can improve energy security and address global climate change.

The mission of the Vehicle Technologies Program is to develop more energy-efficient and environmentally friendly highway transportation technologies for light-, medium-, and heavy-duty vehicles that meet emissions regulations and reduce petroleum dependence without sacrificing performance or passenger safety. Accomplishing the mission will contribute to climate change mitigation, energy and economic security, and enable more productive use of the Nation's total energy resources. The *FY 2009 Omnibus Appropriations Act* provides over \$273 million for the Vehicle Technologies Program, compared to \$213 million in FY 2008.

As the sector responsible for more than two-thirds of U.S. oil usage, advances in transportation technology can have a major impact on reducing oil dependence.¹ Additionally, according to one study, for every one percent improvement in vehicle fuel efficiency across the Nation's fleet, consumers could save more than two billion gallons of fuel annually.²

Our research agenda is guided by an extensive analysis, test and evaluation effort, as well as stakeholder involvement. Typically, projects undergo independent peer evaluation every year. This evaluation helps inform future direction and project close-out.

The Department leads a cooperative effort among energy companies, utilities and vehicle manufacturers to develop the next generation of personal transportation. Our entire program is reviewed every other year by the National Academy of Sciences National Research Council (NRC). NRC findings are evaluated and recommendations implemented to improve the effort's effectiveness.

In the area of personal transportation, the Department's Vehicle Technologies Program addresses the Nation's petroleum dependency on two fronts—improving efficiency of the vehicles we drive, and substituting to new fuels, including biofuels and electricity. The Program Research and Development (R&D) portfolio includes:

- Hybrid and Plug-in Hybrid Vehicles (PHEV)—R&D for battery, electrical machines, electric motors and battery systems research for hybrid, and PHEVs
- Fuels—Improved utilization of petroleum and non-petroleum fuels, addressing light-, medium-, and heavy-duty vehicles
- Materials—Advanced material development and manufacturing, e.g., carbon fiber and thermoelectric materials
- Internal Combustion Engines (ICE)—Efficiency improvements for conventional ICEs
- Heavy-Duty Vehicle Systems and Components

Development of PHEVs can provide significant improvements in fuel economy and petroleum displacement by using electricity from the grid at off-peak hours. PHEVs are similar to the current generation of hybrid vehicles, except that the battery is significantly larger, providing a range of up to 40 miles in an all-electric mode and allowing the battery to be charged by “plugging in” to a standard wall socket.³ Forty miles in an all-electric mode is more than adequate for the typical urban commuter, but not all U.S. drivers are typical; after 40 miles, the engine takes over and the vehicle operates similar to today's hybrids, achieving excellent fuel economy.

PHEVs displace petroleum by substituting electricity from the grid for gasoline. A PHEV stretches a vehicle's mileage up to 100 mpg on a gasoline basis.⁴ Since PHEV owners would typically charge their vehicles at night, this would limit the impact to the electric grid and allow consumers to take advantage of off-peak electricity rates, in states where time-of-day pricing is in effect. A study by the Pacific Northwest National Laboratory has shown that 70 percent of the current vehicle fleet could be replaced with PHEVs without significant impact to the electric power grid.⁵

A key component of the emergence of PHEVs is a new generation of lithium-ion batteries. The success of the lithium-ion battery is imperative for PHEV deployment and commercial acceptance. However, these batteries are still too expensive and require further technological improvements for widespread consumer acceptance. Con-

¹Transportation Energy Data Book Edition 27, Table 1.13.

²“Tires and Passenger Vehicle Fuel Economy,” NRC, http://books.nap.edu/openbook.php?record_id=11620&page=4

³“PHEV Batteries,” Transportation Technology Research and Development Center, Argonne National Laboratory, http://www.transportation.anl.gov/batteries/phev_batteries.html

⁴“All About Plug-In Hybrids (PHEVs),” <http://www.calcars.org/vehicles.html>

⁵“U-M, PNNL study: Are plug-ins the next wave of hybrid vehicles?” Pacific Northwest National Laboratory, <http://www.pnl.gov/news/release.asp?id=272>

tinued development of battery and electric motor technologies will allow future generations of hybrids and PHEVs to compete with conventional ICE vehicles on a cost competitive basis.

While the U.S. has a robust industry base in certain types of conventional batteries like alkaline “flashlight” batteries and lead-acid “starter” batteries, we have very little manufacturing capability for new generation batteries like lithium-ion, for which more than 95 percent of the world’s production is located in Asia.⁶ Because the vehicle fleet of tomorrow will include more and more hybrids, PHEVs, and even all-electric vehicles, there is a pressing need to establish the facilities to manufacture those batteries in the United States. The President made the first step towards doing just that last week when he announced the release of a \$2 billion Advanced Battery Manufacturing solicitation funded by the *American Recovery and Reinvestment Act* (Recovery Act). The solicitation includes up to \$1.5 billion to establish battery manufacturing facilities, representing an important step forward for vehicle technology. Making batteries in the United States will facilitate the Administration’s goal of putting one million PHEVs on the road by 2015. In addition, these battery manufacturing facilities can supply advanced batteries for defense applications, consumer electronics, power tools, utility voltage regulation, and truck idling mitigation.

Along with increased battery and PHEV development, deployment of alternative fuels can reduce transportation oil consumption. DOE is a leader in facilitating the deployment of alternative fuels, including ethanol blends, biodiesel, hydrogen, and electricity while developing fuel infrastructures through partnerships with State and local governments, universities, and industry. The fuels effort supports R&D directed towards providing consumers with fuel options that are cost-competitive, enable higher fuel economy, deliver lower emissions, and reduce the use of oil. One specific activity is the evaluation of the impact intermediate blends of ethanol, such as E15 and E20 (15 percent and 20 percent ethanol mixed with gasoline), have on performance, emissions and durability of the existing vehicle fleet and on small, non-road engines. While alternative fuels can reduce dependence on oil imports, DOE recognizes that careful analysis is needed to assess the effects of such fuels on emissions.

Reducing vehicle weight and energy loss during vehicle operation directly improves vehicle fuel economy. The introduction of cost-effective, high-strength materials and thermoelectric⁷ materials can significantly reduce vehicle weight without compromising safety while improving efficiency. The use of lightweight, high-performance materials such as carbon fiber, polymers, and metal alloys will contribute to the development of vehicles that provide better fuel economy, yet are comparable in size and comfort to today’s vehicles. The goal is to develop and validate cost-effective high strength material technologies that could significantly reduce vehicle weight without compromising cost, performance, safety, or recyclability.

Improved combustion technologies and optimized fuel systems can provide near- and mid-term fuel efficiency gains. The goal here is to achieve engine efficiency for passenger vehicles of 45 percent, a substantial increase from the current average of 30 percent.⁸ DOE’s Vehicle Technologies Program focuses much of its effort on improving vehicle fuel economy while meeting increasingly stringent emissions standards. Achieving these goals requires a comprehensive understanding of relationships among fuel economy, emissions, and engine and hybrid system control strategies, in order to minimize the fuel economy penalty associated with emission controls. Researchers at universities, private industry and DOE’s National Laboratories are working to identify technologies and engine control strategies that achieve the best combination of high fuel economy and low emissions for advanced diesel, gasoline, and hydrogen internal combustion engines for application in conventional and hybrid-electric drives.

In the future, we see a continuing trend toward electrification of vehicle drivetrains and ancillary components, as well as light-weighting and widespread deployment of biofuels for use in the light-duty vehicle sector.

Highway vehicles account for 80 percent of the transportation sector with heavy-duty vehicles consuming approximately 25 percent of the fuel.⁹ Trucks and other heavy-duty vehicles are of the utmost importance to the business community, with

⁶“Sourcing Report: Lithium Batteries,” <http://www.chinasourcingreports.com/csr/Electronic-Components/Lithium-Batteries/p/CSRLIT/Industry-Overview.htm>

⁷“Thermoelectric” refers to the conversion of heat directly to electricity.

⁸“Summary of Fuel Economy Performance” (Washington, DC: Annual Issues), National Highway Traffic Safety Administration, U.S. Department of Transportation, available at <http://www.nhtsa.dot.gov/portal/site/nhtsa/menuitem.43ac99aefa80569eea57529cda046a0/>

⁹Transportation Energy Data Book Edition 27, Table 2.5, page 2–1.

69 percent of freight tonnage transported by truck.¹⁰ When diesel prices go up, the trucking industry and many businesses struggle. The Energy Information Administration's 2008 Annual Energy Outlook (AEO) predicts that U.S. heavy truck fuel consumption will increase 23 percent between 2009 and 2020.¹¹

Technological advancements are adopted by the heavy-duty vehicle industry more quickly than the light-duty sector due to several factors, including the willingness to be early-adopters and the immediate payoff and high return on investment that the industry sees upon implementation. It takes approximately 15 years for a technology to reach maximum penetration in sales of new cars and light trucks.¹² For the heavy-duty fleet, the timetable is closer to three years.¹³ The quick adoption of technology by heavy-duty vehicle fleet operators may enable more rapid realization of job creation, improved energy security, and carbon mitigation benefits.

The Department leads the 21st Century Truck Partnership, a cooperative effort between the commercial vehicle (truck and bus) industry and major federal agencies to develop technologies that will make our nation's commercial vehicles more efficient, clean, and safe. Specifically, Vehicle Technologies Program R&D aims to increase engine efficiency, develop hybrid powertrain technologies, reduce parasitic and idling losses, and validate and demonstrate these technologies. As noted above, NRC reviews the Partnership's progress every other year and provides findings and recommendations which are evaluated and implemented to improve overall effectiveness.

Heavy-duty vehicle R&D focuses on advanced combustion and increased engine efficiency, including utilizing waste heat recovery; optimizing engines for urban and highway hybrid applications; encouraging the use of renewable diesel fuel; and reducing power-train losses. One research goal is to develop and demonstrate an emissions-compliant engine system for a typical tractor trailer or "Class 8 trucks" with 20 percent greater engine system fuel efficiency by 2014. NRC recommended that DOE complete a demonstration of improved engine thermal efficiency. DOE will consider this recommendation as part of a future heavy-duty vehicle solicitation.

Medium-duty trucks such as buses, delivery vehicles, and waste hauling trucks are important because they normally operate under city driving conditions and often in air quality non-attainment areas. Medium-duty applications are also an excellent way to transition light-duty technology into the heavy-duty sector. R&D accomplishments in this area include the dual mode hybrid technology co-developed with a transmission manufacturer. This technology was first developed for hybrid transit buses, with the goal of attaining higher power density and lower component cost for the electric drive motor and power electronics. Since October 2003, more than 500 hybrid buses have been deployed in 44 U.S. cities, a deployment that was supported by the Federal Transit Administration.¹⁴ Converting transit bus fleets to hybrids in the nine largest U.S. cities would impact 18 thousand buses, equivalent to replacing 720 thousand conventional vehicles with hybrid cars.¹⁵ The success with hybrid transit buses has not only capitalized on an opportunity to penetrate the mass transit market, but has also opened the technology pathway for the next generation of commercially viable advanced heavy- and light-duty hybrid vehicles. NRC recommended that the potential benefits of hybrid Class 8 trucks be evaluated and that if benefits appeared promising, this activity should accelerate development of the necessary hybrid technology and demonstrate it in prototype vehicles.

Electrification of heavy-duty vehicles and idle reduction measures can yield major fuel savings in the trucking industry, as truckers often idle their vehicles at truck stops for hours at a time to provide sleeper compartments with electricity for heat, air conditioning, and small appliances. Truck stop electrification allows truckers to operate necessary systems without idling the engine, reducing diesel fuel emissions and saving trucking companies the cost of that fuel. The Department's Vehicle Technologies Program has also investigated ways to electrify mechanical engine accessories to achieve greater efficiency and is developing thermoelectric devices to convert exhaust heat energy to electricity to provide on-board power. The NRC committee recommended continued R&D of the system components that will provide additional improvements in idle reduction and parasitic losses. DOE agrees with this recommendation.

¹⁰American Trucking Trends 2008–2009, p. 5.

¹¹"Annual Energy Outlook 2008," Energy Information Administration, Table A7.

¹²"Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2006," EPA420-R-011, July 2006, p. 62.

¹³"Heavy Truck Research, Development, & Demonstration: Looking for Return on Investment," 2009 SAE Government-Industry Meeting Presentation, U.S. DOE, slide 9.

¹⁴Motor & Power Electronics Development, Arthur McGrew, Allison Transmission, General Motors Corporation, February 8, 2007.

¹⁵*Ibid.*

The next step toward making significant technological advancements will be to look at the vehicle system as a whole. In a heavy-duty vehicle, the powertrain, fuels, materials, aerodynamics, hybridization, and idle reduction capabilities must be engineered together to reach the most efficient vehicle energy balance.

The goal with this systems approach is to improve Class 8 freight efficiency in “ton-miles per gallon”¹⁶ by 50 percent through accelerated R&D by industry teams led by truck manufacturers. This would involve developing and integrating a unique combination of technologies which may include engine efficiency, light-weighting, hybridization, and parasitic load reduction. Each of these radically redesigned tractor trailer systems would then be evaluated in controlled engineering tests followed by rigorous in-service use by fleet operators.

The benefits of mitigating the Nation’s addiction to oil through diverse research, development, deployment, and demonstration activities include energy security and greenhouse gas reduction. During this period of economic challenge, it is critical that we forge an even stronger R&D alliance with industry to develop the next generation of world-class clean, efficient vehicles for both personal and commercial transportation.

The Department’s focus on hybrid and PHEV R&D for battery, electrical machines, electric motors and battery systems research; improved utilization of petroleum and non-petroleum fuels; advanced material development and manufacturing; efficiency improvements for conventional ICEs; and heavy-duty vehicle systems and components will help mitigate the security, environmental and economic challenge the Nation faces today.

Thank you again for the opportunity to appear before you today to discuss these important issues. I am happy to answer any questions.

BIOGRAPHY FOR STEVEN CHALK

Steven Chalk is the Principal Deputy Assistant Secretary in the Office of Energy Efficiency and Renewable Energy (EERE) at the U.S. Department of Energy. In this capacity, Mr. Chalk is responsible for managing the programs, staff and policies of EERE and interfacing with constituent groups in the efficiency and renewable energy sectors.

Mr. Chalk recently held the position of EERE’s Deputy Assistant Secretary for Renewable Energy, where he was responsible for the management of the government’s research, development, and commercialization efforts in solar, wind, geothermal, biomass, and hydrogen technologies. Mr. Chalk also previously managed EERE’s Hydrogen and Fuel Cell Technologies Program, the Solar Energy Technologies Program and Buildings Technologies Program.

In September 2008, Steve was honored with a Service to America Medal in the Science and Environment category. This award recognized his management of several innovative clean energy projects, as well as his leadership in the Federal Government’s efforts to expand the use of renewable energy and energy efficiency, particularly in the communities of New Orleans and Greensburg, Kansas.

While leading the Solar Energy Technologies Program, Mr. Chalk was responsible for planning and implementing the Solar America Initiative, which aims to make solar technologies cost competitive by 2015. In the building technologies area, Mr. Chalk led DOE’s efforts toward net zero energy homes and buildings. The portfolio includes component research such as solid state lighting, market transformation activities such as EnergyStar, and appliance standards regulations. Before this, Mr. Chalk led the President’s Hydrogen Fuel Initiative where he oversaw development of a five-year, \$1.2 billion research investment in hydrogen production, delivery, storage, and fuel cells. This portfolio also includes hydrogen safety, codes and standards, and education activities.

In his early career at DOE, Mr. Chalk managed technology development programs in fuel cells, diesel emissions control, and materials for DOE’s advanced automotive technology office. Steve also worked in the nuclear energy field where he oversaw DOE test programs for tritium production. Steve started his career with the Navy developing propellants and explosives for conventional weapons.

Mr. Chalk holds a Bachelor of Science in Chemical Engineering from the University of Maryland and a Master of Science in Mechanical Engineering from the George Washington University.

Chair BAIRD. Dr. Clay.

¹⁶Since a fully-loaded Class 8 tractor trailer combination weighs 80 thousand pounds, the term “freight efficiency” in ton-miles per gallon is a more accurate characterization of this vehicle’s efficiency.

**STATEMENT OF DR. KATHRYN CLAY, DIRECTOR OF
RESEARCH, ALLIANCE OF AUTOMOBILE MANUFACTURERS**

Dr. CLAY. Thank you. Mr. Chair, good morning. My name is Kathryn Clay, and I am the Director of Research for the Alliance of Automobile Manufacturers. The Alliance is a trade association made up of 11 car and light truck manufacturers, including BMW group, Chrysler LLC, Ford Motor Company, General Motors, Jaguar Land Rover, Mazda, Mercedes Benz USA, Mitsubishi Motors, Porsche, Toyota, and Volkswagen. On behalf of the member companies of the Alliance, I would like to thank you for giving me the opportunity to speak with you about vehicle technology research supported by the Department of Energy and for opportunities for this work to serve both public and industry interests in reinventing the automobile.

Meeting our national goals of reductions in greenhouse gas emissions and reducing our reliance on foreign oil will require the development of a suite of technologies. Responding to this challenge, automakers are leaders in research and development investment. Total R&D investment by the industry was \$79 billion in 2007, up eight percent from the previous year.

Automakers invest in a diverse array of vehicle technologies. There is no silver bullet or one right answer to what the autos of the future should look like. In the coming decades the vehicle fleet will likely be much more diverse technologically, with the growing proportions, flex fuel, clean diesel, fuel cell, hydrogen, internal combustion engine, hybrid electric, and pure electric vehicles coming into the fleet. Continued improvements to the efficiency of the internal combustion engine will also play a significant role for gasoline vehicles.

I would like to begin by identifying general principles that should guide the Department of Energy Vehicle Technology Program to maximize its effectiveness and then provide recommendations for work on two particular technologies.

First, the Department of Energy Program should aim to promote technological diversity to the maximum extent feasible, including the vehicle technologies I have mentioned previously. Second, recognizing that each alternative vehicle technology will depend on a well-functioning and available infrastructure. The Vehicle Technology Program should work collaboratively with other departmental divisions on alternative fuels infrastructure challenges.

For example, the Transportation Electrification Infrastructure Program recently included in the Recovery Act has the potential to significantly advance vehicles like plug-in hybrids.

Third, the program should support work that spans the full range of the R&D spectrum, all the way from basic research to commercial deployment. Getting the balance right will be challenging, but no part of the spectrum can be neglected if new technologies are to be brought from the laboratory bench all the way through to the marketplace.

Fourth, the Department should consider linkages between the Vehicle Technologies Program and government purchasing programs. Acting as early adopters, government fleets can help lead the way to bringing new automotive technologies to market.

And finally, the Department should develop metrics of success that promote innovative, high-risk, high-reward research. This committee originated the legislation that authorized the Advanced Research Projects Agency for Energy or ARPA-E, and well knows the importance of emphasizing this type of research. There is an opportunity for the new ARPA-E to cross pollinate other programs and to encourage the inclusion of more forward-leaning research, despite sometimes lower certainty in their ultimate outcomes.

Next, let me highlight two areas of critical importance: the ongoing Hydrogen and Fuel Cell Learning Demonstration Program, and the recently-established Advanced Battery Manufacturing Program. The Hydrogen and Fuel Cell Learning Demonstration Program has included 140 fuel cell vehicles and 20 hydrogen stations and has worked with automotive and energy company teams including GM and Shell, Chrysler, Daymore, and BPE and Ford and BPE. Under this program vehicles have traveled nearly two million miles and the second-generation vehicles have achieved ranges of up to 254 miles with fuel economies from 43 to 58 miles per kilogram of hydrogen.

This program has demonstrated success both in terms of hydrogen technology advancements and also for the learning demonstration model itself and should continue to receive support.

Last week President Obama announced up to 1.5 billion in grants to establish a domestic manufacturing base for advanced batteries. A strong, diverse supplier base for advanced batteries will help all automakers move forward to bringing electric powertrain vehicles to market.

It is essential that the recipients of this funding have the knowledge and expertise needed to establish battery production at scale. Opportunities for technology transfer through joint ventures with other manufacturers could help establish a domestic advanced battery manufacturing base more quickly. These awards also should emphasize not only the battery manufacturing construction but also a strong commitment to manufacturing R&D. Without such a strong program element, the manufacturing capacity that we buy with our investment will become outmoded soon after it enters production.

We look forward to working with the Department of Energy, and we hope to continue this work to position our industry to be at the cutting edge of the new clean energy economy.

Thank you.

[The prepared statement of Dr. Clay follows:]

PREPARED STATEMENT OF KATHRYN CLAY

Good morning, my name is Kathryn Clay and I am the Director of Research for the Alliance of Automobile Manufacturers. The Alliance is a trade association made up of eleven car and light truck manufacturers including BMW Group, Chrysler LLC, Ford Motor Company, General Motors, Jaguar/Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche, Toyota, and Volkswagen. On behalf of the member companies of the Alliance I would like to thank you for giving me the opportunity to speak with you about vehicle technology research supported by the Department of Energy and opportunities for this work to serve both public and industry interests in reinventing the automobile.

Meeting our national goals of reductions in greenhouse gas emissions and reducing our reliance on foreign oil will require the development of a suite of technologies. Responding to this challenge, automakers are leaders in research and development

investment—total R&D investment by the industry was \$79 billion in 2007, up eight percent from the previous year.

