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TRANSPORTATION SECTOR FUEL EFFICIENCY

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

ON

TRANSPORTATION SECTOR FUEL EFFICIENCY, INCLUDING CHALLENGES TO AND INCENTIVES FOR INCREASED OIL SAVINGS THROUGH TECHNOLOGICAL INNOVATION INCLUDING PLUG-IN HYBRIDS

JANUARY 30, 2007

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TRANSPORTATION SECTOR FUEL EFFICIENCY

TUESDAY, JANUARY 30, 2007

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 2:31 p.m., in room SD–366, Dirksen Senate Office Building, Hon. Jeff Bingaman, chairman, presiding.

OPENING STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

The CHAIRMAN. Why don't we go ahead and get started. I am advised that Senator Domenici is delayed in a meeting but will be here as soon as he is able to.

Today we have a very important hearing on the state of fuel efficiency technology in the transportation sector and our prospects for reducing our reliance on oil in the U.S. economy. I have heard this reliance described as the oil intensity of our economy and this may be a useful way to capture what is an attainable goal for us in the near term.

In various ways we have been trying to reduce how much oil we use since the oil shocks of the 1970's. Those oil shocks focused the Nation's collective attention on the problem of the dramatic imbalance between our domestic supply and the consumption of oil in this country. We have had some modest successes. We have largely removed oil from power generation. We have reduced our use in home heating, and for about a decade, not the last decade but for a decade, we reduced our use in cars and trucks.

Since the mid-1980's, however, we have been losing ground in fuel efficiency. The transportation sector is now the leading consumer of energy in the United States. It accounts for over 80 percent of forecast increased oil demand in this country in the future. Consumers are paying more at the pump. Our environment is threatened as we risk triggering a dangerous warming cycle and our economic wellbeing and national security depend largely on unstable parts of the globe. So clearly we are not on a sustainable path at the current time.

Biofuels will be a part of the solution and a part that we will examine in depth on Thursday of this week in a workshop or conference that we are having in the committee. But since a typical vehicle only has an efficiency of about 20 percent, it seems clear that the best opportunity is to try to increase efficiency. Recent news about the development of new battery technologies, advanced concept vehicles with fuel economy ratings as much as two or three times what we have today, give us hope that the right Federal policies could help us make substantial progress on this front in the near future.

Questions that we are going to be looking at are how much progress on fuel economy can we realistically hope for in the near term with these advanced technologies? Second, how quickly can we get these new technologies deployed in this country? Third, what policies and programs at the Federal level will best encourage getting these technologies deployed?

Before we go to the witnesses from out of town, and we have many of them today, I wanted to recognize Senator Stabenow, who is the distinguished Senator from Michigan and is very focused on this set of issues and has been since she has come to the Senate. She does a great job representing Michigan in many, many ways. We welcome her and look forward to any comments she has.

[The prepared statements of Senators Murkowski and Sanders follow:]

PREPARED STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

Thank you Mr. Chairman for scheduling this hearing.

My belief is that we need a balanced policy to address the nation's energy need. That we need to promote renewable and alternative fuels, push fuel conservation and energy efficiency and promote more domestic sources of fossil fuels to meet this nation's energy needs.

Today's hearing certainly focuses on promoting alternative fuels and promoting energy efficiency. Given that nearly 70 percent of the oil we consume today goes to fuel the transportation sector—a percentage that could rise in the future—it is vital that we address transportation, by both encouraging efficiency and technology breakthroughs to reduce our dependence on imported oil.

I certainly am a supporter of raising the mileage that vehicles get for the fuel they consume. I support an increase in Corporate Average Fuel Efficiency (CAFE) standards. I'm sure most of us do. The question is how far we raise CAFE and how fast.