Automakers invest in a diverse array of vehicle technologies. There is no “silver bullet,” or one right answer, to what the autos of the future should look like. In the coming decades, the vehicle fleet will likely be much more diverse technologically, with growing proportions of flex fuel, clean diesel, fuel cell, hydrogen internal combustion engine, hybrid electric and pure electric vehicles. Continued improvements to the efficiency of the internal combustion engine will also play a significant role.

I would like to begin by identifying general principles that should guide the Department of Energy vehicles technology program to maximize its effectiveness, and then provide recommendations for work on two particular technologies.

First, the DOE program should aim to promote technological diversity to the maximum extent feasible, including a wide range of alternative vehicle technologies.

Second, recognizing that each alternative vehicle technology will depend on a well-functioning infrastructure, the vehicle technology program should work collaboratively with other divisions within the department that are addressing alternative fuels infrastructure challenges. For example, the transportation electrification infrastructure program, included in the Recovery Act at a funding level of up to \$400 million, has the potential to significantly advance vehicles like plug-in hybrids.

Third, the program should support work that spans the full range of the R&D spectrum, including basic research, applied research, manufacturing R&D, and deployment and commercialization activities. Getting the balance right will be challenging, but no part of the spectrum can be neglected if new technologies are to be brought from the laboratory bench all the way through to the marketplace.

Fourth, the Department should consider linkages between the vehicle technologies program and government purchasing programs. Acting as early adopters, government fleets can help lead the way to bringing new automotive technology to market. The government should continue to purchase flex fuel vehicles; demand maximum utilization of E-85 in the government flex fuel fleets; use federal fueling to stimulate publicly accessible pumps; and provide funding technology is available.

Finally, the Department should develop metrics of success that promote innovative, high-risk/high-reward research. This committee originated the legislation that authorized the Advanced Research Projects Agency for Energy (ARPA-E), and well knows the importance of emphasizing this type of research. The recent stimulus package included \$400 million to set-up ARPA-E. It would be unfortunate if a newly created ARPA-E had the unintended effect of decreasing investment in high-risk research in other DOE programs like the vehicles technology program. There is an opportunity for the new ARPA-E to “cross pollinate” other programs and encourage the inclusion of more forward-leaning research despite lower certainty in their outcomes.

Next, let me highlight two specific research areas that are of critical importance: the ongoing hydrogen and fuel cell learning demonstration program, and the recently established advanced battery manufacturing program.

The DOE Hydrogen and Fuel Cell Learning demonstration started in 2004. There have been 140 fuel cell vehicles introduced into the program, with 119 currently operating. There are 20 hydrogen stations in the project, located in Northern and Southern California, Detroit Michigan area, Orlando Florida, the New York City area and in Washington DC. The automotive and energy company teams include GM and Shell; Chrysler, Daimler, and BP; and Ford and BP.

Under the program, vehicles have traveled nearly two million miles in the project and there has been 88,000 kg of hydrogen produced or dispensed at the 20 hydrogen stations. The fuel cell vehicles have a projected durability of 1,977 hours. Testing has shown that second generation vehicles have a range of up to 254 miles with a fuel economy from 43 to 58 miles/kg. Phase two of the program is now in planning. This program has demonstrated success both in terms of hydrogen technology advancements and also for the learning demonstration model, and should continue to receive support.

Last week, President Obama announced that the Department of Energy would begin soliciting proposals for up to \$1.5 billion in grants included in the stimulus to establish a domestic manufacturing base for advanced batteries. A strong, diverse supplier base for advanced batteries will help all automakers move forward to bringing electric powertrain vehicles to market. To maximize the benefit of this funding, the DOE should consider the following two elements:

First, it is essential that the recipients of this funding have the knowledge and experience needed to establish battery production at scale. Opportunities for technology transfer through joint ventures with other manufacturers could help establish a domestic advanced battery manufacturing base more quickly.

Second, the awards should require not only the construction of a battery manufacturing facility, but a strong commitment to manufacturing R&D. An emphasis on manufacturing R&D will enable the nascent advanced battery manufacturing industry to be innovative and globally competitive. Without this as a strong program element, the manufacturing capacity we buy with our investment will become outmoded soon after it enters production.

We look forward to working with the Department of Energy to advance a diverse array of vehicle technologies. In doing so, we will position our industry to be at the cutting edge of the new clean energy economy.

BIOGRAPHY FOR KATHRYN CLAY

Current Positions

Energy Scholar
Adjunct Professor of Physics
Director of Research, Alliance of Automobile Manufacturers

Areas of Concentration

Energy, Science Workforce & Education

Education

Ph.D. in Physics, University of Michigan, Ann Arbor
M.S. in Electrical Engineering, University of Michigan Ann Arbor

Commentary

Dr. Kathryn Clay is the Director of Research for the Alliance of Automobile Manufacturers. Previously, she served as a member of the professional staff of the Senate Energy and Natural Resources Committee. While on the Committee, Dr. Clay worked to develop the *Energy Independence and Security Act of 2007* and the *Energy Policy Act of 2005*. She was also centrally involved in the development and passage of legislation (the *America COMPETES Act of 2007*) to promote federal investment in science and the development of innovative technologies.

Dr. Clay has also served in positions with the staff of the Energy Subcommittee of the U.S. House of Representatives Committee on Science, at the Massachusetts Division of Energy Resources, and as a research fellow in the Alternate Fuels Vehicle Division of Ford Motor Company.

Chair BAIRD. Mr. Baloga.

STATEMENT OF MR. THOMAS C. BALOGA, VICE PRESIDENT OF ENGINEERING-US, BMW OF NORTH AMERICA, LLC

Mr. BALOGA. Chair Baird, Ranking Member Inglis, and Members of the Committee, thank you for the opportunity to provide testimony before your subcommittee. It is a privilege to be here.

My key messages for the Subcommittee are, number one, please don't pick vehicle technology winners or losers yet. We need an effective pallet of solutions that should include an appropriate mix of vehicles powered by highly-efficient internal combustion engines, powered by batteries, and powered by hydrogen.

Number two, research on batteries for vehicles is a high-priority issue.

Number three, funding for vehicle on-board storage of hydrogen should continue.

Number four, without a developing infrastructure for hydrogen refueling, companies like ours are severely challenged to continue investments into hydrogen-powered vehicles.

And lastly, number five, to the extent possible, please allow research funding support for companies like ours that have made huge investments in manufacturing and jobs in the U.S., even though our global headquarters is not located in America.

The BMW group is comprised of Rolls Royce cars, BMW cars and motorcycles, MINI cars, and Hosmarna motorcycles, and we are the world's largest manufacturer of premium automobiles. In the United States about 8,000 people work directly for us in our offices, research facilities, and manufacturing plant. We have been a manufacturer in the USA since 1992, and our Spartanburg, South Carolina, plant has produced more than 170,000 vehicles in 2008, and we exported about 70 percent of the total production around the world. And this makes BMW the largest vehicle exporter in the United States.

In the year 2000, before many were taking CO₂ emissions seriously, BMW management conceived and implemented a company program called Efficient Dynamics to reduce CO₂ emissions and improve fuel economy, while at the same time preserving the ultimate driving machine performance our owners have come to expect. So far we have invested about \$1 billion in this Efficient Dynamics Program and equipped well over one million vehicles worldwide with this technology.

A main principle of Efficient Dynamics is that we develop and equip the entire vehicle fleet with improvements as quickly as possible. Rather than focus on one or two models for big improvements, we aim for step-by-step, fleet-wide improvements. Our innovations are time consuming and costly, but they deliver reliable benefits, and they trickle down into vehicles that everyone drives.

The point I would like to make here is that BMW as a premium auto manufacturer, as well as other premium auto manufacturers, have invested heavily in technology to improve fuel economy and reduce CO₂ and that the low-hanging fruit to get these improvements are gone. Research is vital to advance technology, and working with our suppliers and partners we develop systems that eventually make their way down to lower-priced cars and light trucks.

While the DOE has been a very good stimulator for innovation as far as we are concerned, it would be helpful to us as a heavy investor in the U.S. to be able to apply for and win DOE contracts on our own. Let me give some examples of technology that we are working on with partners to show the positive effect of DOE funding.

In a modern internal combustion engine only about one-third of the fossil fuel energy is used to drive the engine crankshaft. That means about two-thirds of the fuel's energy is lost by friction and heat in the exhaust and coolant. Now, hybrid vehicles use methods to recharge the battery when the vehicle is braking or coasting but not under acceleration. Since BMW is known as the ultimate driving machine, we are also focused on improving efficiency when the vehicle is accelerating and typically wasting significant heat energy from the exhaust.

So to recover some of this exhaust heat, BMW has been leading a pioneering effort to bring a thermo-electric generator to market. Now, this system is connected to the vehicle exhaust and uses the difference in temperature of the exhaust and air to create electric current to recharge the battery. So the waste heat is converted into electricity, and this could save perhaps up to 10 percent in fuel economy.

We also have a system called the turbo-steamer concept that also can extricate heat from the exhaust. This is more complicated and costly. However, the potential benefits are even greater than the thermal electric generator. So it would be very helpful, for example, if we could get DOE funding for this turbo-steamer project as well.

When comparing the technology of hydrogen power versus battery power, the similarities and differences must be considered. A similarity, for example, is that hydrogen is an energy carrier just like a battery. A battery is charged to store energy while water is split to make energy available as free hydrogen. A major difference is that hydrogen refueling can be performed in a few minutes, while a battery fast charge today takes several hours. While the electric grid provides limited infrastructure for charging a battery-electric vehicle, a far greater infrastructure is needed. Likewise, there is a very limited hydrogen refueling infrastructure, and a far-greater hydrogen refueling infrastructure is likewise needed.

Today's battery electric vehicle batteries are too large, too heavy, too limited in range, and far too expensive. There can be no debate on the merits of battery research, and we fully support efforts by the DOE to fund battery research. But doing this should not lead to the complete elimination of hydrogen storage funding. That would be very unfortunate. We need both.

BMW has partnered with U.S. companies to collaborate on projects involving storage of hydrogen for on-board vehicles, and we see hydrogen as playing an important role in the future as a means to become independent from fossil fuels.

And lastly, despite our 30 years of hydrogen-powered vehicle experience, we have an increasingly difficult challenge to justify further investments in hydrogen power without evidence that a hydrogen infrastructure is being developed.

And in conclusion, I would like to repeat the main points of my testimony. Please don't pick vehicle technology winners and losers yet. It is too early for that. We need a diversity. Research on batteries for vehicles is certainly a very high-priority issue. Funding for on-board storage of hydrogen should continue, and without a developing infrastructure of hydrogen for refueling, we have a difficult time continuing our investment in hydrogen-powered vehicles. And lastly, to the extent possible, please allow research funding for companies like ours that have made investments in manufacturing and jobs in the U.S., even though our global headquarters is not located in America.

Thank you for the opportunity to provide testimony, and I would be pleased to answer any questions.

[The prepared statement of Mr. Baloga follows:]

PREPARED STATEMENT OF THOMAS C. BALOGA

Chairman Baird, Ranking Member Inglis, and Members of the Committee. Thank you for the opportunity to provide testimony before your subcommittee on near-term priorities and future directions for the Vehicle Technologies Program within the US Department of Energy. It is a privilege to be here. My name is Tom Baloga and I am the Vice President, Engineering-US for BMW of North America, LLC. My key messages for the Subcommittee are:

1. Please don't pick technology winners or losers yet; we need an effective palette of solutions that should include an appropriate mix of vehicles powered by highly efficient internal combustion engines, powered by batteries, and powered by hydrogen.

2. Research on batteries for vehicles is a high priority issue.
3. Funding for vehicle on-board storage of hydrogen should continue.
4. Without a developing infrastructure for hydrogen refueling, companies like ours are severely challenged to continue investments into hydrogen-powered vehicles.
5. To the extent possible, please allow research funding support for companies like ours that have made investments in manufacturing and jobs in the U.S. even though our global headquarters is not located in America.

BMW Presence in America

The BMW Group, comprised of Rolls Royce cars, BMW cars and motorcycles, MINI, and Husqvarna motorcycles, is the world's largest manufacturer of premium automobiles. In the United States, about 8,000 people work directly for us in our offices, research facilities, and manufacturing plant. We have been a manufacturer in the USA since 1992. Our Spartanburg, SC plant produced more than 170,000 vehicles in 2008 and we exported about 70 percent of the total production around the world. This makes BMW the largest vehicle exporter in the United States.

We are investing \$1 billion to further our commitment to America by building an all-new assembly facility and thereby expanding the capacity at our Spartanburg plant by 50 percent. We've doubled the size of our NJ Headquarters by adding a state-of-the-art Engineering Center, Technical Training facility, and a new home for our Eastern Region. An independent study reported that our plant has already provided an additional 23,000 jobs in the US. When you combine all this with our distribution and dealer network, we are directly or indirectly responsible for close to 50,000 jobs in America. The United States is our largest market, and we are very happy to play a role in creating new jobs here and leading the global auto industry to innovate and promote sustainability.

Leadership in Sustainability Technology

Sustainability is the degree to which natural resources are conserved and environmental impact minimized. BMW has been a leader in sustainability technology for many years. This means that as a company, we have not only achieved continuous improvements in fleet fuel economy and CO₂ reductions, but we have also achieved significant improvements to minimize our impact on the environment. For example:

- The U.S. EPA awarded BMW's plant in Spartanburg, SC "Energy Partner of the Year in 2007" in recognition of BMW's implementation of one of the most ambitious landfill gas-to-energy projects in North America. The Spartanburg plant pipes in methane gas from a landfill ten miles away to supply about two thirds of its power needs. The amount of recovered energy could heat about 15,000 homes per year. Furthermore, methane is a "greenhouse gas" and removal of this emission from the landfill is a further benefit.
- The BMW Group has been named "the world's most sustainable automotive manufacturer" for four years in a row by the Dow Jones Sustainability World Index (DJSI World).

Leadership in Fuel Economy Improvement and CO₂ Reduction

- In its 2007 report for 1990–2005 results entitled "Automakers' Corporate Carbon Burdens" the Environmental Defense Fund identified BMW as the company that improved its U.S. average fleet fuel consumption by more than any other firm, reducing CO₂ emissions by 12.3 percent and improving fuel economy by 14 percent.
- In its August 2008 report for EU countries entitled "Reducing CO₂ Emissions from New Cars: A Study of Major Car Manufacturers' Progress in 2007" the European Federation for Transport and Environment concluded that "BMW is the carmaker that made by far the greatest year-on-year CO₂ and fuel efficiency improvement in 2007." Fleet CO₂ was reduced by 7.3 percent.

The Five Elements of BMW EfficientDynamics

In 2000, before many were taking CO₂ emissions seriously, BMW management conceived and implemented a company program called "EfficientDynamics" to reduce CO₂ emissions and improve fuel economy, while at the same time preserving the Ultimate Driving Machine performance our owners have come to expect. So far, we have invested about \$1 billion in this program and equipped well over one million vehicles worldwide with this technology. The results of this EfficientDynamics program can be directly correlated to the industry-leading reports from EDF and the

European Federation mentioned previously. The five elements of the BMW EfficientDynamics program are:

- Powertrain Optimization
- Energy Management with Hybridization
- Weight Reduction
- Aerodynamic Improvements
- Hydrogen Power

The multitude of leading-edge technologies that are part of the BMW EfficientDynamics philosophy are as diverse as they are innovative. From new fuel combustion technologies to lighter construction materials, low-friction components and improved aerodynamics all the way to comprehensive and highly sophisticated energy management. However, the aim of each of these innovations is the same: to deliver maximum driving pleasure from a minimum of fuel.

To achieve this aim, new engines have been developed: gasoline engines with lean-burn technology and High Precision Injection. Diesel engines with third-generation common rail injection and light-weight materials.

An Auto Start Stop function and Brake Energy Regeneration make more of every drop of fuel. Improved aerodynamics—such as an innovative air vent control—together with tires with reduced rolling resistance and a range of efficiency-enhancing modifications to the drivetrain all lead to the same result: more dynamic performance from less fuel.

To assist the Subcommittee with near-term priorities and future directions for the Vehicle Technologies Program within the U.S. DOE, I would like to briefly focus on Powertrain Optimization, Energy Management with Hybridization, and Hydrogen vs. Battery Electric Power, followed by a recommendation for expanding research collaboration to companies based outside of the USA.

Powertrain Optimization

This past December, BMW launched two new vehicle models equipped with clean diesel engines. The X5 diesel built in America and the 335d are available in all 50 States and use the latest clean diesel engine technology to meet even California's stringent emission requirements. In a modern internal combustion engine, only about one third of the fossil fuel energy is used to drive the engine crankshaft. This means that approximately two thirds of the fuel's energy is lost via friction plus engine heat into the exhaust and coolant. More efficient use of this lost energy is a high priority at BMW; we already use sophisticated engine management technology and turbo charging to extract as much energy as possible from the burned fuel, but we just recently announced something new at the Geneva Auto Show.

We will be launching a full hybrid X6 model built in the USA later this year so we are far along with hybrid technology. Hybrids use methods to recharge a battery when the vehicle is braking or coasting, but not under acceleration. Since BMW is known as the "Ultimate Driving Machine" we are also focused on EfficientDynamics when the vehicle is accelerating and typically wasting significant heat energy from the exhaust. To recover some of this exhaust heat, BMW has been leading a pioneering effort to bring a "thermoelectric generator" to market. The system is connected to the vehicle exhaust and using a material called Bismuth Telluride (plus other materials under investigation), the difference in temperature of the exhaust and ambient air can generate an electrical current to recharge the battery. We have reason to believe that under certain conditions of using this "Seebeck Effect" more than 10 percent savings in fuel use could be realized. Waste heat is converted into electricity stored in the battery that relieves the normal charging system and reduces fuel consumption. In operation, the exhaust gas is being further cooled as heat energy is extracted and, as expected, the higher the exhaust temperature such as in acceleration, the more electricity is produced. We hope to be able to bring this system to market in perhaps five years. This research was made possible through financial support of the DOE which we acknowledge and appreciate. We had been working on a "turbo-steamer" project to evaluate the potential for converting exhaust heat into steam to power a turbine and supply additional propulsion to the vehicle, and these concepts are mutually complementary. The turbo steamer concept is more complicated, but still worthwhile to investigate because the potential benefits in recaptured energy look significant and very promising.

It's important to note that we see the internal combustion engine itself available for high single digit percentage increases in efficiency, and we continue to actively research further improvements. Furthermore, extraction of exhaust heat is only one of many projects in process for powertrain optimization.

Energy Management with Hybridization

Hybridization means converting and storing some of the “moving” (kinetic) energy of the vehicle to electrical energy that can be used to charge the battery, power accessories or power the vehicle. Later this year, we will launch a full hybrid X6 model Sports Activity Vehicle built at our plant in South Carolina, then followed by a 7 Series mild hybrid sedan. For better understanding, a “full hybrid” can operate using only battery power; a “mild hybrid” uses a battery to provide a boost to save fuel, but cannot use a battery alone for propulsion. These models use hybrid technology that came from a consortium of partners working together in Troy, Michigan. The three partners BMW, Daimler, and GM collaborated, on the one hand, to developing a common shared technology, and on the other hand, to develop a unique application and integration of the technology into our own company vehicles based on our individual philosophies and technical needs. The partnership worked very well, and we are grateful to our partners.

Even before we launch our hybrid vehicles, BMW is using one hybrid principle, brake energy regeneration, to improve fuel economy and reduce CO₂ emissions. Today’s vehicles require much more electrical energy than older models, due to the much wider array of electric and electronic on-board comfort and safety systems. This energy is created by the alternator which converts the engine’s power output into electricity. In conventional systems, the alternator is permanently driven by a belt connected to the engine. A system we call BMW’s Brake Energy Regeneration operates differently: the alternator is activated only when you take your foot from the accelerator or apply the brake. The kinetic energy that would otherwise go to waste is now used efficiently, converted into electricity by the alternator and stored in the battery. Producing electricity in this highly efficient way delivers an additional advantage: when you apply the accelerator, the alternator is deactivated—so the full power of the engine can be directed to the drive wheels. Brake Energy Regeneration thus increases fuel efficiency while simultaneously enhancing driving dynamics. As an extra precaution, the Brake Energy Regeneration system monitors the level of battery charge and will, if necessary, continue to charge the battery even during acceleration to prevent a complete discharging of the battery.

We have many other technologies for saving fuel and reducing CO₂ and I would be pleased to forward this information to Members of the Subcommittee.

Hydrogen vs. Battery Electric Power

- Hydrogen has no carbon so hydrogen by itself will not generate air pollution.
- Hydrogen can be generated using clean and sustainable sources like hydro, wind, solar, and biomass sources.
- Hydrogen can be produced in this country and other locations away from troubled parts of the world.

Based on the above listed circumstances, BMW has worked to gain more than thirty years of experience with hydrogen powered automobiles. We have just completed a successful global “Hydrogen 7” Program in which 100 hydrogen powered BMW 7 Series cars were equipped to run on either gasoline or hydrogen. (A few cars equipped to run exclusively on hydrogen were also built in order to explore the state-of-the-art in emission reductions and exhaust measurements.)

These “bi-fuel” hydrogen/gasoline cars were very successful to demonstrate that a hydrogen-powered internal combustion engine can operate today, and in the bi-fuel configuration, can help bridge the gap until a hydrogen refueling infrastructure is available.

To expand on our battery powered vehicle knowledge, the BMW group has just launched a battery electric vehicle (BEV) program with approximately 500 battery electric “MINI E” cars. These cars are being deployed in the US (about 480) and in Germany to gain insight into this unique technology.

When comparing the technology of hydrogen power versus battery power, the similarities and differences must be considered. A similarity is for example that hydrogen is an energy carrier just like a battery. A battery is charged to store energy, while water is split to make energy available as free hydrogen. A major difference is that hydrogen refueling can be performed in a few minutes, while a battery “fast charge” today takes several hours.

While the current electric grid provides a limited infrastructure for charging a BEV, a far greater infrastructure is needed. Likewise, there is a very limited hydrogen refueling infrastructure, and a far greater hydrogen refueling infrastructure is needed.

While expanded infrastructures are needed, the critical challenge for the auto industry with both BEVs and hydrogen powered vehicles is in energy storage. *Fur-*

thermore, an infrastructure of BEV charging stations and hydrogen refueling are necessary if the auto industry is expected to continue to invest in these technologies.

Today's BEV batteries are too large, too heavy, too limited in range, and far too expensive. Our MINI E BEVs were changed from four-seaters to two-seaters because of the battery size and weight, and the effective range of the vehicles is relatively good, but only equivalent to approximately two gallons of diesel fuel. There can be no debate on the merits of battery research and we fully support efforts by the DOE to fund battery research, but doing this with the complete elimination of hydrogen storage funding would be very unfortunate. BMW has partnered with U.S. companies to collaborate on projects involving storage of hydrogen for use on-board vehicles and we see hydrogen as playing an important role in the future as a means to become independent from fossil fuels.

1. Hydrogen powered internal combustion engine vehicles consume air with nitrogen and thus are not 100 percent zero emissions vehicles, but they are virtually emissions-free.
2. Hydrogen powered internal combustion engine vehicles consume the surrounding air including methane, hydrocarbons, and other pollutants and exhaust water vapor you can drink and cleaner air than the air we breathe.
3. Hydrogen powered bi-fuel internal combustion engine vehicles can provide a critical bridge solution to getting a hydrogen infrastructure in place. Drivers can seamlessly select between super clean hydrogen power or fossil fuels as necessary to reach available gasoline or hydrogen refueling stations.
4. Hydrogen storage on-board is a critically important element for the success of hydrogen, and it is prudent to continue to invest in this technology for the future.

Despite our thirty years plus of hydrogen-powered vehicle experience, we have an increasingly difficult challenge to justify investments in hydrogen power without evidence that a hydrogen infrastructure is being developed.

Thank you for the opportunity to provide testimony to the U.S. House of Representatives Committee on Science and Technology, Subcommittee on Energy and Environment.

BIOGRAPHY FOR THOMAS C. BALOGA

Tom is responsible for U.S. engineering involving Environmental, Safety, Intelligent Transportation Systems, Product Development, and Product Analysis activities of the BMW Group. The BMW Group includes BMW, MINI, and Rolls Royce.

Prior to BMW, Tom was the owner and principal of INIT LLC, an innovation consulting firm, President of Britax Child Safety, Inc., Manager of Safety Engineering for Mercedes-Benz USA, and a Senior Test Engineer for Mack Trucks, Inc. He is the primary inventor on multiple U.S. and foreign patents.

Tom served on the Board of Directors for Public Safety Equipment, Code 3, and Kustom Signals.

Tom has degrees in Automotive Technology from The Pennsylvania College of Technology, and Mechanical Engineering from The Pennsylvania State University.

Chair BAIRD. Thank you, Mr. Baloga.
Dr. Johnson.

STATEMENT OF DR. JOHN H. JOHNSON, PRESIDENTIAL PROFESSOR OF MECHANICAL ENGINEERING, MICHIGAN TECHNOLOGICAL UNIVERSITY

Dr. JOHNSON. Chair Baird and Ranking Member Inglis, my name is John Johnson. I am a Presidential Professor of Mechanical Engineering at Michigan Technological University. My expertise is in diesel engines, including R&D management. After completing my Ph.D. degree I spent two years as a first lieutenant in the United States Army at the Tank Automotive Center in Warren, Michigan, managing engine research projects. I then worked as a chief engineer of an applied engine research at International Harvester, which is now Navistar. In 1970, I came to Michigan Tech. I was

chair of the committee that wrote this report in June, 2008, on the review of the 21st Century Truck Partnership.

The opinions I will give today are my personal ones, although they draw on the findings and recommendations in the report. I am also a member of the Academy's Committee on Light-Duty Fuel Economy and the Committee on Medium and Heavy-Duty Vehicle Fuel Economy.

The Committee on Medium- and Heavy-Duty Fuel Economy was formed based on a mandate that NHTSA, under Section 108 of the *Energy Independence and Security Act of 2007*, entered into an agreement with the National Academies to evaluate medium- and heavy-duty truck fuel economy. The Academy report must be completed by March of 2010. The legislation under Section 102 also mandates that NHTSA itself conduct a study on the fuel efficiency of commercial medium- and heavy-duty on-highway vehicles and work trucks, and two, mandates that NHTSA then conduct a rule-making to implement a commercial medium- and heavy-duty on-highway and work truck fuel efficiency improvement program.

Despite the many benefits of the partnership, including helping the engine industry meet the EPA 2007 particulate and 2010. NO_x standards, the program suffered from dwindling resources devoted to the program by DOE. Funds were about 87 million in fiscal year 2002, and decreased to 30 million in fiscal year 2008. This funding pattern does not reflect the number of productive R&D opportunities. It also does not reflect the economic weight of the industry.

In the 2002 economic census the truck transportation industry consisted of more than 112,698 separate establishments, with total revenues of 165 billion. These establishments employ 1,437,259 workers, who take home an annual payroll of 47 billion. This industry is made up of 10 major truck manufacturers, 10 trailer manufacturers, 18 refuse truck and five bus manufacturers and six major engine suppliers, along with over 20 major supplier companies that supply transmissions, cooling system components, turbochargers, brakes, tires, electrical and electronic components, hybrid systems, emission after-treatment systems, and other parts.

Because of the low-level of funding from DOE, the 21st Century Truck Partnership chose to focus its R&D effort on the Class 8, long-haul type of vehicle, which consumes 75 percent of the petroleum in the heavy- and medium-truck sector. It was forced to cancel many projects originally in the 21st Century Truck roadmap.

Federal, State, and local governments and commercial trucking firms such as utility and delivery operations that use medium-duty trucks are also interested in fuel economy of their vehicles since it also affects their operating costs. They want advanced technologies such as hybrid vehicles.

In light of the potential fuel economy regulations by NHTSA as required by Section 102 of the Energy Act, it is important that the Federal Government fund the DOE program at levels such as \$200 million per year with \$90 million per year for engine, emission control systems, and biodiesel fuels research. The program should be funded for five to ten years at this level so that the industry will have the technology in the 2015 to 2020 timeframe to meet potential fuel economy regulations.

Safety is an important part of the program with support in the past from DOE and DOT, with DOT providing the majority of the budget. As crash protection measures have not substantially reduced truck-related highway fatalities during the past decade, the main objective going forward will be to prevent crashes using crash avoidance technologies and in-vehicle communication systems. There is a need for 25 million per year for safety-related research, which should be designated for DOT by line item for the 21st Century Truck Partnership.

The next decade needs R&D programs to decrease medium- and heavy-duty truck petroleum fuel consumption by the use of advanced diesel engine and after-treatment technologies, advanced truck and trailer aerodynamic designs, and low-rolling-resistant tires. The use of hybrid systems for applications that have duty cycles that can reduce the fuel consumption, including advanced cooling systems and engine components that use less energy, light weighting of the vehicles and trailers so that more payload can be carried which reduces the fuel consumption in gallons per ton payload miles needed.

A major effort must be carried out to develop biodiesel fuels that meet ASTM specifications, are energy and greenhouse gas efficient in the production of the bio-component, and make good use of the land without compromising the food supply and the price of the fuel.

One of our findings on the management strategy and priority setting pointed out that the program operated as a virtual network of agencies and government labs with an unwieldy structure and budget process. This would be significantly improved if heavy-truck funds for EPA, DOE, and DOT were designated by line items that are directed at this program. I know that this is very difficult because each of these agencies go to different Congressional committees for their funds.

Thank you for giving me the opportunity to discuss with you the 21st Century Truck Partnership, and I also think the partnership would benefit in the future from an external, independent review as was done by the National Academies in their review of the 21st Century Truck Partnership.

[The prepared statement of Dr. Johnson follows:]

PREPARED STATEMENT OF JOHN H. JOHNSON

My name is John Johnson; I am a Presidential Professor of Mechanical Engineering at Michigan Technological University. My expertise is in diesel engines, including R&D management. After completing my Ph.D. degree, I spent two years as a 1st Lieutenant in the U.S. Army at the Tank-Automotive Center in Warren, Michigan managing engine research projects. I then worked as Chief Engineer of Applied Engine Research at International Harvester which is now Navistar. In 1970, I came to Michigan Technological University. I have participated in 12 different National Academies Committees since 1980. I was the Chair of the Committee that wrote the report published in June 2008 entitled "*Review of the 21st Century Truck Partnership*." The opinions I will give today are my personal ones although they draw on the findings and recommendations in the report. The first part of my testimony will give a brief review of the 21st Century Truck Partnership including the members of the Partnership and the approach used in our review—these figures came directly from the report. I am also a member of the Academies Committee on Light-Duty Vehicle Fuel Economy and the Committee on Medium- and Heavy-Duty Vehicle Fuel Economy.

The Committee on Medium- and Heavy-Duty Fuel Economy was formed based on the mandate that the National Highway Traffic Safety Administration (NHTSA), an

agency of the U.S. Department of Transportation, under Section 108 of the *Energy Independence and Security Act (EISA) of 2007*, enter into an agreement with the National Academies to evaluate medium- and heavy-duty truck fuel economy. The Academy report must be completed by March 2010. The legislation, under Section 102, also (1) mandates that NHTSA itself conduct a study on the fuel efficiency of commercial medium- and heavy-duty on highway vehicles and work trucks and (2) mandates that NHTSA then conduct a rule-making to implement a commercial medium- and heavy-duty on-highway and work-truck fuel efficiency improvement program.

Figure 1 reviews some important facts about the Partnership. It shows the history of the program, including Federal Agency, National laboratory, and industrial partner participants.

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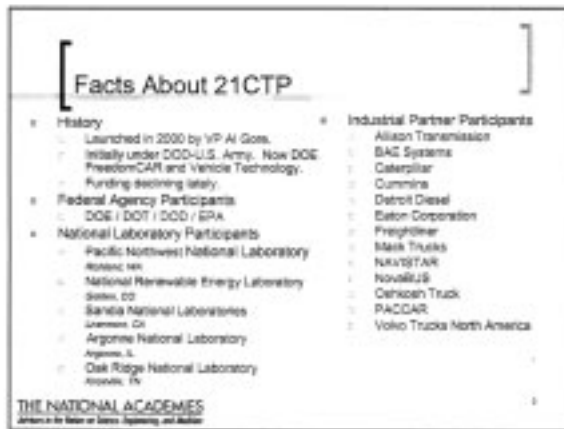


Figure 1

Figure 2 shows the DOE R&D funding for heavy and light vehicles in the years FY 03- FY 08.

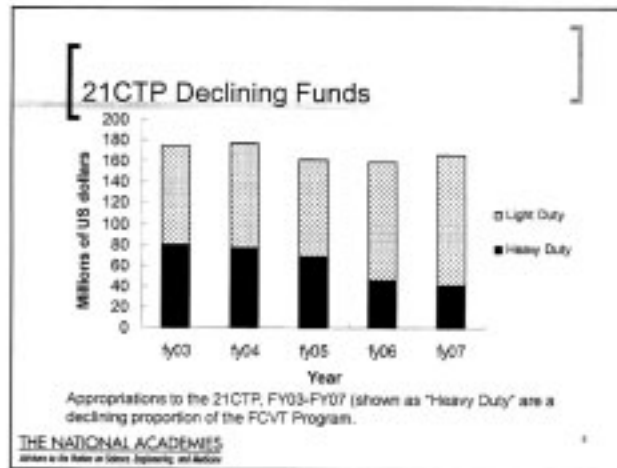


Figure 2

Figure 3 shows the 21st Century Partnership Strategic Approach to the Program.

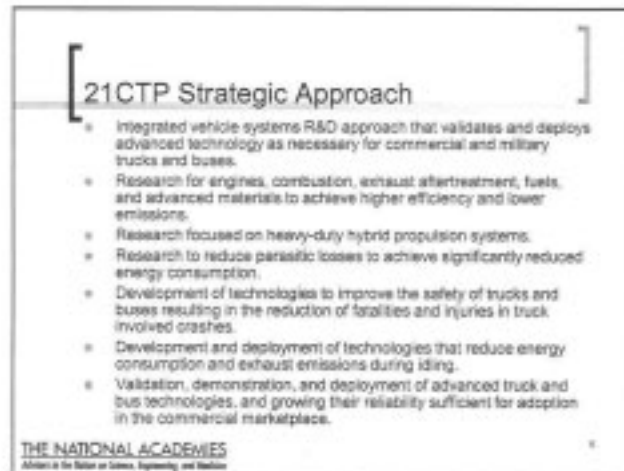


Figure 3

Figure 4 shows the committee activities that were undertaken to review the program – the meetings took place in the period from February through August 2007.

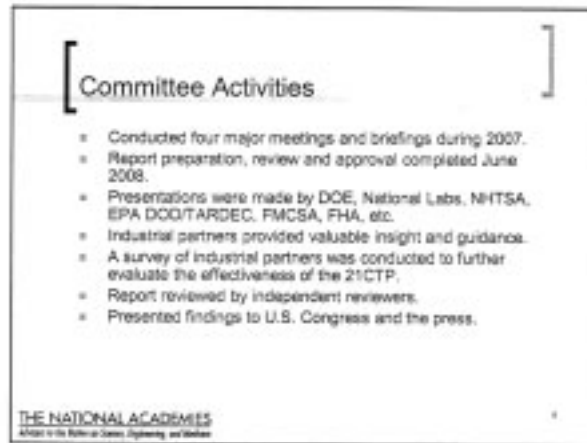


Figure 4

Figure 3 shows the 21st Century Partnership Strategic Approach to the Program.

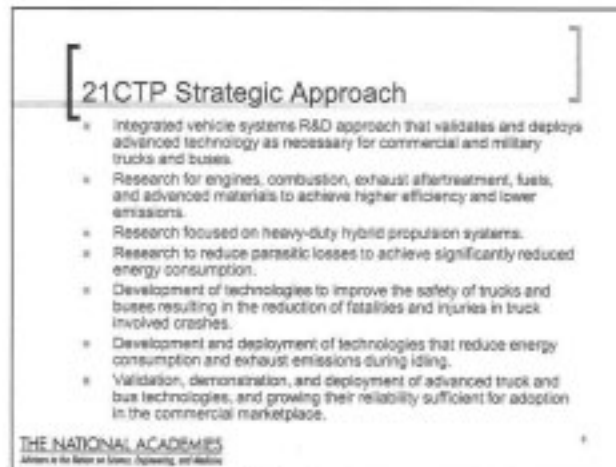


Figure 3

The staff members from the various committees dealing with energy in the House and Senate have copies of the report. I came to Congress in June 2008 to meet with several staff members of the Subcommittee and again March 5, 2009 to meet with a broader group of staff members from the various House and Senate committees.

Despite the many benefits of the Partnership, including helping the engine industry meet the EPA 2007 particulate and 2010 NO_x standards, the program suffered from the dwindling resources devoted to the program by DOE. Funds were about

\$87 million in FY 2002 and decreased to \$30 million in FY 2008. This funding pattern does not reflect the number of productive R&D opportunities.

It also does not reflect the economic weight of the industry. According to the report: In the 2002 Economic Census, "The truck transportation industry consisted of more than 112,698 separate establishments, with total revenues of \$165 billion. These establishments employ 1,437,259 workers, who take home an annual payroll of \$47 billion. Truck and bus manufacturing also account for a significant share of national income. According to the same census, light-truck and utility-vehicle manufacturers have total shipments of \$137 billion. Heavy-duty-truck manufacturing had sales of \$16 billion. Another way to look at the trucking industry's economic contribution is to compare the revenue from trucks with other sectors in the transportation industry, in which case trucks account for about one-fourth of the industry's total revenues."

This industry is made up of 10 major truck manufacturers, 10 trailer manufacturers, 18 refuse truck and five bus manufacturers, and six major engine suppliers along with over 20 major supplier companies that supply transmissions, cooling system components, turbochargers, brakes, tires, electrical and electronic components, hybrid systems, emission after-treatment systems, and other parts.

Because of the low level of funding from DOE, the 21st Century Truck Partnership chose to focus its R&D effort on the Class 8 long-haul type of vehicle, which consumes 75 percent of the petroleum in the heavy- and medium-truck sector. It was forced to cancel many projects originally in the 21CTP roadmap, including light-weighting vehicles, all-electric components on vehicles, aerodynamic modeling and design, and low rolling resistance tires. Federal, State, and local governments and commercial trucking firms, such as utility and delivery operations that use medium-duty trucks, are also interested in the fuel economy of their vehicles since it also affects their operating costs—they want advanced technology such as hybrid vehicles.

In light of the potential fuel economy regulations by NHTSA as required by Section 102 of EISA, it is important that the Federal Government fund the DOE program at levels such as \$200 million/year with \$90 million/year for engine, emission control systems, and biodiesel fuels research. The program should be funded for five to ten years at this level so that the industry will have the technology in the 2015–2020 timeframe to meet potential fuel economy regulations. Safety is an important part of the program with support in the past from DOE and DOT, with DOT providing the majority of the budget. As crash protection measures have not substantially reduced highway fatalities during the past decade, the main objective going forward will be to prevent crashes using crash avoidance technologies and in-vehicle communications systems. There is need for \$25 million per year for safety related research which should be designated for DOT by line item for the 21st Century Truck Partnership.

The next decade needs R&D programs to decrease medium- and heavy-duty truck petroleum fuel consumption by the use of advanced diesel engine and after-treatment technologies, advanced truck and trailer aerodynamic designs, and low rolling resistance tires. The use of hybrid systems in applications that have duty cycles that can reduce the fuel consumption, including advanced cooling systems and engine components that use less energy, light weighing of vehicles and trailers so that more payload can be carried which reduces the fuel consumption in gallons/ton of payload-miles are needed. A major effort must be carried out to develop biodiesel fuels that meet ASTM specifications, are energy and greenhouse gas efficient in the production of the bio component and make good use of the land without compromising the food supply and the price of food. It is important that the price differential between gasoline and diesel fuel does not increase more than the 60–70 cents per gallon that has existed in the past few years. Decreasing the truck petroleum fuel consumption with lower fuel consumption vehicles should help this diesel fuel market demand condition that now exists. More biodiesel fuel use should help decrease the demand for the petroleum fuel if the research program is aggressive.

One of our findings on the management strategy and priority setting pointed out that the program operated as a virtual network of agencies and government labs with an unwieldy structure and budget process. This would be significantly improved if heavy truck funds for EPA, DOE and DOT were designated by line items that are directed at this program. I know that this is very difficult because each of these agencies go to different Congressional committees for their funds. Our findings and recommendations also stated that there is a need for an Executive that crosses agencies to manage this program.

I am very supportive of a bill that commits the United States Government to a research program that results in the development of fuel efficient and safe heavy-duty trucks. The U.S. has always been a world leader in developing advanced

trucks—the heavy-duty diesel engine has always been cutting edge technology in durability, reliability, low fuel consumption, and now in 2010 low in emissions. This product development and manufacturing base in the U.S. must be maintained if we as a country are to be strong in the global economy. This industrial base is also important to the military, particularly to the Army and Marines since diesel powered vehicles and diesel fuels are critical elements of our ground forces. We must maintain this base which will happen with an aggressive R&D program in the commercial sector that includes maintaining National Laboratories and Universities as strong components in the program.

Thank you for giving me the opportunity to discuss with you the 21st Century Truck Partnership Program including my personal opinions of what is needed to maintain the United States as a world leader. I also think the Partnership would benefit in the future from an external, independent review, as was done by the National Academies in their Review of the 21st Century Truck Partnership in 2007–2008.

I would be happy to answer your questions.

BIOGRAPHY FOR JOHN H. JOHNSON

John H. Johnson is a presidential professor, Department of Mechanical Engineering–Engineering Mechanics, Michigan Technological University (MTU). He is a fellow of the Society of Automotive Engineers and the American Society of Mechanical Engineers. His experience spans a wide range of analysis and experimental work related to advanced engine concepts, emissions studies, fuel systems, and engine simulation. Prior to joining the MTU Department of Mechanical Engineering–Engineering Mechanics, he was a project engineer for U.S. Army Tank Automotive Center, and Chief Engineer, Applied Engine Research, International Harvester Co. John served as Chair of the MTU Mechanical Engineering–Engineering Mechanics Department from 1986–93. He has served on many committees related to engine technology, engine emissions, and health effects with the Society of Automotive Engineers, the National Research Council (NRC), the Combustion Institute, the Health Effects Institute, and the Environmental Protection Agency. He consults to a number of government and private sector institutions. In particular, he served on the NRC Committee on Fuel Economy of Automobiles and Light Trucks, the Committee on the Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards, the Committee on Advanced Automotive Technologies Plan, and was Chair, Committee on Review of DOE’s Office of Heavy Vehicle Technologies. He received his Ph.D. in mechanical engineering from the University of Wisconsin.