I recently introduced legislation, a companion bill to legislation introduced by my senior colleague Ted Stevens, that would raise CAFE to 40 miles per gallon by 2017, assuming that is technologically and economically feasible. My bill (S. 298) will also require that CAFE rating reflect the real-world performance likely from most vehicles. And the bill requires a study of extending a CAFE standard to commercial trucks—a provision that I am delighted to see one of the witnesses, FedEx, in his testimony also espouses.

My bill would provide additional funding for research into the battery issues inherent if we are to move toward plug-in hybrid vehicles. I gather that the $100 million I proposed in my bill is merely a downpayment on the likely cost of research to solve the research issues related to lithium-ion batteries that will be presented at this hearing.

I certainly am a supporter of the expanded use of bio-fuels, fuel that can be made in America and not have to be imported from overseas. Having said that I will be very interested in what makes sense, both economically and environmentally, in how far and how fast we push development of fuels like ethanol, made from corn, of cellulosic ethanol that could be made from a variety of fibers, and those other alternative fuels, from bio-diesels to methanol or butanol, not to mention hydrogen fuels.

In the Energy Policy Act we mandated that we use 7.5 billion gallons of ethanol by 2012, enough to replace other additives and provide a 10 percent content in gasoline in many air-attainment areas. It likely will require even more ethanol for it to make up 10 percent of all gasoline sold nationwide. E-85, fuel containing 85% ethanol and 15% hydrocarbon components, may also make sense. But I certainly will like to see more information on how well 85 does in cold climates, for example, and how much ethanol made from different base crops will be required to propel vehicles a given mileage. I know corn-based ethanol provides less energy per gasoline that gasoline. Does cellulosic ethanol have similar problems?

There are a lot of important issues to be addressed at this hearing. I look forward to hearing the testimony. Thank you.

PREPARED STATEMENT OF HON. BERNARD SANDERS, U.S. SENATOR FROM VERMONT

Chairman Bingaman, Ranking Member Domenici, today's hearing is so important. Our constituents want to get more out of every buck they put into their gas tanks; our environment is in trouble because of the greenhouse gas emissions spewing from the tailpipes of our cars; our national security is weakened by the fact that we import so much oil; and quite frankly, our domestic auto industry—and the economies and families dependent on it—is crumbling because they haven't been thinking with an eye toward the future. For all of these reasons, we must make our cars and trucks more efficient and we must do it soon.

In fact, I will not mince my words: a lack of federal leadership to increase mileage standards is a huge failure. It should be a source of embarrassment for all of us and I will talk to each and every one of my colleagues in the Senate about the dire need for action.

I appreciate the witnesses appearing in front of the Committee today and look forward to getting some important answers from them.

STATEMENT OF HON. DEBBIE STABENOW, U.S. SENATOR FROM MICHIGAN

Senator STEBENOW. Well, thank you, Mr. Chairman. I first want to thank you for your leadership and for all of the important work that the committee has done and will do. I look forward to working with you. We are really in this together about where we need to go as a country. So I appreciate the opportunity to be here to talk about a critical issue for those of us in Michigan, for our American automakers and really for the country.

I want to welcome three Michigan witnesses. I said to our chairman that, you are going to get an overdose of Michigan today, but we are very proud to offer our perspectives because of the important leadership that is being done in Michigan: Betty Lowery from General Motors in Detroit; John German from Honda in Ann Arbor; and Dr. Walter McManus from the University of Michigan.

I am very proud to represent people who work hard every day in this industry, and the auto industry is the linchpin of Michigan's economy, making up 22 percent of our State's work force. The Big Three employ nearly 400,000 Americans in 176 major facilities in 34 States. I think it is not an exaggeration to say that the automobile industry created the middle class of this country. As we move forward together, we need to achieve our goals and also allow them to continue to be strong and an important part of our middle class wage base.

Motor vehicle and auto parts are the biggest export from the United States, with $87 billion. In 2005 the Big Three exported 1.1 million cars and trucks. The auto industry has made efficiency a priority. It is very exciting to go to the North American Auto Show and see the technologies that are being introduced. My priority is to help them be able to do that as quickly as possible.

They are taking a number of steps to increase fuel efficiency. They are very important. The Big Three announced in June of last year that they will double their production of vehicles that use biofuels by 2010 and that is a very important step in achieving oil savings and moving us forward to energy independence.

I would like to submit a copy of a letter, Mr. Chairman, for the committee's record that indicates their commitment.

The CHAIRMAN. We will be glad to include that in our record. Thank you.

Senator STEBENOW. Thank you.

I also would indicate that it is going to be critical for us to make sure that the pumps at consumer-friendly service stations are available for those of us who are anxious to purchase or have purchased flex-fuel vehicles. Part of making this successful for consumers, of course, is something that the committee has looked at, which is addressing what happens in terms of the availability of pumps.

But just to give you just a quick moment about each of the Big Three automakers, one of the most exciting developments at General Motors is the new Volt, which is a plug-in hybrid car that is expected to be available in the next 3 years. I think we can have an important role in helping to make sure that happens. Not only does the Volt run on pure electricity, but its flex-fuel engine can be powered by E–85 ethanol, enabling the Volt to get 525 miles for every gallon of gasoline used in the E–85 blend.

Of course, the critical element here is battery technology and we need to be doing everything we can to support I think and, excuse the pun, jump-start this advanced technology to see how we can move this to the marketplace as quickly as possible.

Last September the U.S. Army became the first customer of GM's latest fuel cell technology with the Chevrolet Equinox fuel cell vehicle fleet. These vehicles will be used for non-tactical purposes on military bases in Virginia and California. They provide 186 miles of petroleum-free operating range and will save millions of dollars in fuel and refueling supply chain costs. It is exciting to see the first 100 hydrogen fuel cell vehicles that have been turned over to the Army. But there obviously is tremendous capacity, much more that we need to be doing.

If you go downtown to the Washington Auto Show—I hope you will have a chance—you will see the Ford Edge, the first driveable plug-in hydrogen fuel cell vehicle. The car is powered by compressed hydrogen and a plug-in battery pack that can be charged with a standard power cord. The Edge combines multiple advanced technologies to produce zero tailpipe emissions.

Our friends at Daimler-Chrysler have put their first fuel cell vehicles on the road, with more than 100 in operation worldwide. Most recently, Daimler-Chrysler announced that more than 20 Dodge Sprinter plug-in hybrid electricals will be placed in the United States over the next year to research further the needs for these vehicles in real world service.

Clearly the automakers are committed to alternative fuels and new fuel efficient technologies and I really believe that they are. Regardless of how we have gotten here, the focus is a laser focus on how we move these new technologies to market. The real question I would ask is what we can do to make it easier to create and implement the new technologies as quickly as possible both for American families so they have the vehicles that they want and the fuel efficiency that they need.

I believe the slowest route would be for Congress to again fight over CAFE standards, Mr. Chairman. I think there is a faster way to achieve the goal. We have already taken a critical step in establishing and using biofuels through the renewable fuel standard in the Energy Policy Act of 2005 and it is working. Now it is time to take this aggressively to the next level. We need to aggressively invest in biofuels research, establish the necessary infrastructure so that average consumers can pull up to the pump and choose American-grown fuel to fill their car.

We also need to expand our portfolio of biofuels and not rely completely on E–85 ethanol. Michigan State University, my alma mater, is an example of leading international research on cellulose ethanol and biofuels, which we need to aggressively invest in.

I am excited about the new farm bill, Mr. Chairman, and our will work with Chairman Harkin and those of us on the Agriculture Committee that care deeply about this, we have an opportunity to dramatically beef up an energy title that we put into the farm bill 5 years ago.

I also strongly believe that the Federal Government must make a real commitment to purchasing vehicles. The industry needs to know the market will be there so that they retool plants, which takes more than 1 year, and we have to opportunity, not only through the military but through others, to create that market. I believe we should set a standard for purchasing vehicles and that we should aggressively move forward.