Dr. Johnson served on the SAE Board of Directors from 1982–85. He was the editor of seven *Progress in Technology* books on emissions. Over 100 SAE papers have been authored by Dr. Johnson. He received the SAE Arch T. Colwell Merit Award (outstanding paper—emphasis on the originality of the contribution as well as the excellence of the presentation) in 1983 and 1994. In 1993, he and his research colleagues received the SAE Horning Memorial Award, which was given in recognition of distinguished active research in diesel emissions to the better mutual adaptation of fuels and engines. In 1998, he and his doctoral student received the SAE Myers Awards for Outstanding Student paper. Dr. Johnson has been a member of the SAE Engineering Activity Board–Publications Advisory Committee (PAC) from 1975–1987 and the Chair from 1982–87. He was a member of the SAE Technical Communications Committee, which replaced the PAC, from 1987 to 2004. In 1988, he received the SAE Forest R. McFarland Award in recognition of serving with dedication as Chair of the PAC. From 1990–2000 he was Editor-in-Chief of the SAE Transactions Editors Committee and in 2000 he received the SAE Certificate of Appreciation for this leadership effort.

In 2002, the American Society of Mechanical Engineers’ honored Dr. Johnson with the Soichiro Honda Medal. He was recognized with this medal for advancing the understanding of vehicle cooling problems and research investigations into the origin of diesel exhaust pollutants and their impact on human health. Dr. Johnson has authored over 200 papers and reports and holds one patent.

Chair BAIRD. Dr. Johnson, thanks for your testimony, and thanks for your role on producing that report. We too rarely thank people who devote so much time to such things, and they are very, very helpful to us. Thank you.

And we understand—I am not sure we all do understand that. We are grateful on this committee and thank you very much. And

sometimes they aren't even paid for travel. When the Transportation Commission after the last Transportation Bill ran out of funds, they did it on their own money.

Mr. Greszler.

STATEMENT OF MR. ANTHONY GRESZLER, VICE PRESIDENT OF GOVERNMENT AND INDUSTRY RELATIONS, VOLVO POWERTRAIN NORTH AMERICA

Mr. GRESZLER. Thanks, Chair Baird, Ranking Member Inglis, thank you for the opportunity to appear today. I am Vice President for Government and Industry Relations with Volvo Powertrain North America in Hagerstown, Maryland, in Congressman Bartlett's district, and we are part of Volvo Group North America, which is not cars. Our divisions are truck divisions here include Mack Truck, Volvo Trucks, and Nissan Diesel truck brands here in the United States. I am speaking to you today on behalf of the industry representatives of the 21st Century Truck Partnership.

Twenty-one CTP is uniquely structured to coordinate efforts to improve the efficiency, emissions, and safety of Class 3 to 8 commercial trucks and buses. Our members include original equipment manufacturers, diesel engine manufacturers, major component suppliers, and a number of U.S. Government agencies.

Member companies are all multi-national with major U.S.-based research and development activities. Products from this group of companies consume over 30 percent of U.S. motor fuel and heavily influence global motor fuel consumption as well. Smaller suppliers can gain access to the 21 CTP Programs by working through any of the partner companies.

Our objective is to assure sustainable, cost-effective freight transport in an environment of limited petroleum supply and carbon emissions constraint. This means we need technology development plus related infrastructure and policy enablers to greatly improve vehicle and freight system efficiency and to develop low carbon fuel sources.

Requirements for heavy-duty vehicles are markedly different from light duty, and they require unique solutions. Furthermore, the demand for freight movement is directly tied to our economic growth, and it is projected to grow at two to two and a half percent over the next 20 years per year. In fact, recent DOE projections show that if light-duty fuel use targets are met and heavy-duty trends continue, that heavy-duty fuel use would actually exceed light duty by 2040. These facts demand a major focus on efficient freight movement combining strong government and industry efforts.

Federal support for commercial truck technology during the past few years has focused mainly on vehicle components and sub-systems. This has generated encouraging results in laboratory demonstrations; however, development should now focus on technology that can be effectively deployed in real vehicle applications. We propose a strong emphasis on design for vehicle integration and in-use demonstration.

At 42 percent peak thermal efficiency, heavy-duty diesel engines are already the most efficient mobile energy converters in common use. Through joint R&D programs with the Department of Energy,

the industry has already demonstrated a capability of an additional eight points of improvement in peak thermal efficiency in lab testing. The real challenge, however, is to accomplish this in a truck with the emissions, operational, and vehicle constraints and in a fully-representative drive cycle. We strongly support public and private partnership for such a demonstration program.

We also need to find ways to achieve 2010, emissions at lower cost and with improved fuel efficiency, requiring a continuing focus on in-cylinder emissions and on exhaust after treatment.

Hybrid powertrains can offer fuel savings in stop-and-go applications in the range 30 to 50 percent. However, the primary reasons to hybridize the Class A long-haul vehicles are to reduce idle time by using hybrid energy, reduce fuel use through electrification of components, and energy management during traffic-induced speed variation and in rolling terrain. Research and development is required to fully realize the potential of an integrated electric hybrid powertrain. Longer life and less expensive energy storage systems are required. Working with organizations like the Hybrid Truck Users Forum can accelerate technology development, and in fact, discussions are already underway with HTUF regarding future industry forums.

At 65 miles per hour, aerodynamic drag is typically more than 50 percent of the total road load on a heavy truck. Heavy vehicle aerodynamic development has been focused on the tractor, where manufacturers compete vigorously on aerodynamic performance and fuel economy. However, enormous opportunities exist in improving trailer aerodynamics and further opportunities exist through optimization of the aero performance of the tractor and trailer together, offering up to 12 percent improvement in aerodynamic losses, and further benefits can be realized by aerodynamic trailer treatments if these designs can overcome the issues of durability, costs, and operability.

Cost-effective low carbon fuels and compatible engines will be necessary building on work already done in biofuels.

In conclusion, the heavy-duty vehicle industry is a small base of companies with a huge impact on petroleum consumption and our economic growth. Despite this, there has been minimal federal investment to address these many opportunities. We believe that \$200 million annually in federal funding is required to support these initiatives. The 21st Century Truck Partnership is the only forum in which the relevant companies come together, and we recommend that 21 CTP serve as the focal point to create a long-term vision for the future of commercial vehicle technology.

Thank you.

[The prepared statement of Mr. Greszler follows:]

PREPARED STATEMENT OF ANTHONY GRESZLER

Chairman Baird, Ranking Member Inglis, thank you for the opportunity to appear today. My name is Anthony Greszler. I am the Vice President for Government and Industry Relations with Volvo Powertrain North America in Hagerstown, Maryland, a part of Volvo Group North America, including Mack, Volvo, and Nissan Diesel Truck brands in the U.S. I am currently serving on the NAS "Committee for a Study of Potential Energy Savings and Greenhouse Gas Reductions from Transportation" and on the Transportation Research Board Special Task Force on Climate Change & Energy. I am speaking to you today on behalf of the industry representatives of the 21st Century Truck Partnership.

Background and Purpose

The 21st Century Truck Program (21CTP) is uniquely structured to coordinate efforts to improve the efficiency, emissions, and safety of Class 3 to 8 commercial trucks and buses. 21CTP members include original equipment manufacturers, diesel engine manufacturers, major component suppliers and a number of U.S. Government agencies. 21CTP member companies are all multi-national with major U.S.-based research and development activities. Products from this group of companies are widely used and not only consume over 30 percent of the U.S. motor fuel, but also heavily influence global motor fuel consumption. 21CTP also provides a forum for small suppliers to gain access to major R&D programs by working through any of the partner companies.

As heavy vehicle and component suppliers our objective is to assure sustainable, cost effective freight transport in an environment of limited petroleum supply and carbon emissions constraint. This means we need technology development plus related infrastructure and policy enablers to greatly improve vehicle and freight system efficiency while also developing low-carbon, non-petroleum fuel sources.

Requirements for heavy duty vehicles are markedly different from light duty, and require unique solutions. Furthermore, the demand for freight movement is directly tied to economic growth and is projected to grow at two to two and a half percent for the next 20 years. Recent DOE projections show that, if light duty fuel use targets are met and heavy duty trends continue, HD fuel use will exceed LD by 2040. These facts demand a major focus on efficient freight movement—combining strong government and industry efforts—comparable to the effort on light duty over the past decades.

Heavy Truck Technology Development Needs

1. Vehicle Integration and Demonstration

The small amount of federal support for commercial truck technology during the past few years has been focused on vehicle components and sub-systems. While this has generated encouraging results in laboratory demonstrations, the next development should focus on technology that can be effectively deployed in real vehicle applications. **Going forward, we propose a strong emphasis on initial design for vehicle integration and final in-use demonstration which meets emissions, safety, and operational requirements.**

2. Engine Technology

At 42 percent peak thermal efficiency, heavy-duty diesel engines are already the most efficient mobile energy converters in common use. In addition, through joint R&D programs with the Department of Energy, the industry has already demonstrated the capability for an additional eight (8) percentage points of improvement in peak thermal efficiency in lab testing. The real challenge however, is to accomplish this in a truck within the emissions, operational, and vehicle constraints in a fully representative drive cycle. **We strongly support public—private partnership for a demonstration program to support such an initiative.**

Current public-private partnership was instrumental in the successful launch of 2007 emissions-compliant Heavy-Duty Engines while maintaining fuel efficiency. Those engines are the basis for upcoming 2010 emissions products which will deliver near zero emissions. Although we do not envision further tightening of criteria emissions, we do need to find ways to achieve 2010 emission levels at lower cost and with improved fuel efficiency. This requires a continuing focus on both in-cylinder emissions reduction and on exhaust after-treatment to reduce back pressure, size, weight, and cost.

3. Heavy-Duty Hybrid, Electrification & Reduced Idle Solutions

Hybrid Powertrains can offer significant fuel savings in stop-and-go applications. In fact, several medium- and heavy-duty “Stop-and-Go” vocations have reported fuel savings in the range of 30–50 percent with both electric and hydraulic hybrid powertrains. The primary reasons to hybridize a Class 8 on-highway powertrain are three-fold: 1) reduced idle time through the hybrid energy storage and use of electric auxiliaries; 2) reduced fuel use through electrification of components—thereby, improving efficiency; and 3) reduced fuel usage during cruise through energy management with traffic induced speed variation and in rolling terrain. Research and development is required to fully realize the potential of an integrated Electric Hybrid Powertrain with Electrified Auxiliaries. In addition, longer life and less expensive energy storage systems are also required to complete this package. Working with industry organizations like the Hybrid Truck Users Forum (HTUF) can accelerate

technology development, provided adequate funding is achieved. In fact, discussions are already underway with HTUF regarding future industry forums.

4. Truck and Trailer Aerodynamics

At 65 mph, aerodynamic drag is typically more than 50 percent of the total road load on a heavy truck. The tractor and trailer operate as an aerodynamic system with strong interactions between the front (tractor) and rear (trailer) parts of the system. Heavy vehicle aerodynamic development has focused on the front of the system where tractor manufacturers compete vigorously on aerodynamic performance and fuel economy. However, enormous opportunity exists in improving trailer aerodynamics and further opportunity exists through optimization of the aero performance of the tractor and trailer together because the quality of the airflow delivered from the tractor to the trailer has a significant performance impact on trailer aerodynamic devices offering up to 12 percent improvement in aerodynamic losses. Further benefits of another 10–15 percent can be realized by aerodynamic trailer treatments, if the designs can overcome issues of durability, cost and operability.

5. Fuels

Vehicular improvements alone will not achieve the full potential for fuel and greenhouse gas savings. Cost-effective changes to fuels and to vehicle usage need to be considered. Vehicle research and development will be necessary to take full advantage of some improvements. Investigations need to be conducted that build upon work already done in biofuels, natural gas, hydrogen and other alternative fuels. This is only possible if we: (1) Ensure that fuel standards are written to support optimal engine performance; (2) Ensure that fuels meets the appropriate standards; and (3) Provide the necessary fuel infrastructure.

Fuel Efficiency Assessment

There will be a need for vehicle fuel efficiency assessment and accounting as we seek to minimize fuel use and CO₂ emissions. With the tremendous variation in vehicle specifications, this will require a fuel efficiency model accepted by industry, end-users, and government agencies. The model should be verified by testing on typical vehicles while allowing for simulated results for variations.

In Conclusion:

The heavy-duty vehicle industry is comprised of a small base of companies with a huge impact on current and future petroleum consumption as well as our nation's economic growth. Despite the critical need to deal with trucking industry challenges, there has been minimal federal investment to address many untapped opportunities. We believe that \$200 million annually in federal funding is required to support these initiatives. **The 21st Century Truck Partnership is the only forum in which the relevant companies come together.** Given the significant technical challenges in developing a fully integrated truck that optimizes all of the aforementioned characteristics, it is essential that the industry has strong strategic alliances and significant resource support from the appropriate federal agencies. To accomplish these objectives, **we recommend that 21CTP serve as a focal point to create a longer-term vision for the future of commercial vehicle technology.**

21st Century Truck Partnership member companies

Allison Transmission, Inc.
BAE Systems
Caterpillar Inc.
Cummins Inc.
Daimler Trucks North America LLC
Detroit Diesel Corporation
Eaton Corporation
Freightliner Trucks
Mack Trucks, Inc.
Navistar, Inc.
PACCAR Inc.
Volvo Trucks North America

BIOGRAPHY FOR ANTHONY GRESZLER

**Vice President Government and Industry Relations
Volvo Powertrain North America**

Education

Case Western Reserve University, Cleveland, Ohio

BS, Mechanical Engr, 1972

MS, Mechanical Engr, 1976

Background and experience

Mr. Greszler has been involved with diesel engine design and development since 1977, with experience in diesel mechanical systems, cooling, lubrication, performance development, emissions, controls, complete vehicle powertrains, and advanced concepts. He has also been involved with heavy-duty natural gas engines and other alternative fuels, particularly DME.

From 1977–2001 he was with Cummins Engine Co. responsible for design and development of heavy-duty diesel engines, including two years in Europe on N14 and L10 engines and eight years as L10 & M11 Chief Engineer, including on-highway and off-highway applications.

In 2001, he became Vice President, Engineering for Volvo Powertrain, North America with responsibility for engine development for Mack Trucks and Volvo Trucks North America, including Mack ETECH, ASET, and E7 natural gas engine, support for Volvo D12 in North America, and development for future North American engines including U.S. 2007 and 2010 emissions. In 2005, he took responsibility for Advanced Engineering for Engines and Vehicle Propulsion with focus on diesel combustion/emissions, hybrid propulsion, advanced transmissions, and alternative fuels. Currently, he is focusing on CO₂ mitigation from road freight transport. Other activities include serving as an officer of the Engine Manufacturers Association, member-Transportation Research Board Special Task Force on Climate Change and Energy, and National Academy of Science “Committee for Potential Energy Savings and Green House Gas Reduction from Transportation.”

Volvo Powertrain, a division of Volvo AB, is responsible to supply engine, transmission, and drivetrain components to all Volvo divisions including Volvo Trucks, Mack Trucks, Renault VI, Nissan Diesel, Volvo Construction, Volvo Penta, and Volvo Bus. Volvo Powertrain is one of the world’s largest suppliers of 9–16 liter diesel engines.

DISCUSSION

Chair BAIRD. Thank you all for fascinating testimony, and a number of issues come to mind.

I will recognize myself for five minutes first, and then we will proceed in alternative order as is our custom here.

DOE’S RESPONSE TO RECOMMENDATIONS

Mr. Chalk, there is a number of—as we listen to the recommendations of the folks from industry, they offer a number of recommendations and observations. I want to ask you first, what are you doing to take into account, what is the agency doing to take into account the kind of recommendations we have just heard?

And then I will reverse that a little bit and ask the industry, how well do you think that is working, and how can it be made better?

Mr. CHALK. Thank you. A lot of the recommendations you heard this morning came directly from the National Research Council report, which the Department of Energy asked for, and we do this on the automotive and the truck side so that we can make our program better. So in general we concur with all the recommendations in the report.

There is some tension in some areas. When we have a small amount of money to work with, you know, we do a top-down systems approach. That really cuts down on or possibly defrays some of the component-level work that we could do that is more the traditional role of the government to enable any long-term research.

So we try to balance that, but we will incorporate the recommendation to do a system demonstration of the 50 percent that includes, you know, the after treatment and penalties associated with regenerating the after treatment, if it is a particular filter, all the other system recommendations that were incorporated and try to do that demonstration and prove that that is, in fact, possible, which is a significant accomplishment of the program to go from 42 to 50 percent.

We are also reconsidering the budget there. We have opportunity on the Recovery Act. DOE has discretionary funding, so we will relook at the heavy duty to make sure that our budget is commensurate with the problems to be solved in terms of oil dependence and climate change, and that can be done in a timeframe that matters in terms of addressing those issues. And we have opportunity, of course, now in formulating our fiscal year 2010 budget to make those adjustments as well and consider the NRC recommendations.

The swing has been there because as mentioned, you know, light-duty, highway vehicles are three times heavy duty. So we really focus on the lion's share of the problem so to speak, but as I said in my testimony, the trends are, and it has been mentioned here, that while light duty is flat and we can maybe decrease that a lot if we make good gains there, the heavy duty is actually increasing. So we have to look at that and see what gains could be made, and I think that systems analysis will help us do that. We will know how much more we can get out of thermal efficiency, the engine, how much more we can get aerodynamics.

FUNDING FROM THE RECOVERY ACT AND PRIVATE PARTNERSHIPS

Chair BAIRD. Let me—okay. Thank you.

A couple of issues I heard that I want to make sure we have a chance to elaborate on, I appreciate the input. One is this issue of private partnership. Mr. Baloga, you mentioned it. I think Dr. Clay and others may have mentioned it. The ability of private entities—Mr. Baloga, talk to us a little bit about that. It sounded like you were saying you would like the ability, you have got some expertise in your firm, you would like the ability to compete for some grants. Is it your experience that that is precluded or basically is all the research being done in-house and not as collaborative as you would like to see it or—

Mr. BALOGA. Well, what we would like to be able to do is bid on contracts for cooperative research on our own. Right now we do that with partners, and the DOE has been very accommodating to different projects; however, we need to partner with someone who is themselves able to apply for the contract. And that puts limitations—

Chair BAIRD. Is that because of domestic versus international ownership?

Mr. BALOGA. Yes.

Chair BAIRD. That is the issue? Okay.

Mr. BALOGA. Yes.

Chair BAIRD. And I think Mr. Inglis is going to follow up on that a little bit—

Mr. BALOGA. Right.

Chair BAIRD.—so there is going to be a fair bit of money in the stimulus package, and I am going to ask each of you if you could invest that money, how would you invest it?

Dr. JOHNSON. I will just work my way—I mean, and I am going to ask you to do this in, not just in the interest of your own industry but in the interest of the country. So if you—looking objectively what would you do?

Dr. JOHNSON. The truck component is extremely important, and as I mentioned in my testimony, the industry is very diverse, and they are not as politically visible as the automotive industry or the car and light truck. And diesel engine technology is really important. It is the heart of the truck. Diesel engines are most efficient as Tony mentioned, and hybrids are very important, too, and I think they need further stimulus. There is a lot of difficulty with the batteries and storage as Tony talked about because of these larger vehicles, and they need more, different storage capacity maybe than a plug-in hybrid. So—

Chair BAIRD. Mr. Greszler.

Mr. GRESZLER. Yeah. Thank you. First of all, we strongly support the idea of integrating technologies. We think that is one of the core things that has been lacking in the previous programs, to make sure the whole technology package works together in a vehicle and meets emissions as well as the operational requirements in a real duty cycle. And we greatly appreciate the new emphasis the DOE is now placing on that.

As far as specific technologies, there continue to be a need for more in-cylinder combustion work, certainly waste heat recovery, which Mr. Baloga mentioned, but that is—we are well on the way with waste heat recovery evaluations in heavy duty, but, again, it is difficult to integrate that into a truck with a cooling requirement. So we have to be careful.

Hybridization and in particular, long-haul hybridization, which will be a different kind of a technology than what you see in light duty because it is not so much stop and go. It is more dealing with managing the duty cycle and the energy use in the vehicle, and we need different kinds of batteries, we need particularly high-energy capability because we have to restore and utilize energy at a very high rate.

So that is one of the big factors that we deal with. So there are specific areas that we think make a lot of sense, sir. Thank you.

Chair BAIRD. Dr. Clay.

Dr. CLAY. I would like to speak to the portion of the stimulus that recognizes the importance of science investment. There is tremendous funding provided in the Recovery Act for increases in science investment, and I think there are opportunities for powerful breakthroughs that we can direct some of that science funding to the so-called Pasteur's quadrant, where we are looking at user-driven science.

So I think in this particular area with vehicle technologies there are tremendous opportunities and very exciting ways we could apply that. So potential breakthrough game changers that we could use that kind of science funding and linkages between the science and the applied energy programs like the Vehicle Technologies Program could include things like combustion research, where we

would be able to use our tremendous user facilities at our national laboratories for breakthroughs in optimizing combustion research. And also things like the advances in material science and nanotechnology to revisit some of the battery technologies that the Department of Energy previously supported in past decades but hit roadblocks. And with 20 years of advances in material science and nanotechnology, I think it would be very exciting to use some of that funding to revisit those chemistries and to see if some of those roadblocks might not be able to be overcome.

Chair BAIRD. Thank you. My time has expired now. I will recognize my colleague. I want to also acknowledge the presence of Mr. Davis, Ms. Edwards, and Ms. Woolsey who have joined us as well. And I see Mr. Bilbray is here and Mr. Bartlett. Dr. Bartlett, good to see you as well.

Mr. Inglis.

Mr. INGLIS. Thank you, Mr. Chair.

INNOVATION AND JOB CREATION

Mr. Baloga, it is impressive that I learned this morning that 70 percent of the production from the Spartanburg facility is export bound. It is also tremendously impressive that there are 5,000 employees, about 5,000 at the Spartanburg plant, 17,000 employees in the supplier network and the region. So it is consistent with what you were saying about the importance of not disfavoring an international company in research projects.

Might you describe some of those impediments so that we could understand better what we could do to remove those impediments? Because obviously for South Carolina, which is now the number two unemployment state in the country, and the place where your plant is actually higher unemployment than the State average. Were it not for BMW we would be in a world of hurt more than we are hurting now.

Mr. BALOGA. Well, thank you, Mr. Inglis.

We certainly have a lot of innovation to offer, and as a premium manufacturer obviously we can charge a higher price for technology, and that is really where breakthroughs take place. If you look at going all the way back in safety technology or emissions technology, the premium segment of the auto industry is where the major breakthroughs occur because of the funding aspect of it to pay for this technology.

So we really have a lot to offer. If we develop it on our own, then we put it in our vehicles, and it eventually trickles down into the mainstream. Whereas by partnering with companies in the U.S., we are able to get DOE funding and other government funding contracts for this technology, and eventually it makes its way into production and is widespread throughout the industry.

But if we could get the funding directly, we would be able to more quickly get this innovation into the mainstream and into production. What happens is there is actually a delay. We have to pick an appropriate partner, we have to go through the process, make sure the partner's correct, make sure we have all of the I's dotted and T's crossed. And this investment of resources really slows down the whole project. So if there was a way that we could directly bid for contracts and so forth, now, of course, the innovation that

comes out of that is property of the contract, and it is available. There are no secrets when it is a government contract. So this information gets shared very quickly.

So I would say that this: by enabling this to happen with a company like ours that has made a huge investment and just so happens to have a global headquarters outside the U.S., this would actually bring the technology faster to the forefront, bring it faster into the mainstream vehicles, and that is something we would like to happen.

Mr. INGLIS. You know, it is interesting. You mentioned that the premium vehicles have been the ones that have caused the breakthroughs, which makes sense. I hadn't thought about it until you said it, but it makes sense because there is some opportunity to improve and a customer who is made willing to pay for that improvement.

Mr. BALOGA. Exactly.

Mr. INGLIS. By analogy, something this committee is getting used to hearing from me is, you know, as long as the externalities aren't attached to the price of gasoline, it is the same thing. Right? I mean, if we are right on this margin with unrecognized externalities associated with gasoline, if you recognized them and attached those—internalized those externals, then suddenly the economics change, and everybody sort of becomes more of a premium manufacturer at that point because then you are saying, oh, this stuff is pretty expensive, this gasoline, when you attach the national security cost, for example, to it. Then suddenly all kinds of innovation starts becoming possible. A little bit like the premium brand. I hadn't really thought about that. So that is a helpful thing this morning.

AVOIDING PICKING WINNERS AND LOSERS

How—somebody tell me how you, how we avoid picking winners and losers. Anytime we fund something, we are sort of picking a winner. So, for example, Dr. Clay didn't like it very much, but the H Prize we tried to do, that was an attempt to—for us to fund something. It favors hydrogen over something else.

How do you avoid doing that? Anybody got any suggestion about how to avoid winners and losers? Dr. Clay.

Dr. CLAY. Thank you, Congressman. I wanted to say thank you for mentioning the H Prize. I wanted to say, you know, the Alliance supports a diversity of technologies, and I think it is to the interest of the country and the industry to have as many innovative tools in the toolbox as we can to try to get that kind of research. And the beauty of the Prize Authority as a general tool is that it is able to leverage a tremendous amount of private investment, and it allows a breadth of entrance and ideas that you can't get through a formal RFP process.

So I do want to say that I, you know, personally and in my former capacity, supported the goal of the H Prize and supported the idea of hydrogen technology. Our fear at the time was that by making it so specific to hydrogen that we might actually inadvertently discourage using that Prize Authority for other programs. I think that with the new Administration and the comments that Secretary Chu made before this committee, that that is no longer

a concern, the idea of using innovative ideas like Prize Authority is something that will become internalized to the Department of Energy going forward.

And so just hopeful that we will see a successful H Prize going forward.

Mr. INGLIS. And maybe later in another round we can talk about just how do you avoid this winners and losers thing. I don't know how you do it other than an elegant price signal. If you send a price signal through the economy, then you don't have to worry about picking winners and losers.

We will come back to that, Mr. Chair.

Chair BAIRD. Thank you, Mr. Inglis. I would just say I think based on what we know about global overheating and ocean acidification, I think we have to pick some losers. The losers are those that pollute the planet. The winners are those that pollute less, and we do need to pick some losers at the very least, and I would say fossil fuel-based consumption at some point has to be a loser in favor of things that don't create climate overheating and acidify the ocean and kill this planet.

So Mr. Tonko.

Mr. TONKO. Thank you.

INDUSTRY FUNDING LEVELS AND VIABILITY

Ms. Clay, Dr. Clay, the investment in R&D that you cited was, I think, the year 2006 to '07 was an increase of eight percent. Can you chart that since '07, forward? Is it as strong an increase?

Dr. CLAY. Those—Congressman, those numbers are reported to the National Science Foundation that does a compilation. I believe the numbers for 2008, are not yet compiled.

I think it is difficult to say given the economic downturn whether the industry is. I simply don't know the answer to whether the industry maintained that funding level. I can say that the industry is as committed philosophically going forward as to developing advanced technologies, and so given the availability of resources but that you will see that level or that level of commitment going forward from the industry.

Mr. TONKO. And can we track it backward from '06, to '96? Was there a steep curve of R&D investment?

Dr. CLAY. Congressman, I am actually, I am not certain what the trend is. I would be happy to find out and give you that information.

Mr. TONKO. It seems to me that the secret here to get an energy efficient vehicle, be it our cars or our trucking industry in sync with what consumers now want, we need to ramp up significantly the R&D investment.

And I would ask is your interpretations of where the weakness might lie, is it with industry or government infusion of R&D investment?

Dr. CLAY. I think actually this ties nicely back to, unfortunately Congressman Inglis had to step out, but I think that this ties nicely back into his point about market signals. I think that one of the main drivers for investment in advanced technology is a certainty that that technology has a reasonable chance of competing with the entrenched technologies. So with the volatility of gas prices that we

have seen, it is difficult for investors or would-be investors in things like advanced biofuels or in battery technology, it is difficult for them to run the numbers forward and know whether their investments are likely to pay off with marketable vehicles.

If we had greater certainty in gasoline prices, if we knew that they were to stay let us say above the \$4 mark that we hit last summer, that would send a very strong signal to the investment community that the alternative fuel vehicle technologies would find acceptance in the marketplace.

And so one policy option for driving technologies into the marketplace is to provide those strong market signals.

Mr. TONKO. Is it just a function, though, of gasoline prices, or is it a function of cleaning the environment?

Dr. CLAY. Well, I believe that the way that you can get to that goal of cleaning the environment is by driving the market signals, because anything that you do to drive the market signals for petroleum will encourage consumers to buy more fuel-efficient vehicles. And so as a secondary effect you will inextricably be able to deliver better greenhouse gas profiles per mile and also other associated emissions would also go down.

Mr. TONKO. It seems to me with some of the investments made in foreign produced, it would trigger some sort of indicator to the investor market. It seems like we are falling behind as an industry because we haven't kept pace with the sort of vehicle that Americans would love to purchase.

BATTERIES

And if I could just flip to the battery discussion for both you and Mr. Chalk, how important is it for us to create diversity within that focus?

Mr. CHALK. You say diversity within the focus. Do you mean within the lithium ion family?

Mr. TONKO. Well—

Mr. CHALK. Or—

Mr. TONKO.—within the battery discussion itself. Should we put all our eggs in that one technology basket as I heard mention of earlier, you know, as an expression, or should we look at other forms of battery technology that might be more suitable to bigger vehicles or to the car fleets, the auto fleets? Should there be something beyond lithium ion that we look at?

Mr. CHALK. Well, I would say yes, and we always survey the latest chemistries in batteries, but I would say within the lithium ion family there is a bunch of diverse electrolytes and cathodes and things like that, so it is not just, you know, one manufacturer will have a totally different chemistry than another manufacturer, even though they both may be classified as lithium ion. So there are lots of different types within the lithium ion family. In general, though, whether we are talking about power generation or vehicles, we have a very diverse portfolio that, you know, the magnitude of the problem is such that we have to have hydrogen and biofuels and electricity and—go ahead, sir.

Mr. TONKO. If I might just ask—my time is running short. With the stimulus money, with the Recovery Act money, are we going to

look beyond lithium ion? Are we going to look at battery technology that takes us beyond that?

Mr. CHALK. What we are saying is the—and the President last week announced the \$2 billion that was in the Recovery Act for manufacturing batteries, and basically what we are saying is those batteries coming off of those lines have to be compatible with a plug-in hybrid electric vehicle. The chemistries and things like that are up to the proposer if they can meet those requirements.

Mr. TONKO. Dr. Clay, any comments on the battery?

Dr. CLAY. Yes. I think one important point is that when we speak about hybrid vehicles that the realization should be first that hybrid vehicles are, in fact, a suite of technologies themselves. So a lot of our discussion tends to focus on plug-in hybrids, and that is a very exciting technology and should receive discussion.

There are a range, though, of possible hybrid configurations going from vehicles like the Toyota Prius that is a full hybrid but has a smaller battery pack than something like the GM Volt that has been announced, and then pushing further back you can have an even smaller battery pack where you have what is called a stop-start hybrid with very small battery that is able to reclaim preventative braking and deliver significant fuel economy benefits. So because there is a range of hybridization possible, that hybrids themselves are not a single technology, we need to be thinking about a range of battery chemistries that are suited to each of those niches along the way.

And so I think if we start conceptualizing hybrids as a continuum, then we will naturally start looking at investments and battery technologies along a continuum, and that will naturally bring us to looking at a diversity of battery chemistries.

Mr. TONKO. Okay. So can we hope that the Recovery Act stimulus money can accomplish that broader view?

Mr. CHALK. We are looking at it. I would, I want to emphasize, though, that there is nothing that has the power density and the energy density of the lithium ion. So, you know, one point we want diversity, but we also want critical mass because if we are going to address these problems, we eventually have to build something so that we do have to down select and pick some winners, so to speak, and go with our best shot. But all the time we are looking at what is the latest coming out of small innovative companies or out of our national laboratories to see if something better is coming along that can meet those requirements.

Mr. TONKO. Thank you.

Chair BAIRD. Mr. Ehlers. Dr. Ehlers.

THE RELATIVE MERITS OF VARIOUS TRANSPORTATION INNOVATIONS

Mr. EHLERS. Thank you, Mr. Chair, and thank the guests for their testimony. It is very stimulating and very useful. That is not always true around here, but I do appreciate it.

The—just a couple minor comments first. I appreciate Mr. Greszler bringing up the issue of trailer design. I have often wondered why no one has worked on aerodynamic trailers. I have a personal interest in this. I used to drive a truck, a semi-trailer and tractor, and it was pretty primitive back then. No consideration. I

was pleased to see the cabs at least showing some improvement, but there is so much more that could be done there in a lot of ways.

The—in all the discussion about batteries, first of all, batteries have been the problem for at least 50 years. I have a good friend who is a physical chemist who has been working on batteries for at least that long. A very, very complex issue and not easily resolved. It is not just a matter of saying, well, we are going to do some research, and we are going to have wonderful batteries. It is far more complex than that, and we should all recognize that.

One interesting sidelight since I enjoy flying, there is a lot of discussion now of electric airplanes, which would be used only for recreational purposes, but this in itself would be very helpful in terms of petroleum use, air cleanliness, and so forth. And so there is a lot of other uses for good batteries than in automobiles.

The—in terms of the hydrogen, I have been skeptical about that for a considerable amount of time. There—and the infrastructure problem as far as I can tell not being addressed. Every time I raise the issue everyone says, yes, yeah, that has to be addressed, and we will do it, but they all have different ideas. Absolutely, all the infrastructure involved is incredibly complex. You will need new means of carrying the fuel, transporting the fuel to distribution centers, getting it into the vehicles. It is not an easy problem at all. And I am not opposed to the use of hydrogen fuel cells. I think it would be wonderful, but we have immense problems to overcome there if we are really going to do that large scale. And the infrastructure, I think, is going to be very difficult.

One quick comment about federal investment. Roughly a decade ago the Department of Energy cooperated with the three, the Big Three, on a research project. I don't remember the name of it. It was under the Clinton Administration. We were going to produce a vehicle that would do 100 miles on a gallon, and many of my colleagues were very skeptical about it and didn't support it. I was skeptical, but I thought, let us give it a try. As far as I know nothing ever came out of that, and that has increased my skepticism of the Federal Government working with the automobile companies. Can they, in fact, put aside their own personal interests and work in a cooperative way on research with the Federal Government? I don't know. I hope so, but the evidence hasn't been there so far.

I appreciate Mr. Baloga's comments about the heat recovery. Immense amounts of heat lost, generated by automobiles, and anything you can do to recover that is bound to be good. And I certainly encourage further investigation of that. That is a wide-open field with lots of possibilities. And once again, not easy but it can be done and easier than many of the other alternatives.

I don't have any particular questions, because you have been, all been so thorough in your comments, but I am pleased to see the Department of Energy taking a substantial interest in this issue, and I hope that we can develop good cooperative working relationships. The—it is just from every aspect you look at the environmental, the foreign policy issues of our dependence on oil, everywhere you look this is one of our biggest problems today, and we really have to address it in a very strong uniform fashion, and I

think this hearing is helping us see that and also bringing out the ideas you have of doing that.

So I just want to thank you very much for your comments and the ideas you have presented. Thank you.

Chair BAIRD. Thank you, Dr. Ehlers.

Ms. Woolsey.

Ms. WOOLSEY. Thank you, Mr. Chair, and thank you to the witnesses.

DOMESTIC JOBS

Mr. Baloga, you in your testimony say that to any extent possible research funding to support companies come, go to global industries not located in the United States. Tell me, and this is in total innocence that I ask this. I have no, I have nothing here that is trying to set you up or anything. Tell me how in Great Britain with BMW, how does—how would those investments come to the United States? I mean, where is the real partnership here? I mean, is there one? How do we ensure that if the United States invests in partnership with BMW that the jobs stay in the United States? I mean, we are hurting for jobs, so is there, I mean, the subsidies that BMW gets from Europe or the European Union or from Great Britain, do those come to the United States? Can we bid for them over there?

Mr. BALOGA. Well, I guess let me answer the question like this.

Ms. WOOLSEY. Okay.

Mr. BALOGA. The technology that is developed as a result of these cooperative packages and contracts makes its way into the hands of the American public in the way of better-performing vehicles on the road—

Ms. WOOLSEY. I understand that, and I believe in that totally. I am talking about jobs. I mean, we won't have people that can afford to buy the cars that—if we don't have people working here in our country.

Mr. BALOGA. Right.

Ms. WOOLSEY. So how do we keep that money, if BMW benefits, yes, we will benefit in the big picture. How do we keep—is there a way to bring, ensure that money stays in the United States for jobs?

Mr. BALOGA. Well, the research on the projects would be for the cars, the vehicles built in this country and of course, if the research project is for something that would be making more efficient manufacturing, certainly that would be directly resulting in jobs in the U.S., and that would be tied to our plant, for example, Spartanburg, that we are expanding by 50 percent.

The—I think to answer your question, perhaps the best way to go about it would be to think of it in terms of an investment in a company that is going to be favorable to the market that is being its friend. We all tend to be more amenable to friends. There is a saying that says, "Keep your friends close and your enemies closer." There is a good reason for that, not that we want to speak about this in terms of friends and enemies, but when there is an investment in this country by our company, there is a certain closeness, a rapport that is established. The great people of South Caro-

lina have made the success down there with the plant. That is the reason we stay here and expand because it has been so successful.

So I think the success—

Ms. WOOLSEY. Well, thank you. Okay. I get all that. I just want to make sure the jobs stay here, too, so—

Mr. BALOGA. Thank you.

Ms. WOOLSEY.—I appreciate that. I do have an open question for anybody on the panel.

OTHER PROMISING TECHNOLOGIES

Are there promising technologies that aren't as far along as plug-in hybrids and hydrogen that with a big push may be more promising in the long run? Any—yes, Mr. Greszler.

Mr. GRESZLER. Yeah. I would say absolutely there are, and we mentioned one, which is waste heat recovery. There are multiple techniques for waste heat recovery. We looked at, we are looking at rank and basically steam-type cycle, which Mr. Baloga mentioned. We are also looking at thermal electric. There are some advanced work with things like thermal acoustics. All of these techniques have some promise of taking energy used or wasted in the exhaust stream and recovering it to produce useful energy, for example.

None of them are really at a point where they are truly effective in a vehicle, and there are a variety of reasons for that: efficiencies in some cases of the materials, the cooling system requirements, how we package it within a vehicle, the heat exchangers and the efficiencies all need to be worked on to make them truly effective.

But there are a lot of opportunities there as far as something that is really not, you know, closely available but something that could be made available in the near future with the right focus.

Ms. WOOLSEY. Well, should we be focusing on those technologies along with, I mean, you know, side by side, or do we have to give up—should we only be investing in the more, the further-along technologies and let the others come along as they can?

Mr. GRESZLER. Personally I think we need to do some of both, but we certainly need to be moving technologies into production and into the marketplace, or we accomplish nothing. But if we don't keep a focus on advanced technologies that require more research, then we have nothing in the future. So somehow we have to manage both of those.

Ms. WOOLSEY. Thank you very much. Thank you, Mr. Chair.

Chair BAIRD. Ms. Woolsey, thank you. I very much appreciate your line of questioning about American jobs, because it is so central to all of our districts. Before you arrived Mr. Inglis commented, as representative of the great State of South Carolina, the impact of BMW. I am going to recognize him for about 20 seconds before I turn to Mr. Bilbray.

Mr. INGLIS. Yeah. Thank you, Mr. Chair.

Ms. Woolsey, you might have missed earlier that BMW, a German company, has invested \$6 billion in South Carolina, and the numbers I gave earlier of about 5,000 jobs in South Carolina, 17,000 in the region actually are low when you consider the U.S. The total U.S. number is apparently about 50,000 jobs because

BMW is here making and selling cars. It is an incredible benefit of international trade.

Thank you.

Chair BAIRD. Thank you, Mr. Inglis.

Mr. Bilbray.

Mr. BILBRAY. Thank you, Mr. Chair, and I will also point out that American car manufacturers produce jobs overseas; Canada, Mexico, Australia, so there is no guarantees.

ETHANOL AND FUEL EFFICIENCY STANDARDS

Mr. Chair, I apologize first. I want to point out, make sure we remember the context in which we are discussing here. We are talking mobile sources, and we are talking about total emissions in this country is 28 percent. And so as we think about this, we think about plug-ins. We are thinking about the creation of hydrogen. We also have got to remember that 35 percent of the emissions total in this country are from one source, and that is electric generation.

So we are talking about 28 today. But we have got 35 percent out there that is going to be related to this addressing the 28, and remember that electric generation is the most clean—the biggest user of zero emission generation. They produce power, I think it is 22 percent of all electric generation is done with technology that has zero emissions.

So I bring this up because it is important as we talk about the line that if we do not address that 35 percent, which actually historically has used the cleanest, the most zero emission generation, we are never going to get a climate change strategy that works. And so as we talk about mobile, remember, this is a smaller version. It is not going to be the major. We need to still address that, and so as we talk about plugging in our hybrids, when we talk about generating hydrogen, we have got to remember we still come back to the elephant in the closet, and that is the fact that if we don't go to zero emission generation for our electricity, everything we are doing in mobile is a lost leader.

Speaking of that, and, oh, by the way, if you want to talk about mileage and fuel consumption, if we eliminated all of the obstruction that local government does with inappropriate traffic control, we could probably do more savings and more reduction. It was estimated that 95 percent of all stop signs could be yield signs. Stop signs are five times more polluting than not having any and use up more fuel. But that is for another hearing.

I think the one thing I would like to say here is we talk about different strategies, and I guess it is Mr. Chalk, the issue of the CAFE standard, I have got a question here. Historically our CAFE standards have always been based on a 100 percent gasoline mixture. Right?

Mr. CHALK. With biofuels credits and things like that. Yes.

Mr. BILBRAY. Well, and I am talking about the standard itself. Now, do we include the reduction in mileage because of the 30 percent less fuel efficiency of something like alcohol ethanol when we are reformulating this fuel efficiency standards? (Because the old standards that we developed in the '70s and the '80s, which I strongly supported extending over a period of time, have we modified now what those standards are, considering the fact that now

it is mandated that we use 10 percent alcohol in all fuels sold in the United States, and thus the mileage, the practical mileage has dropped?) What are we using? Are we using a new formula based on the fact that ethanol is there, or are we still operating off the concept, at least the standard, of 100 percent gasoline?

Mr. CHALK. I don't know the answer to that question. It is—the Department of Transportation issues the rules, you know. The CAFE is to increase fuel economy by 35 percent by 2020. I don't know if they made that adjustment for what we would call gasoline equivalent, but that seems like the right thing to do.