We also know we need to invest in tax incentives, and I will not go through all of those, but we know that consumer tax credits, a manufacturing tax credit for retooling plants, as well as focusing on a number of other tax policies, will make a real difference in terms of an incentive.

Mr. Chairman, I would just say in closing that I really believe the Energy Committee and the Agriculture Committee and the Finance Committee working together can develop a very comprehensive national policy that allows us to do what we all want to do in terms of energy independence, fuel efficiency, moving us in the direction as a country that we need to go as it relates to biofuels and advanced technology vehicles.

There is a tremendous amount that we can do together. I believe we are up to the task. I hope that we will be able to act boldly and be able to require and assist that we move forward in a way that will allow us to achieve what I believe everyone wants to achieve.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much. Thanks for your leadership on this and thanks for being here today to participate.

Senator STEBENOW. Thank you.

The CHAIRMAN. Why don't we excuse you and bring forward the six witnesses who have come from industry primarily and some from academic settings to give us their views. While they are coming up, let me see if Senator Domenici has an opening statement that he wanted to make.

STATEMENT OF HON. PETE V. DOMENICI, U.S. SENATOR FROM NEW MEXICO

Senator DOMENICI. Senator, did you give an opening statement?

The CHAIRMAN. Yes, I did.

Senator DOMENICI. They are getting seated and I will make one. It will be brief, if you do not mind.

First, it is great to note the presence of some members of the committee that have not been able to attend heretofore. I am glad to see them. They are on your side. They are new faces that make this a very exciting committee for the foreseeable future, at least until we have another election. But then we do not want to have any impact on any of you. You are going to be in good shape by that time, having served your time here.

The CHAIRMAN. I do not know where we are going to put all the other chairs over here, Mr. Chairman, after the next election.

[Laughter.]

Senator DOMENICI. Well, that is a good point, Senator. We do not know. We might have to put some of yours in a back room while we have ours out here. I do not know.

But in any event, I want to add my thanks to the distinguished panel that is here before us for participating today. In his recent State of the Union address, the President laid out a rather worthy schedule with a goal to reduce our consumption of gasoline by 20 percent in 10 years. This is not the first time he has focused attention on transportation energy. At last year's State of the Union address, the President focused attention on the importance of reducing our Nation's Middle East oil dependence.

Our dependence on foreign oil has been growing for years. The number of miles that Americans drive has grown by about 3 percent every year since 1950. Today one out of every nine gallons consumed in the world, believe it or not, in the world, goes to American cars, trucks, and buses.

Now, I am not one who wrings his hands about that. The truth of the matter is we are a very highly productive country and therefore use a lot of transportation fuel. But I do think the opportunity is with us now to do something to reduce the amount and do it in such a way that we have a minimal effect on the lifestyle of Americans and the business of American companies.

More and more, the petroleum that fuels America's drivers is produced abroad. We imported only 20 percent in 1960. By 2005, 60 percent of petroleum came from overseas.

I believe it is a mistake to pit production measures and conservation measures against each other. We need to do both. I support policies to increase domestic petroleum, natural gas production, and I have come to believe that it is time for Congress to do something to improve transportation efficiency in this country.

The average fuel economy of a passenger automobile on the road today is 27.5 miles per gallon. It has been the same since 1985. One reason it has been the same for so long is that the fuel economy numbers were actually put up into the statute. The result has been years of deadlock while we could have been making real progress as new automobiles became available.

I believe that part of the solution is to give authority to set CAFE standards for our passengers to the Executive Branch. This is consistent with the approach we have already taken on trucks. The Secretary of Transportation should be required to set standards after balancing the need for energy security, environment, environmental concerns, and safety and cost. Both are hard, and will require bold action, but must be balanced with production measures as well as bold initiatives to diversify.