Mr. BILBRAY. I think we darn well ought to have it somewhere, because we either have to understand that we can't increase the mileage as we are mandating that the fuel mixture have less energy capabilities in it, and we have got to reflect that, and I know it is a catch-22. I come from the Air Resources Board in California, and these catch-22s show up all the time, but here is the thing. What are we doing in government on this?

Mr. CHALK. Well, I just add that there are so many other factors that would affect those miles per gallon rather than the fuel use, so it may, in the wash it may come out not to be a relatively minor affect, even though 10 percent of that fuel might have 30 percent less energy in it.

Mr. BILBRAY. And, you know, especially at a time that the ethanol industry is pressuring EPA to allow more fuel into the mixture, even though we know there are environmental and technical problems there.

Mr. CHALK. Well, the renewable fuel standard would actually add a lot. It would add 36 billion by 2022.

Mr. BILBRAY. I am not talking about that. I am talking about the percentage of mandated, percentage of ethanol inside the gasoline we are required to buy in this country.

Mr. CHALK. Right. But to get the 36 billion gallons we would have to have probably a higher blend than 10 percent to get there. That—the best way to get that 36 billion gallons out in the infrastructure would likely be by increasing the content of the alternative fuel in a gallon of gasoline rather than have pure ethanol or something like that at the pump.

Mr. BILBRAY. But it can't be ethanol unless we have a major modification in the vehicles themselves, because we already, we knew this in '92, that ethanol was going to create destruction of the equipment, the seals, and cause emissions problems, and now we can't put more ethanol in the fuel, so we have to go on another kind of renewable to be able to increase the standard.

Mr. CHALK. Well, actually, we can. We know how to do it. It is relatively minor cost to the vehicle, less than \$200 by most studies. We can make things compatible, and there is fuel flexors, there are many fuel flex vehicles out there. So it is an adjustment that can be made. We have the know how, the car companies know how to do that to go to higher blends of ethanol.

Mr. BILBRAY. Well, I would appreciate looking at that because—

Mr. CHALK. Okay.

Mr. BILBRAY.—at ARB they are still very concerned. In fact, let me point out, Mr. Chair, ARB just this month came out with a

study showing that ethanol has the air emissions benefit of regular gasoline. It is no more than we have had before.

Mr. CHALK. Let me try to enlighten you a little bit on that. We can do it in terms of capability. The car companies know how to tune the engines. There is an evaporative emissions issue in California—

Mr. BILBRAY. Big issue.

Mr. CHALK.—and that is really—there is not—it has to be re-engineered around so that when you put more and more ethanol, you get higher vapor pressures in a gallon of gasoline, you have to make sure that that evaporative emission is captured.

Mr. BILBRAY. Well, Mr. Chalk, why is ethanol given a dollar tax credit by—that other biofuels are not allowed? Why is ethanol specifically chosen as a winner in our tax cuts?

Mr. CHALK. Congress has decided it. It is not a dollar. It may be changed, but it was 54 cents. I don't know if the latest Farm Bill changed it or not. I possibly could be wrong there, but so it is a policy, I think, driven from the farm subsidies.

Mr. BILBRAY. So in other words we have chosen a winner here, and that is ethanol gets a subsidy, but other biofuels like algae fuel does not get the same subsidy?

Mr. CHALK. If it was turned into ethanol, it would.

Mr. BILBRAY. You know, Mr. Chair, let me just tell you something. That is exactly the problem. Ethanol is—I will still go on with the fact that it is a lost leader. We are putting massive amounts of money thinking some day a better fuel will show up. At the same time we are not giving the same benefits to alternatives, and that is the kind of thing of picking winners and losers, and obviously it is—I understand this when the farm lobby shows up, when people come over and start talking, but I think that when we talk about fuel efficiency and we are talking about the big picture, here is a place where we pick winners and losers and—

Chair BAIRD. Mr. Bilbray, I—

Mr. BILBRAY.—I appreciate that, Mr. Chair.

Chair BAIRD.—concur with you. I think, however, the best witness for this would be POGO, not our colleagues here, because we have seen the enemy and he is us, and I think it may have something, the answer to your question may have something to do with the primary structure of Presidential races more than energy efficiency.

I would be—Mr. Davis.

INNOVATIONS IN FUEL EFFICIENCY

Mr. DAVIS. Mr. Chair, thank you very much, and Ranking Member, for having this hearing this morning. I live in rural America. I have a Congressional District that has 10,000 square miles, 63 people for each square mile lives in that Congressional District. We have very low-income individuals. We are excited about the fact that maybe we can have an automobile that will go someplace as quick as a combustion engine, much cheaper, and less polluting. We hope that is in the future. We really want to see that happen.

As a young fellow I bought a '77 model diesel automobile. I won't mention the name of it, but it got 50 miles to the gallon in 1977. If I am not wrong, that is about 30 some years ago. I doubt that

you can find an automobile that is built in America today, and that one was, that will get 50 miles per gallon. What has happened?

And so I ask that question for a reason. I know as we engage in lessening our carbon footprint, we have to look at new technology as well as old technology. I am not sure what happened to those automobiles, and I am not sure that one is still around, but I am not sure why we are not able, 30 some years later with all the money we have spent on being able to find energy efficiency automobiles, with the effort that we have had for many, many years to look at—as we do research on the South Pole and we see the carbon content continue to escalate, as our climate starts changing.

Now, I have heard on this committee some folks say climate change is not happening. That it is just a natural phenomena, and that global warming is not happening. That it is just something that normally happens throughout the eons. It reminded me when I heard someone say that today there was a fellow that was working with Galileo, and he said, why do we study the stars? They all look the same to me.

So I guess in my, not necessarily a question but a statement I want to make, I know as we go through this research of trying to find alternatives to fossil fuels or at least to be able if we are going to use fossil fuels to make those automobiles more efficient, maybe we should go back to some of the old technology we have already had. Maybe we ought to start renewing some of those.

So my challenge to you as we spend taxpayer dollars on research and development, for goodness sakes let us not see huge vacated industrial science like some in my district that was an ethanol plant that is rusting down that was built in the late '70s and early '80s that is no longer being used. You are the scientists. You are the ones who are asking for the dollars. We are the ones who are giving you the dollars and demanding that you do some research, some research to give our planet and the American consumer and the world some relief.

I look at Europe who has been charging over \$5 a gallon for gasoline for the last two decades, and if the cost requires you to find more efficiency, obviously they have got a smaller car and a smaller horsepower, smaller engines, I don't know how much better mileage they get than we do here. When I look at the population in Europe and the population in America, they use about three-fourths as much fossil fuels as we do. Of course, they got a little bit harsher climate, so maybe they use that for heating.

So as we engage, Dr. Clay and Dr.—Mr. Chalk, I—you folks are kind of overseeing these dollars, I guess, that we are kind of shoveling out there with a scoop, like a barn scoop. Let us be sure that we are getting our money's worth. If we look at technology and it is going to be battery driven, if it is going to be driven by hydrogen automobiles, whatever it may be, utilize America's taxpayers' dollars wisely this time.

And I do believe that research and development makes a difference. My father told me 50 years ago, maybe longer than that, some day there will be a small pill that you will put inside a reactor in an automobile that will be a nuclear, a little nuclear energy that you can put—and it will drive you for the entire life of that

automobile. Maybe that is possible. I don't know, but some folks on this committee probably wouldn't agree that ought to be used, or some environmental group may not.

But I just think as we look at research it all needs to be included and not just a part of it. That is basically a comment from me. Help us. That is what you are here for. Asking you to help us is why I am here.

Chair BAIRD. Anyone wish to comment on the comment?

Mr. CHALK. Well, I would just say that we have a diversity of portfolios, and we are very serious about making progress in this area. You know, of course, we lose our grip sometimes when energy prices go back down, and I think history has shown that, and I think what we have to do is maintain the focus even though compared to last year when gasoline was four bucks a gallon and people were really worried, now that it has gone down a little bit, there might be a tendency to relax. We have got to stay focused on what we are doing and make this work.

Chair BAIRD. Dr. Johnson.

Dr. JOHNSON. Let me try to answer your question. The diesels today produce much lower emissions, significantly more, and there is a significant cost with these after treatment systems. And the people like BMW and VW, because they have developed diesel engines in Europe in the light duty, they are starting to bring them over to the United States.

One of the problems in the last few years has been that diesel fuel is 60 to 70 cents a gallon more because of the market demand. And so the whole problem that we have been discussing here is the price of fuel fluctuates, and I really didn't come to testify about that, but I think we need a tax on fuel so that we get a floor of about \$2 over five years, and then be neutral and give this tax back to individuals and back to industry so it is neutral, not just a tax. That will help drive the market, and that is what is true in Europe. They have a fuel tax. They have had it. They have got about 50 percent diesels. They have got smaller vehicles, and it is a natural market phenomena, and the problem with CAFE is that the market price of fuel goes up to \$4 and then back down to \$1.80 or \$1.90, and it just changes the whole thing. And you cannot change the manufacturing plants and the product development schedules to meet that, you know, and that is really the problem, you know.

Mr. DAVIS. I know I am imposing on the timeframe we have here, and I, Mr. Chair, I thank you for allowing me. I have also heard that through integrating into the actual structure of an automobile natural gas, a capacity where you could get at least 250, maybe 300 miles on a compressed natural gas capacity, if it is integrated into the system of the automobile. Eighty percent less carbon emissions supposedly with natural gas.

Why are we not looking at that until we at least find that bridge, until we bridge to that next energy source, whether it be batteries or whether it be hydrogen or whatever it may be? Is there research on that now, and is that possible even to convert automobiles today to a natural gas system, which is more clean, efficient burning?

Dr. JOHNSON. I am really not an expert in that, but the people are working on—but, again, one of the problems are that cars live

for 15 years, diesel vehicles live for 30 years, and the infrastructure for the fuel and the distribution is always a problem. Just like the flex fuel vehicles. There just isn't any fuel out there that has been given a credit for the 85 percent—

Mr. DAVIS. But every home has natural gas just about and very easy to hook up to it, and almost every service station in America has a natural gas heating system. I think that is—we have to look at least as a bridge fuel until we get to that new source or whatever it may be.

Dr. JOHNSON. Honda has looked at that and are looking at it and other companies probably will.

Mr. CHALK. You can buy a Honda vehicle in the 170-mile range with natural gas.

Chair BAIRD. Dr. Bartlett.

Mr. BARTLETT. Thank you very much.

In Armed Services we don't have earmarks. We have plus-ups, and they are fundamentally different.

Mr. Greszler, it has been my privilege for the past several years to be the proud author of a multi-year series of plus-ups for Volvo Powertrain, Mack Truck in my district, and I want to thank you very much for your aggressiveness in developing a really good hybrid truck for the Air Force.

THE NEED FOR FLEX FUEL VEHICLES

There are three reasons for looking at alternatives to oil.

One of those is the possibility that the release of the sequestered carbon and fossil fuels is increasing the CO₂ in the atmosphere and causing climate changes.

A second reason for moving to these alternatives is that we have only two percent of the world's oil in this country. We use 25 percent of the world's oil, and we import about two-thirds of what we use. That clearly, clearly presents a huge national security risk, and we need to move to alternatives to free ourselves from so much dependence on foreign oil.

And a third reason and perhaps the best reason of all is that the fossil fuels and the quantities we would like to use just aren't going to be there in the future. For a prognostication of this I would suggest you do a Google search. It is on our website, too, but do a Google search for Rickover and energy speech. The father of our nuclear submarine gave what I think is the most insightful speech of the last century 52 years ago the 14th day of this May, and he predicted quite precisely where we would be today.

In our desire to find these alternative fuels we have already had two bubbles that have broken. By the way, the future for electricity is pretty secure. We have lots of ways of producing electricity, nuclear, wind, solar, microhydro, true geothermal tapping the molten core of the earth. There is no silver bullet out there for liquid fuels.

And I look for those two bubbles, big bubbles that have already broken. The first was the hydrogen bubble. Finally they figured out hydrogen is not an energy source, and you almost never hear anybody talking about hydrogen today. It is a great candidate for a fuel cell, of course, which is always about 20 years away.

The second bubble that broke was the corn ethanol bubble. National Academy of Sciences, and we did in our office some back-of-

the-envelope computations that came to essentially the same conclusion before their report, they said if we converted all of our corn into ethanol, every bit of it, and discounted for fossil fuel for which you ought to do, it is just silly to burn fossil fuels in another way and pretend that you are displacing them, that that would displace 2.4 percent of our gasoline. They said that we would save more gasoline if we tuned up our car and put air in the tires.

So these two bubbles have now broken, and there is a third bubble out there with a lot of irrational exuberance attending it, and that is the cellulosic ethanol bubble. Well, the point is that we really aren't sure what the alternative fuels of the future are going to be.

Mr. Chalk, doesn't it make sense that if we don't really know what the alternative fuels of the future are going to be but we know that they are going to have to be there for one of these three reasons, perhaps all three of the reasons I mentioned previously, that we ought to be developing flex fuel vehicles? The average cars in the fleet, what? Fifteen, 16 years? I have no idea what the alternative fuels are going to be 16 years from now. Doesn't that make some sense to be producing these flex fuel vehicles so we will be ready no matter what?

Mr. CHALK. Well, I think a little bit of the dilemma there, if you don't know what fuel you have got to design for, it is hard to make the vehicle fuel flexible if you don't know what the fuel is. But for what we do know we can do that. In terms of ethanol we can go from, you know, E-15 all the way to E-85 with these fuel flex vehicles.

Mr. BARTLETT. Won't they burn methanol, too? Can't we make them to burn ethanol? I mean, methanol.

Mr. CHALK. I think they would have to be tuned differently but the same technology would be suitable.

Mr. BARTLETT. Detroit said that they could make half of all the cars flex fuel by 2012, and 80 percent of them by 2015. Is this a course that you would, you could support?

Mr. CHALK. Not commenting specifically on your proposal because we don't have an Administration position on it yet, but I would talk about a little bit the attributes as, you know, we have the renewable fuel standard. We have a law there on how much corn ethanol, for instance, is topped at 15 billion gallons. We have cellulosic targets, and that provides assurity to the market. I think what you are proposing would also provide assurity to the market. If there was a regulation or a law that said X number of fuel flexible vehicles had to be made, that provides a level playing field for everybody. It is fairly cost effective, and we are going to need it if we are going to increase the amount of ethanol or whatever carrier we use in the gallon of gasoline. We are going to need fuel flex vehicles.

There are issues that we talked about with the California standards and very tight evaporative emissions. We have to work on that issue so mandating fuel flex vehicles might include things that have evaporative emissions like alcohols could be an issue.

I would say we are testing right now. We have a blends testing where we are trying to see if we can go above 10 percent in a gallon of gasoline, and the preliminary results are very good for most

highway vehicles. There are issues with smaller engines that are used for lawn and gardening and things like that, but I think, you know, those issues can be addressed over time with phase-in and all.

So having the assurity of that is what the market requires I think is very helpful.

Mr. BARTLETT. Mr. Chair, if you would permit me one more brief question.

The renewable fuels standard anticipates a really pretty aggressive introduction of alternative fuels in the future, and we are now looking at cellulosic ethanol. About almost half of that billion tons that they propose to make ethanol comes from corn stover. The report says that 75, we can harvest 75 percent of the corn stover from the fields, and the Secretary of Energy, Dr. Chu in his testimony said that we could harvest 50 percent of it and be sustainable. I am told by the Department of Agriculture that for every bushel of corn we produce in Iowa, three bushels of top soil go down the Mississippi River.

Now, top soils are deep in the midwest, and it will take awhile, but if that is true, that is not really for the long-term, sustainable, even with our present-day agriculture, is it?

Representative Woolsey and I in the '07 Act introduced legislation that would require sustainability studies. I am enormously concerned about the sustainability. We drive along the road and look enviously at all of that biomass. Now, for sure, for a year or two we could rape the landscape and make some ethanol out of that, but what is the sustainability?

Is your department going to focus on sustainability? Because to be realistic we really need to know what—

Chair BAIRD. Mr. Bartlett, I am going to preempt the question because we are well over your time at this point.

Mr. BARTLETT. Oh. Thank you.

Chair BAIRD. That—I share the concern profoundly, but I think I want—respect for other Members recognize Ms. Edwards at this point.

Ms. EDWARDS. Thank you, Mr. Chair, and thank you to the panel.

HYDROGEN FUEL

I have some questions about hydrogen. A few years ago I was greatly enamored, you know, about the prospects for hydrogen. I had read Jeremy Rifkin's book, I was excited about that, about, you know, the idea that somehow we could make a huge investment into hydrogen technologies, and that would be the way to really jumpstart us in this, what he described as a new revolution, you know, equivalent to the revolution, the industrial revolution in the 19th and 20th century.

Since that time then I think, Dr. Clay, you sort of spoke to this, you know, we—I don't know how much real headway we have made really with hydrogen. The storage problems, the distribution problems, safety issues, et cetera, and so it makes me wonder in the FreedomCAR Program whether we have placed so much emphasis on hydrogen at the expense of other technologies related to vehicles.

Now, there might be another question, I think, about whether we need to make investment in hydrogen technology, bringing down the costs of production at fixed sites for other kinds of power distribution but not necessarily for vehicle use.

And so I wonder if you all would be able to speak to that and particularly as it relates to the production. I mean, I think, currently now with the hydrogen production technology it is so reliant on fossil fuels that it makes me wonder what we get for it even if we are increasing the amounts of hydrogen that we are producing that is usable.

Dr. CLAY. Thank you. Yes, I think you are bringing up some really critical points, and I think there are some interesting parallels between your question, Congresswoman, and Congressman Bartlett's questions, because it goes to this issue of the vehicle and the fuels being seen as a unit. So we need to think in the systems way about the vehicles and the fuels.

So the challenges that you cite on the vehicle side, on storage, et cetera, and the resources that we have invested in trying to overcome those technologies, even if we were to solve all of those problems and break through those barriers, there are significant challenges that remain on the infrastructure side, and how we actually, even if we were to bring hydrogen fuel cell vehicles to consumers, how those consumers would be able to access convenient refueling.

This is a very parallel—we can learn something from our experience with flex fuel vehicles as Congressman Bartlett brought out, that flex fuel vehicles are now on the roadways, over seven million on the roadways today, but there are fewer than 2,000 fueling stations available where there are on the order of I believe 130 or 140,000 service stations for gasoline available. So we clearly have a long way to go on providing the infrastructure on the flex fuel side to make the most of that investment we have made in bringing flex fuel vehicles to the market.

I think that that is a cautionary tale to our continued work on hydrogen, that as we continue to invest in hydrogen technologies on the vehicle side, that we need to working in tandem with the infrastructure side, and those two really have to be seen as a partnership.

Ms. EDWARDS. Could I just ask you then on the production side in terms of the relative gain around CO₂ emissions, currently are we really making gains on decreasing carbon emissions with the existing technology?

Dr. CLAY. On hydrogen in particular?

Ms. EDWARDS. On hydrogen in particular.

Dr. CLAY. And this came out earlier in an earlier question. If we talk about electrifying or electrifying transport or whether that is through batteries or fuel cells, which are still electric vehicles, we are not answering all of the challenges before us if we don't also think of decarbonizing the fuel.

Ms. EDWARDS. The process.

Dr. CLAY. The process of creating that biofuel and the life cycle implications for greenhouse gases for biofuels and the life cycle implications for producing that hydrogen. So most of the hydrogen that is produced today is reformed from natural gas. But the beau-

ty of hydrogen as an energy carrier is that just like electricity it is an energy carrier that can use a multiple number of primary fuels in its development. So right away you have got energy diversity because you can be doing, you can be using both fossil fuel sources, nuclear, renewable energy, et cetera to both provide the electricity for plug-in hybrids, but also for the electrolysis to produce the hydrogen.

Ms. EDWARDS. Right. But our goal would be to reduce the use of the fossil fuel part of the production process, which we really haven't quite figured out yet.

Dr. CLAY. Exactly right. And I think we are at the beginning of a new era where we no longer can think about the transportation and electrical generation systems as separate, that if we think about decarbonizing, that everything that we do to decarbonize transportation has to be linked with our efforts to decarbonize electrical generation.

Ms. EDWARDS. Right. Thank you, Mr. Chair.

Chair BAIRD. Thank you for a very interesting line of questioning, and there has been a real apparent shift in DOE's emphasis on hydrogen, and Mr. Baloga talked about this a little bit.

What I would like to do is we are approaching noon, maybe a couple more questions from myself and maybe Mr. Inglis if he wants. Can you talk a little bit, Mr. Chalk, about that shift, about the apparent shift from hydrogen focus, why it happened, what the implications are, to somewhat follow up with Ms. Edwards.

Mr. CHALK. Yeah. Our hydrogen program is still robustly funded. There has been more emphasis on the plug-in hybrid electric vehicle because we feel like we can get there sooner with that technology and make a difference in terms of decreasing our dependence on oil, and obviously as Dr. Clay just mentioned, it depends on how you get that electricity or how you get that hydrogen, whether you have a net benefit.

But I would say diversity of resources is critical, and we can use fossil fuels like coal if we sequester the CO₂, and that can work, and provide—

Chair BAIRD. Well, let me stay on hydrogen for a second. When you say it is robustly funded, give us a trend pattern in terms of funding levels.

Mr. CHALK. Right now it is funded at about \$146 million if you look at the line item, but some of our activities have actually moved into our vehicle area. So in a way that is mass, and what we have done is, from a systems standpoint, moved our technology validation, safety, and code standards all in our vehicle programs and be technology neutral so to speak. But that is what pays for the hydrogen demonstration.

Chair BAIRD. I haven't a clue what you just said.

Mr. CHALK. Okay. Well, the funding has been steady, and there has been more emphasis on the plug-in—

Chair BAIRD. The funding for the hydrogen portion, and it sounded to me like you had a whole bunch of camouflage in there that I couldn't sort out. Funding for hydrogen research per se has been steady over time.

Mr. CHALK. Yes, and the budget is camouflaged a little bit because we moved some activities, and that is what I was trying to

explain, but in essence it has been fairly steady. It may have decreased a little bit but not much.

Chair BAIRD. What would your signal be to Mr. Baloga or others who have spent a great deal of investment in hydrogen research and possibly developing a hydrogen car? Do you plan to do that? I know the Administration hasn't necessarily set its policy yet but—

Mr. CHALK. Well, Mr. Baloga's technology is hydrogen combustion. That is fairly well known. There is some research we could do there, but that is essentially commercial technology. The real long pole in the tent has been mentioned and it is hydrogen storage and fuel cell costs, and with the investment made, we have made a lot of progress, and those budgets have maintained steady and actually have gone up.

So we are maintaining the focus on the longer-term pathway of hydrogen, but there has been a lot more emphasis on what we can do in the next five years in terms of making a difference on imported oil, getting jobs out in the economy, and addressing climate change.

FUNDING LEVELS AND SOURCES

Chair BAIRD. I have been handed a note that Ms. Edwards has a question about—what I will do is just yield some time so you can phrase the question yourself.

Ms. EDWARDS. Just very quickly, do you have an idea of the amount of, comparable amount of money that the European union has invested in hydrogen technology? Because my recollection it is between two to \$4 billion. And so when you look at the investment that we have made in comparison, I mean, are we really getting our bang for our buck?

Mr. CHALK. The European investment, at least government investment, would not be nearly that high. It would be on par with what we are spending. I don't have the exact numbers. I can get back with you on the record for that.

INSERT FOR THE RECORD

The global government investment for hydrogen and fuel cell research, development and demonstration is estimated to be \$1 billion annually.¹ The Department's budget for hydrogen and fuel cell research in fiscal year 2009 is approximately \$266 million. The European Commission,² Germany,³ Norway,⁴ and the United Kingdom⁵ have a combined 2009 budget of approximately \$157 million for hydrogen and fuel cell research. The European Commission plans to invest approximately \$625 million over the next five years and Germany plans to invest approximately \$744 million

¹FuelCellToday Market Study, "Fuel Cells: Commercialization," January 2008, available at <http://www.fuelcelltoday.com/online/news/articles/2008-01/Fuel-Cell-Commercialisation>

²P. Vannson, "EU R&D for Green Road Transport: Fuel Cells, Hydrogen and Vehicle Technology Programmes," 2009 DOE Hydrogen Program & Vehicle Technologies Program Annual Merit Review, May 18, 2009, available at http://www.hydrogen.energy.gov/pdfs/review09/5_vannson_2009_amr.pdf

³K. Bonhoff, "Electrification of Future Mobility—National Programs and Activities in Germany," 2009 DOE Hydrogen Program & Vehicle Technologies Program Annual Merit Review, May 18, 2009, available at http://www.hydrogen.energy.gov/pdfs/review09/6_bonhoff_2009_amr.pdf

⁴S. Moller, "Norwegian National Hydrogen Strategy," 11th IPHE ILC Meeting, March 11, 2009, available at <http://iphe.net/docs/Meetings/Norway-3-09/Norway-H2-Strategy.pdf>

⁵Technology Strategy Board (UK), "Fuel Cells and Hydrogen Technologies: March 2009 Competition for Funding," available at http://www.innovateuk.org/_assets/pdf/competition-documents/fuel%20cells%20and%20hydrogen%20technologies-071008.pdf

over the next eight years in this area. This is in comparison to the U.S. investment of \$1.2 billion over five years during fiscal years 2004 to 2008.

Chair BAIRD. One other question I have and then I will recognize Mr. Inglis.

Mr. Greszler and Dr. Johnson, you talked about the need for a higher level and a sustainable level of funding, and I think obviously you are interested in the light and heavy-duty trucks, and I share your concern. If the amount of freight that we haul in this country, I think tends to get short-shrifted, I think, when we talk about a host of funding mechanisms. We tend to, we focus on how much the weight of the truck impacts the highway maintenance side, but we seem to forget that we all eat what comes in those trucks or use it in some other fashion.

What about the idea of including—we were about to look. I serve also on the Transportation Committee, and I don't know off the top of my head, I perhaps should, but to what extent highway and transit funds fund DOE's truck and car research programs. And would that be a good use of federal highway funds.

Mr. GRESZLER. I don't know the answer to how funds would transfer between highways and DOE. I suspect that Mr. Chalk could talk more about that. What I could say is that highway infrastructure is critical to efficient freight movement and particularly, unlike light-duty vehicles where you get better MPG with downsizing, with heavy-duty vehicles you get better freight efficiency. You move more freight with less fuel by upsizing so that the longer, heavier the trucks are, the more efficient we actually can be in moving freight. And to the extent that we can facilitate that with infrastructure, we can greatly improve. There are many studies showing 30, 40 percent improvement in freight movement efficiency with longer, heavier trucks that are allowed in some states today but not allowed in all states, for example.

Things like truck stop electrification, smart highways where we can have vehicles communicating and knowing, for example, if there are traffic jams to be avoided or to time entry into a city such as to avoid a traffic jam, knowing where truck stops are available, smart navigation systems all can substantially improve the efficiency of freight movement. And those things do get into the highway infrastructure in a significant way.

Chair BAIRD. The 30 to 40 percent figure is pretty remarkable in light of the comments earlier about some of the research work, trying to move from 41 percent to 47. If I get the numbers wrong—a small percentage, fairly technical research apparently, trying to move the efficiency of the engine, but if you just add a little bit of weight to the vehicle you can get a 30 percent improvement in efficiency. That is an interesting question that ought to be explored.

Dr. Johnson, did you care to comment on that?

Dr. JOHNSON. Well, I think that efficiency—my testimony talked about gallons per payload ton mile. Okay. That is why it does. If you can carry more payload, you reduce that, and it is just like trains. They are very efficient, and I don't have any information about the taxes and the funds, you know, between the highway and DOE, but it is a good idea. There needs to be some way to get more funds because this sector is using a lot of energy, and we need—and it is tough to reduce truck, the basic efficiency of the truck.

This carrying more freight is, then becomes a question of safety and all kinds of other issues that are in the states and locally about these long, double-bottom trucks, as we know from your committee.

Chair BAIRD. You talked earlier about the need for a steady and predictable pricing—

Dr. JOHNSON. Right.

Chair BAIRD.—and I think there is a need for that. I think both for global overheating and ocean acidification issues but also you then make the incentive, economic incentive to do something different. I would like to see a portion of that possibly dedicated to what you are talking about here. It would make sense to me that we might want to do something like that and possibly in the process address some of Mr. Baloga's concerns as well.

Mr. Inglis.

Mr. INGLIS. Thank you, Mr. Chair. By the way, that earlier reference to the elegant price signal I was talking about is something I am working on fast and furious is how do you, how do we internalize the externals associated with our use of fossil fuels in—for transportation needs and for electrical generation? If you do that, then all kinds of competing technologies become possible because then you got a fair fight between the economics of the incumbent technology, which is gasoline and coal, compared to the economics of the, of nuclear, which is a fabulous way to make electricity in my view, and wind and all kinds of other things. Then you are on a—then the market can make a decision between competitors. Right now one competitor, fossil fuels, are getting a freebie, freebie in the air, freebie in national security, and that is not a fair fight.

So as a conservative I insist on accountability, and that means coal be accountable for all the health consequences of what you do, and be accountable for the CO₂ emissions. Liquid transportation fuels, be accountable for the national security risks we run, being dependent on regions of the world that really don't like us, and for all the climate issues associated with it.

Then if you internalize those externals now, compare apples to apples and suddenly all kinds of things become possible, and it is back to that very helpful point for Mr. Baloga about the premium brands suddenly become the innovation engines.

EUROPEAN INNOVATIONS

So but speaking of those innovation engines, Mr. Baloga, the many diesels that you sell in Europe, if I understand it, that get what, 63 miles to a gallon. Why isn't that here? There was a question earlier, and maybe you could elaborate on why it is not here, why it isn't in the U.S.

Mr. BALOGA. Well, California has the most stringent emission control regulations of any entity in the world. One of the things that enabled us to build these whole engines that would meet the California stringent requirements was low sulfur diesel fuel, which the EPA implemented and fortunately now we have, which allowed us to have ultra low emissions, clean diesels we call them, on the roads.

The problem that we have today with the mini diesel is a problem of getting that particular engine as clean as necessary for Cali-

ifornia. Our company has a philosophy we don't sell only cars that meet California standards and then have dirtier cars for the rest of the country. We have only 50 State vehicles that meet California and sell them all over.

So the answer to the question is because that engine family right now has to wait for the next evolution of that engine family that we are working on to get it as clean as necessary for the California requirements.

Mr. INGLIS. I wonder if it is a little bit like what the Chair mentioned earlier about the Corvair? I mean, it is—in other words, the perfect is becoming the enemy of the good maybe.

Mr. BALOGA. Perhaps but we have to comply with the requirements, and we will certainly do so.

Mr. INGLIS. Well, it is sort of—I would think that, there are no Californians here, but I would think—on the panel, but I would think that it would be an unintended consequence. It is sort of interesting that we are passing up an opportunity right now to be driving 63 mile per gallon minis that are being sold in Europe. We are not driving because of that. It is sort of—

Mr. BALOGA. Yes.

Mr. INGLIS.—an interesting, unintended consequence I would think.

Mr. BALOGA. Our fleet average in Europe of the BMW cars on the road in Europe is 158 grams per kilometer, which translated into mile per gallon is about 35 miles per gallon, and we attain that with about a 68 percent fleet of diesel cars in Europe. Now, of course, 68 percent or 70 percent of diesel cars in this country is impossible to imagine, although there are some good signs we are seeing that for the first time diesel fuel is actually less than regular gasoline in terms of cost.

So maybe we will make some progress with diesel cars.

Chair BAIRD. Would you yield, Mr. Inglis?

Do you have a calculation on the per mile CO₂ emissions? In other words, so you are getting 67 miles to the gallon of diesel, but what is the net—in the end are you getting a greater or lesser per mile CO₂ emission?

Mr. BALOGA. The CO₂ is reduced. Yes, it is. The CO₂ is reduced because although there is more carbon in diesel fuel, you get an inherently better, approximately 30 percent better fuel economy. So even if—

Chair BAIRD. That is my question.

Mr. BALOGA.—you get a 15 to 18 percent rise in carbon for the fuel, you get a 30 percent improvement in fuel economy, so the net is an improvement. Yes.

CLOSING

Mr. INGLIS. And Mr. Chair, your indulgence because the time is up. I just think it is interesting that Mr. Baloga just said that the next generation may be, may get you there on the mini, and it is just interesting to note that BMW put in an assembly line, I think opened in 1994, in Spartanburg, and in 2006, BMW closed at Thanksgiving, paid everybody through New Year's, and ripped out a 12-year-old assembly line to replace it with a brand new one. Out

with the old, in with the new. I mean, that is the kind of insistence it seems to me that we need in public policy for getting there.

You know what I mean? If you think about it, BMW likes to say they are an engineering company that happens to make cars. Well, I would just hope that Mr. Chalk takes back to the Department of Energy this kind of inspiration that says, get with it. I mean, we are in a race for the future here, and we need to have that kind of insistence. Just rip out a 12-year-old assembly line. Spend hundreds, millions of dollars to make it better. Wow. What a concept and what an exciting inspiration really that I am inspired by being with and representing companies like that.

So thank you, Mr. Chair.

Chair BAIRD. And we are a legislative branch that happens to impact engineering.

I thank our witnesses very much for your insightful testimony and your expertise, and I thank my colleagues on the panel, and with that then unless anyone has any burning desires that we can't take up afterwards, this hearing will stand adjourned. Thank you very much.

[Whereupon, at 12:05 p.m., the Subcommittee was adjourned.]

Appendix:

ADDITIONAL MATERIAL FOR THE RECORD



March 23, 2009

Via Facsimile and E-Mail

The Honorable Brian Baird
 Chairman
 Energy and Environment Subcommittee
 House Committee on Science and Technology
 2320 Rayburn House Office Building
 Washington, DC 20515

Dear Chairman Baird,

**Clean Transportation
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My name is John Soessel and I am President and CEO of CALSTART, a non-profit, fuel- and technology-neutral organization that is focused on accelerating the growth of the clean transportation technology industry as a way to reduce greenhouse gas emissions, improve air quality, cut dependence on oil, and create new high quality jobs. I am writing in reference to your upcoming hearing on research, development, demonstration, and deployment efforts for high-efficiency, low-emission truck technologies. We have worked over the past several years to develop a powerful and proven program for accelerating advanced truck technology commercialization, and believe that this model should be integrated into the Department of Energy's efforts in this area.

The Hybrid Truck Users Forum (HTUF) program, operated by CALSTART in partnership with the US Army's National Automotive Center (NAC), has been a highly successful program to jumpstart a 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 commercial manufacturing capability for advanced trucks. The strength of this program has been the involvement of the users, the public and private fleets, in understanding and creating market pull for advanced truck technologies. As a result of the HTUF process, the commercial industry is now rapidly developing early heavy-duty hybrid products in several different market applications. The HTUF process has removed one to two years from the product development cycle.

We have worked previously with House Science and Technology Committee staff on these issues and would appreciate it if you could include the attached letter in the hearing record. This is a crucial time for clean transportation technologies, and we believe the HTUF model can play a valuable role in supporting the industry and accelerating commercialization.

Thank you,

John Soessel
 President and CEO

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March 23, 2009

Via Facsimile and E-Mail

The Honorable Brian Baird
 Chairman
 Energy and Environment Subcommittee
 House Committee on Science and Technology
 2320 Rayburn House Office Building
 Washington, DC 20515

Dear Chairman Baird,

**Green Transportation
 Technologies and Solutions**

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 SAE Systems

Mr. George Survant
 Fleet Power and Light

Mr. William Zebel
 WPIA Alliance

Thank you for the opportunity to submit comments for the record for the Evolving Federal Vehicle Technology Research and Development Programs hearing on March 24, 2009. Our comments focus on the opportunity to accelerate the development and deployment of high efficiency, low carbon truck technology through an open and cooperative process. We believe that the process described below would be a natural and valuable complement to existing federal research and development efforts.

CALSTART is a non-profit, fuel- and technology-neutral organization that is focused on accelerating the growth of the clean transportation technology industry as a way to reduce greenhouse gas emissions, improve air quality, cut dependence on oil, and create new high quality jobs. Though regional sounding in name, CALSTART functions nationally in terms of efficient heavy-duty vehicle technology. Over its 15-year history CALSTART has worked effectively with the federal departments of Energy, Defense, and Transportation, as well as the EPA, to develop, demonstrate, and commercialize clean and energy efficient heavy-duty vehicle technologies.

The Hybrid Truck Users Forum (HTUF) was initially designed to speed commercialization of medium- and heavy-duty hybrids. HTUF is operated by CALSTART in a unique partnership with the US Army's National Automotive Center (NAC). The strength of this program has been the involvement of the users, the public, private and military fleets, in understanding and creating market pull for technologies that reduce our dependence on oil. When the program started in 2001, no truck manufacturer was willing to build a hybrid truck, while several transit bus manufacturers began to adopt hybrid technology. By 2008, however, every major truck manufacturer had announced plans to sell one or more hybrid products.

In supporting this program to date, NAC and the Department of Defense have increased the capabilities of the commercial truck and component manufacturing industry to build advanced vehicles and technologies that can support emerging military and civilian needs. As this committee considers how best to promote technological advancement in the trucking sector, we recommend leveraging the success of the HTUF model by integrating and connecting it with other research, development, demonstration, and deployment programs such as the Department of Energy's 21st Century Truck Program. Integrating HTUF into the broader technology advancement efforts would:

- Provide a clear path to market for promising early stage technologies
- Accelerate the commercialization process, generating early and additional efficiency gains and emissions reductions
- Inform the early R&D process by giving a voice to technology customers and end users
- Increase communication and cooperation between key public and private stakeholders

O P P O R T U N I T I E S

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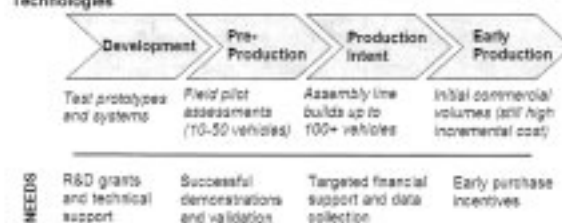


The HTUF mission is closely aligned with the technology advancement goals of the Department of Energy (DOE) and would be very valuable as a complement to the DOE's 21st Century Truck Program.

Getting from Lab to Market

Technology innovation and commercialization is a lengthy process with many stages, actors, and potential problems. Efforts to encourage or accelerate technological advances in targeted areas require support and funding across all stages of the innovation and commercialization process, from early research and development through pre-production and on to early market introduction. Historically, the public sector has focused on early R&D and viewed the later stages as the responsibility of the private sector. The path from lab to market is not always clear, however, and many technologies stall in the pre-production, production intent, and early production stages. Figure 1 below outlines the commercialization stages and requirements for advanced truck technologies.

Figure 1: Commercialization Stages and Requirements for Advanced Truck Technologies



Since 2001, HTUF has been working to provide targeted support and bring innovative new technologies through the pre-production and production intent stages. Recently, HTUF has been actively pursuing purchase incentives to support early production and make hybrid trucks commercially available. HTUF could also play a valuable role in the initial technology development stages by aggregating and providing information about user preferences and requirements to R&D teams.

HTUF: A Proven and Powerful Model

HTUF was designed as a nimble, fast-track process to speed hybrids to market by focusing attention on the needs of key players who could change the industry's direction: the users themselves. HTUF focuses on developing targeted market demand, or "pull" around core, first-mover fleets in key applications. HTUF started by developing committed groups of fleets around the most promising and high profile early market applications that showed the greatest potential to support hybrid trucks. Through the action-oriented users groups, HTUF is able to aggregate user needs and give them the opportunity to signal jointly to manufacturers what they would commit to buying if it met their requirements. This aggregated user information removes some risk for manufacturers and provides a strong incentive to aggressively invest in technology advancement.

After defining key requirements, HTUF helps move fleets and manufacturers through the pre-production stages, providing targeted funding and other support for demonstration, data collection, and validation. With manufacturers and users both indicating a clear intent to move forward with hybrid technology, HTUF's Incentives Working Group is now focusing on securing financial incentives for early production. The idea is to increase early demand and production volumes, ultimately resulting in reduced production costs and a self-sustaining market that no longer requires external support.



The HTUF program has a demonstrated record of success in bringing stakeholders together, speeding technology commercialization, and ushering DOE-supported technologies into production:

- HTUF has become the key industry connection on heavy duty hybrid technologies, attracting leading commercial fleets and every major truck maker and supplier to the process.
- The HTUF process has removed one to two years from the product development cycle. As a result of HTUF, the commercial industry is now rapidly developing heavy-duty hybrid products in several market applications.
- HTUF helped International (Navistar) and Eaton to move into production after they received funding from DOE's Heavy Hybrid Development Program for system development and vehicle integration.
- HTUF has helped integrate common military and commercial needs into early hybrid system designs.
- HTUF has developed a critical mass of supply and demand around hybrid truck technologies, and is currently facilitating the development of purchase incentives to move the industry toward full-scale commercial deployment.

For the past 8 years, HTUF has played a very valuable role in moving hybrid technologies from lab to market. Ongoing efforts in this area would benefit from a more formal and complete integration of HTUF into the overall process and strategic plan.

Possible Roles for HTUF and connections with the DOE Program

The HTUF model is being broadened to focus on high efficiency, low emission truck technology, building off the base of hybrid advancements. With this comprehensive focus, an expanded HTUF program could address the industry's needs in the pre-production, production intent, and early production stages. Such an effort would enjoy a close and synergistic relationship with new and existing R&D efforts at DOE and other federal agencies. This integration would:

- Bring key industry stakeholders together to aggregate information and demand, accelerating the technology development and deployment process
- Close the gap between early stage researchers and end users of technology, resulting in more focused research and a better understanding of end goals
- Provide an implementation process that builds on and complements R&D investments and successes
- Promote communication and cooperation between DOE and other federal entities with an interest in the development of clean and efficient trucks, including the Department of Defense, the EPA, and the Federal Transit Administration

We appreciate the opportunity to provide these comments and hope that the Committee recognizes the potential advantages of a technology advancement strategy for the medium- and heavy-duty trucking sector that leverages the success of HTUF.

Sincerely,

John Boesel
CALSTART, President & CEO

Examples of HTUF Partners (partial list)

Leading North American and Regional Fleets

All Major Truck Makers and System Suppliers

The image displays a grid of logos for various companies. The logos are arranged in several rows and columns. The top row includes logos for Volvo, PACCAR, and other truck manufacturers. The middle rows feature logos for suppliers like Michelin, FEV, and others. The bottom rows include logos for public utilities such as FPL, Exelon, and others. The logos are presented in a clean, organized manner against a dark background.

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21st Century Truck Partnership An Industry Perspective for Future Technology Development and Deployment

Background and Purpose

The 21st Century Truck Partnership (21CTP) is uniquely structured to coordinate efforts to improve the efficiency, emissions, and safety of Class 3 to 8 commercial trucks and buses. Members include original equipment manufacturers and, unique to a public-private partnership, also includes key suppliers including heavy-duty diesel engine manufacturers and major component suppliers. Member companies are all multinational with major U.S.-based research and development activities as well as domestic manufacturing capabilities.

The industry objective is to assure sustainable, cost-effective freight transport in an environment of limited petroleum supply and carbon emissions constraints. This means we need technology development plus related infrastructure and policy enablers to greatly improve vehicle and freight system efficiency and to develop low-carbon fuel sources.

To carry out this objective the industry members are also joined by relevant federal agencies; the Department of Energy, the Department of Transportation, the Department of Defense and the Environmental Protection Agency. The Partnership has strategic alliances with the Engine Manufacturers Association (EMA) and the Truck Manufacturers Association (TMA), who serve on the industry's federal policy group, and the Hybrid Truck Users Forum (HTUF) with whom we share five mutual industry partners (Eaton, Daimler Trucks, Navistar, PACCAR, and Volvo).

In addition, fleet customers and small suppliers gain access to 21CTP programs by working through any of the partner companies. As a recent example, suppliers shared in an award given to Navistar. The National Laboratories also play a key role in working within 21CTP programs.

Technology development needs exist in several key areas:

Requirements for heavy duty vehicles are markedly different from those of light duty, and unique solutions are required. Furthermore, the demand for freight movement is directly tied to economic growth which is expected to grow at two to two and a half percent for the next 20 years. Recent DOE projections show that, if light duty fuel use targets are met and heavy duty trends continue, HD fuel use will exceed LD by 2040 (Ref. Chart 1). These facts demand a major focus on efficient freight movement, combining strong government and industry efforts.

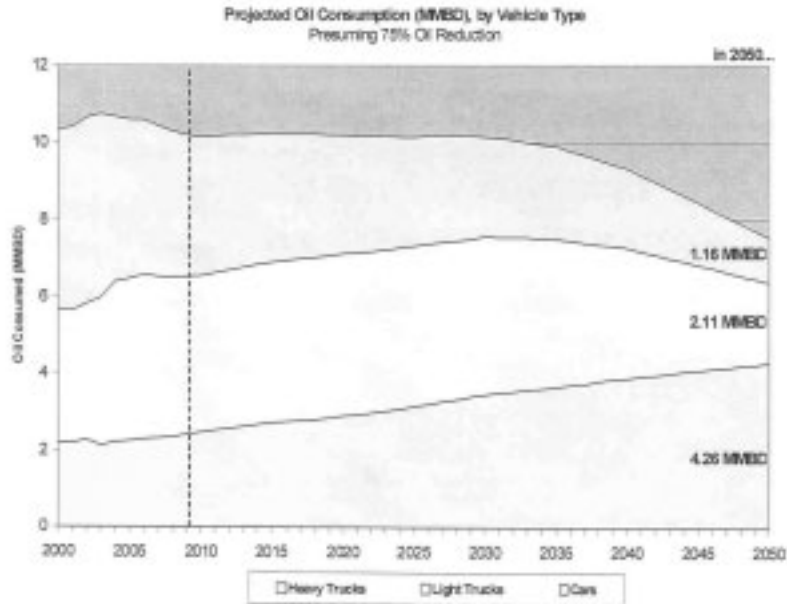
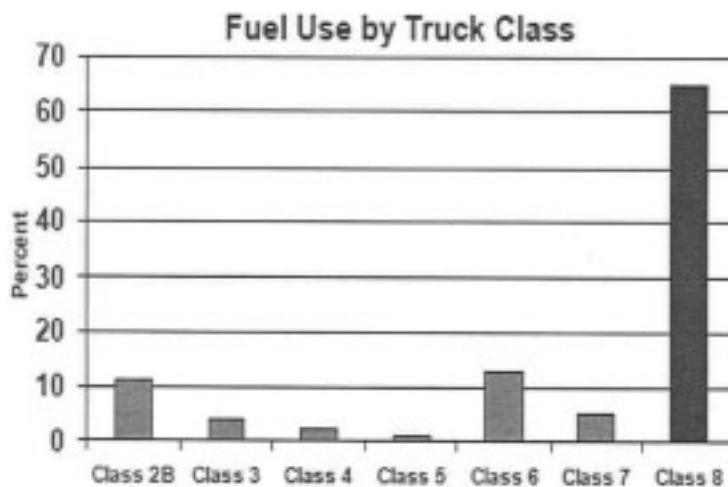


Chart 1

Overarching Approach—Vehicle Integration and Demonstration

Federal support for commercial truck technology during the past few years has focused on vehicle components and sub-systems. While this has generated encouraging results in laboratory demonstrations, it is essential that we now focus on technology that can be effectively deployed in real vehicle applications. Therefore, we propose a strong emphasis on initial design for vehicle integration and in-use demonstration. Further we propose that this demonstration program begin with Class 8 vehicles since they are the greatest consumers of petroleum among commercial trucks by virtue of the amount of work these vehicles accomplish, and an essential objective is to reduce our nation's dependence on foreign oil.



In his testimony before the Committee on Science and Technology Subcommittee on Energy and Environment of the U.S. House of Representatives, Steven Chalk, the Principal Deputy Assistant Secretary of the Department of Energy Office of Energy Efficiency and Renewable Energy, supported this concept. We applaud this effort by the Department to significantly move the 21st Century Truck Program forward.

To accomplish this overarching objective, research and development is required in the following areas:

1. Engine Technology

At 42 percent peak thermal efficiency, heavy-duty diesel engines are already the most efficient mobile energy converters in common use. Through joint R&D programs with the Department of Energy, the industry has already demonstrated the capability for an additional eight (8) percentage points of improvement in peak thermal efficiency in lab testing. The real challenge however, is to accomplish this in a truck within the emissions, operational, and vehicle constraints in a fully representative drive cycle. We strongly support the public-private partnership for such a demonstration program.

Engine technology opportunities include improved fuel injection at pressures exceeding 30,000 psi, in-cylinder combustion optimization, efficient intake and exhaust gas management using advanced turbochargers (variable geometry and multistage), superchargers, variable valve timing, and low temperature cooling of charge gases (air and recirculation). Energy losses due to engine friction, coolant/oil pumping, and other vehicle auxiliaries (such as air compressor or air conditioning) can be further minimized by using improved bearings, low-friction lubricants, and electric drive or mechanically variable pumps. Additional recovery of currently wasted exhaust gas energy can be accomplished using turbo-compounding, secondary Rankine cycle systems to generate either mechanical (torque) or electrical energy, or even direct thermo-electric conversion. Subsystem technologies, including materials, controls, and durability also need to be improved for a practical complete system.

Engine efficiency, over a real drive cycle, is enhanced by increasing the fraction of time that the engine actually runs in its most efficient speed and load region (the "sweet spot") and by minimizing drivetrain losses. Transmissions can be further developed to better maintain engine operation in the sweet spot, even as the vehicle load demand varies due to speed, load, terrain, and other factors. This effect can be further enhanced by fully integrating the engine, transmission, driveline, and ultimately hybrid systems. Low friction transmissions and rear axles may reduce vehicle energy demand by one to two percent. Powertrain integration work is necessary to translate the peak engine efficiency improvement into comparable complete vehicle fuel savings.

We also need to find ways to achieve 2010 emission levels at lower cost and with improved fuel efficiency, requiring a continuing focus on both in-cylinder emissions reduction and on exhaust after-treatment.

2. Medium- and Heavy-Duty Hybrids and Reduced Idle Solutions

Hybrid powertrains can offer significant fuel savings in stop-and-go applications. In fact, several fleets in heavy stop and go vocations have reported fuel savings in the range of 30–50 percent with both electric and hydraulic hybrid powertrains.

However, the bulk of Class 8 trucks are utilized in long-haul operations with much less cyclic duty-cycle. None-the-less, there are significant benefits to hybridize a Class 8 highway vehicle:

- 1) Reduced idle time utilizing the hybrid energy storage system
- 2) Reduced fuel use through electrification of components
- 3) Energy management during traffic induced speed variation and in rolling terrain.

It is estimated that truck idling uses close to two billion gallons of fuel per year for both overnight idling and workday idling. A reduction in idling has obvious benefits not only in reduced fuel usage but also from reduced emissions. There are many idle reduction strategies under tests by fleets today. However, few are integrated into the vehicle powertrain and consequently, results are less than optimal. Furthermore, an integrated hybrid system could reduce inefficient operation of the diesel at slow speed and light load. Research and development is required to fully realize the potential for an integrated electric hybrid powertrain with electrified auxiliaries (fan drive, coolant pump, air compressor, air conditioning and power steering). In addition, longer life and less expensive energy storage systems (batteries, ultra capacitors and hydraulic tanks) are required to complete this package.

3. Truck and Trailer Aerodynamics

Aerodynamic drag is the dominant force acting to impede the motion of a Class 8 tractor trailer operating on the highway. On level ground at 65 mph, aero drag is typically more than 50 percent of the total road load, thus yielding a one percent highway fuel economy improvement for each two percent of aero improvement.

The tractor and trailer operate as an aerodynamic system with strong interactions between the front (tractor) and rear (trailer) parts of the system. Traditional heavy vehicle aerodynamics development has focused on the front part of the system where tractor manufacturers compete vigorously on aerodynamic development and fuel economy. However, enormous opportunities exist in improving trailer aerodynamics and further opportunity exists through optimization of the airflow delivered from the tractor to the trailer.

There are two key areas of opportunity in tractor aerodynamics:

1. Improve sub-optimal parts of today's vehicles: chassis aero (including underbody) and tractor-trailer gap (transition of airflow from tractor to trailer)—five percent to ten percent aero improvement possible.
2. Develop improved tractor shapes that are optimized with aero-improved trailers, not current trailer shapes—seven percent to twelve percent aero improvement possible.

There is a broad consensus today that the greatest opportunity for aerodynamic improvement in the tractor trailer system is in improving trailer aerodynamic performance. There are a number of aerodynamic devices for trailers on the market today and a mounting body of performance data suggesting that many of these devices do, in fact, deliver significant aerodynamic improvement. Several individual devices have demonstrated on-highway fuel economy improvements of five percent or greater, and combinations of devices have demonstrated highway fuel economy improvements of 10 percent to 15 percent.

However, none of these devices appear to be achieving high rates of adoption into trucking fleets today, strongly indicating that more work needs to be done to improve performance, durability, operation, vehicle integration, or economic aspects of the design, and to better communicate known benefits of proven devices. The expertise of the industry partners should be brought to bear to help understand and overcome the objections to the current devices.

4. Fuels

Vehicular improvements alone will not achieve the full potential for petroleum and greenhouse gas savings. Cost-effective changes to fuels need to be considered.

Low carbon fuels and compatible engines will be necessary, building upon work already done in biofuels.

5. Infrastructure and Logistics

The full range of opportunities to reduce fuel use and carbon emissions of MD and HD trucks must also include operational issues, such as congestion mitigation (e.g., truck lanes, smart highways, smart vehicle technologies), regulatory changes (e.g., road-speed governing, heavier and longer vehicles), truck stops (e.g., electrification for idle reduction), and logistic improvements (e.g., improved or adaptive route planning, load management, driver training). These infrastructure improvements can dramatically reduce fuel consumption per vehicle and per freight volume-mile or ton-mile (perhaps up to 30 percent), with little cost to implement. However, each of these improvements will require a coordinated effort with vehicle manufacturers, suppliers, the Department of Transportation, and other agencies.

Intelligent Transportation Systems (ITS) can contribute to congestion mitigation, efficiency, safety, and security for commercial vehicles. Traffic congestion, crash avoidance, credentialing, weighing and inspection processes, transportation security and other commercial vehicle requirements can all be improved via the effective development of ITS through programs like Commercial Vehicle Infrastructure Integration (CVII or, more recently, IntelliDrive). 21CTP is willing to work with DOT to explore ways by which the new IntelliDrive program might be patterned after the voluntary and proven EPA SmartWay program.

6. Fuel Efficiency Assessment

With the tremendous variation in vehicle specifications and duty cycles, 21CTP should develop a fuel efficiency assessment method comprising a model, verified by testing on typical vehicles and accepted by industry, end-users, and government agencies. Consideration of both “ton miles per gallon” and “cubic feet miles per gallon” is necessary to cover the range of freight hauled.

7. SmartWay Program

The trucking industry has shown great support for the voluntary EPA SmartWay program, generating savings of some 700 million gallons of diesel fuel. 21CTP supports continuing SmartWay and seeks to find ways to gain additional fuel savings and environmental benefits by further development of the program.

Resource Requirements:

The Charter for the March 24th, 2009 hearing held by the Committee on Science and Technology’s Subcommittee on Energy and Environment of the U.S. House of Representatives notes that: “Funding for the Partnership steadily increased from \$45.6 million in FY99 to \$86.6 million in FY02. However, despite the potential economic and environmental benefits of improvement in trucks and the considerable technical hurdles that remain, the 21st Century Truck Partnership started to see a decrease in its funding in FY03 and hit a low of \$29 million in FY09.”

Dr. John H. Johnson, Presidential Professor at Michigan Technological University, participant in 12 different National Academy’s Committees, the Chair of the committee that reviewed the 21st Century truck Partnership in 2008, and a member of the Academy’s Committee on Light-Duty Vehicle Fuel Economy and the Committee on Medium- and Heavy-Duty Vehicle Fuel Economy, noted that “. . . it is important that the Federal Government fund the DOE program at levels such as \$200 million/year with \$90 million/year for engine emission control systems and bio-diesel fuels research. The program should be funded for five to ten years at this level so that the industry will have the technology in the 2015–2020 timeframe to meet potential fuel economy.” Further, Dr. Johnson notes: “. . . there is need for \$25 million per year for safety related research which should be designated for DOT by line item for the 21st Century Truck Partnership.”

The Partnership agrees fully with the aforementioned recommendations, but also suggests strongly that there is another critical issue—the Federal Government must remove conditions imposed by the traditional contracts awarding process that impede access to federal research funding in today’s economic times.

Virtually all of the partners, like many other American companies, are suffering through dire business conditions. They, along with small businesses, may be critically limited from participating because of a 50–50 cost share requirement. The Partnership thus recommends reconsideration of this traditional stipulation that should not apply in the current economy.

In Conclusion:

The heavy-duty vehicle industry is a small base of companies with a huge impact on petroleum consumption and our economic growth. Despite this, there has been minimal federal investment to address these many opportunities. We believe that funding of \$200 million annually in the Department of Energy, \$25 million in the Department of Transportation, and \$25 million in the Environmental Protection Agency is required to support these initiatives. The commercial vehicle industry comes together with governmental agencies within the 21st Century Truck Partnership, and we recommend that 21CTP serve as a focal point to create a longer-term vision for the future of commercial vehicle technology.

21st Century Truck Partnership Members

Allison Transmission, Inc.
BAE Systems
Caterpillar Inc.
Cummins Inc.
Daimler Trucks North America LLC
Detroit Diesel Corporation
Eaton Corporation
Mack Trucks, Inc.
Navistar, Inc.
Nova Bus
PACCAR Inc.
Volvo Trucks North America

JOINT STATEMENT OF CNH AMERICA LLC,
CATERPILLAR, INC.,
AND DEERE & COMPANY

We applaud the Subcommittee for holding this important hearing to examine vehicle technology research and development programs. The U.S. Department of Energy's (DOE) Vehicle Technologies Program (VTP) is designed to strengthen our nation's energy security, economic vitality, and environmental quality through public private partnerships. These public private partnerships have enhanced vehicle productivity and efficiency through the development and deployment of advanced technologies. Program activities have included research, development, demonstration, testing, and education.

As successful as the VTP has been at improving productivity and efficiency in on-highway applications, it has not thus far supported advancements in the important non-road market segments of construction, agriculture, forestry, mining, and lawn/turf care. Overall, relatively scant DOE resources have been devoted to funding non-road engine and equipment research and development aimed at improving productivity and decreasing fuel consumption. We believe the creation of a new non-road program focused on these areas within the DOE VTP would help spur investments in, and the development and deployment of, new advanced technologies to improve total machine and job site, or 'operational,' productivity and efficiency.

On May 11, 2004, the U.S. Environmental Protection Agency (EPA) finalized a comprehensive rule to reduce emissions from non-road diesel engines by integrating new engine and fuel controls as a system to achieve significant emissions reductions. Accordingly, we have been required to design, produce and use non-road engines with advanced emission-control technologies similar to those used for new on-highway trucks. The new emissions standards apply to diesel engines used in construction, mining, industrial, agricultural, forestry, and lawn and turf care equipment. The standards took effect for new engines beginning in 2008 and will be phased in through 2015.

Applying on-highway emissions reductions technologies to non-road engines, and engineering these engines into non-road equipment, is proving to be a significant engineering challenge, and is requiring an enormous investment. Complicating matters is the fact these technologies must be installed in equipment subject to exceptionally harsh operating environments where space is often very limited and where the installation must be done in a manner that will not interfere with the functionality of the equipment. This is resulting in the need for costly and complex equipment redesign. We and other non-road engine and equipment manufacturers are investing millions of dollars daily to meet EPA emissions standards.

Furthermore, while global harmonization in emission standards was largely achieved through EPA's leadership in the Tier 4 development, significant lack of global alignment in non-road emission regulation implementation remains. As a result of different regulatory timelines between the U.S., Europe, and Japan for non-road emissions regulations, we are facing additional complexity and cost.

The lack of alignment between these key regulated markets is exacerbated by the international nature of the non-road segments extending into far less regulated markets. This results in a grossly uneven playing field in the world marketplace and increases the complexity of manufacturing, marketing, distribution and servicing of products. As manufacturers compete in highly regulated markets, we must invest in the technology required for these markets, while our competitors serving less regulated markets focus their development spending on product features that contribute to direct customer buying motivations, thereby disadvantaging manufacturers serving highly regulated markets. Aggravating this challenge is the reality that the strongest growth and the greatest export opportunities lie in less regulated markets where competition is becoming more intense and the global playing field is becoming more divided.

The research and development dollars, along with other major investments, being dedicated in these difficult economic times to meet the Tier 4 standards significantly reduces our ability to robustly fund the development of new breakthrough technologies that would improve overall non-road machine and job site productivity and efficiency. It is this type of machine and operational technology research and development that would fit well within the existing VTP.

Diesel engines and equipment are the backbone of the American economy, contributing billions of dollars each year to our domestic growth. Their importance will surely expand, as they are an important tool used to accomplish the massive national efforts critical to the future success of our economy. Rebuilding a safe and efficient infrastructure upon which we can all rely; producing affordable and sustainable food, fiber, and fuel; and otherwise protecting and improving the world

around us requires diesel engines and equipment. And, while criteria pollutant emission levels from diesel engines used in non-road equipment are approaching near zero levels, it is likely that peak thermal efficiency will not significantly exceed 50 percent in the next twenty years. Accordingly, there are other components within non-road equipment systems that can yield greater overall efficiency benefits in performing these critical tasks at a much better cost-to-benefit ratio.

There are a number of non-road engine, machine component, and system areas where technology research and development through a new program within the VTP could yield promising results. Candidates include:

Engine Prime Power and Hybridization

Absence of ram air-cooling, combustion, fuel injection, charge air handling, heat recovery, materials, optimized operation regimes, and hydraulic and electric hybrids;

Aftertreatment Systems and Control

NO_x, Particulate matter, hydrocarbons, materials, subsystems and integration, and alternatives to SCR;

Power Electronics

Lightweight, reliability, durability, and control capability; standard for Class B voltage systems on non-road machines;

Energy Storage

Battery and ultra-capacitor technologies that can meet requirements for use in non-road applications;

Prime Power Energy Transmission

Transmission technologies for hybridization, electric drive, continuously variable transmission, and controls;

Fuels

Ultra-low sulphur diesel, low carbon, alternative, biomass derived, and renewable fuel performance and technological compatibility;

Analytical Modeling

Computer analysis for component and powertrain system optimization, application specific off-road conditions, climate and weather conditions;

Advanced Materials

Recyclability, durability, and life cycle analysis;

Fluid and Thermal Management

Friction, parasitics, advanced waste heat recovery, cooling system optimization, and system energy management;

Systems Integration

Fuel efficiency, productivity, and metrics harmonization;

Automation/Autonomy

Site/Fleet efficiencies, operator productivity, safety, utilization, information management, and GPS, remote sensing, and other telematics;

Energy Conversion

Auxiliary power and thermoelectrics.

In addition to research and technology development into various components and systems within the non-road machine, there are also promising opportunities to gain further efficiencies by improving the way these machines fit and work within the overall job/work site. There are numerous and significant efficiency gains to be had through further development of new breakthrough technologies that seek to garner reduced fuel consumption and minimize machine wear and tear by improving overall machine and operational efficiencies.

A total systems approach to productivity and efficiency is focused on the integration of the machine with the operations. In the case of non-road machines, research and development partnerships to deliver the best overall machine system solution

will significantly reduce fuel consumption, as well as improve overall job site efficiency.

Again, thank you for holding this hearing to examine this important program. Although gains have been made through this program in the on-highway market segment, there are significant opportunities in the non-road markets. These untapped market segments would significantly benefit from a new non-road program within the VTP, and the goals of the program would be more fully realized. We look forward to working with the Subcommittee on this important matter.

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