I support research on a broad range of vehicle technology and we are going to hear some of that today, some very exciting from those so-called plug-in hybrids. We need the whole story on the plug-ins, including what happens when the battery wears out, which comes—produces a rather startling surprise and shock to the owner. But certainly the cars, that kind of car, is becoming something very important. Energy companies and many other stakeholders are putting their resources behind them, and it is going to take a lot of hard work.

I look forward to your testimony and I thank you again, all of you, for coming and helping us as you are doing so willingly today.

Thank you very much, Mr. Chairman. Fellow Senators, it is good to be with you.

The CHAIRMAN. Thank you very much.

Why don't we start with Beth Lowery, who is the vice president for Public Policy for Energy and the Environment with General Motors in Detroit. We are glad to have you here.

If each of you could take 5 to 7 minutes and summarize the main points you think we need to be aware of, that would be appreciated. We will put your full statement in the record as if it were testified to.

STATEMENT OF ELIZABETH LOWERY, VICE PRESIDENT, ENVIRONMENT AND ENERGY, GENERAL MOTORS CORPORATION

Ms. LOWERY. Good afternoon, Mr. Chairman, members of the committee. It is a pleasure to be here. My name is Beth Lowery, vice president for General Motors for environment and energy. I am pleased to speak to you regarding GM's plans for development and implementation of advanced technologies. Senator Stabenow added some already to the record, but to go into a little more detail.

Today's automotive industry provides more in the way of opportunity and challenges than we have seen in our entire history. On the challenge side, there are serious concerns about energy supply, energy availability, sustainable growth, the environment, and even national security issues. We collectively refer to these as energy security.

The key is energy diversity, in which we can help displace quantities of oil that are consumed by U.S. vehicles today. This is a huge assignment for us. It is also an extraordinary opportunity. By developing alternative sources of energy and propulsion, we have the chance to mitigate many of these issues surrounding energy availability. This means we must continue to improve the efficiency of the internal combustion engine as we have for decades. But it also means we need to dramatically intensify our efforts to displace petroleum-based fuels by building more vehicles that run on alternatives such as E–85 ethanol and, very importantly, by significantly expanding and accelerating our commitment to the development of electrically driven vehicles.

First let me speak just a few minutes about biofuels. We have made a major commitment to vehicles that run on E–85 ethanol. Last year we committed to double our production of vehicles capable of running on fuels by 2010 and that is about almost one million E–85-capable vehicles a year by the end of the decade, the single largest commitment to renewable fuels in the Nation's history.

But that is not all. Late last year we also said that we are prepared to make fully half, 50 percent, of our annual vehicle production biofuel capable by 2012 provided there is ample availability and distribution of E–85 as part of our overall national energy strategy.

But as you know, flex-fuel vehicles alone will not get the job done. So we are also partnering with government, fuel providers, and fuel retailers across the United States to help grow the E–85 ethanol fueling station infrastructure. Since May 2005 GM has helped add 175 new E–85 fueling stations in 11 States, with more to come.

Now let me turn to a potentially even more exciting opportunity for the future of our products, electrification of the automobile. Over the last few months GM has made several announcements related to our commitment to electrically driven vehicles. It is a continuum of electrification of vehicles. We are working the entire range. For example, what most people think of as electric vehicles are pure battery-powered vehicles, which generally have been hampered by the inability to include enough battery power on the vehicle to provide adequate driving range. Then there are gas-electric hybrids, which are not per se electric vehicles but which in part are electrically driven. This type of conventional hybrid vehicle has an internal combustion engine and electric drive. It can be powered by both systems simultaneously or by either system independently.

The electric energy in a conventional hybrid vehicle is created by the vehicle and stored on board in a battery. GM's heavy-duty diesel-hybrid transmissions used in transit buses and the Saturn Vue Greenline on the road today are hybrids such as that.

GM is also introducing later this year our advanced two-mode hybrid on our full-sized SUVs and pickups. At the LA Auto Show we announced the plug-in hybrid, a conventional hybrid vehicle with an important difference: The battery will be much more advanced, storing significantly more energy, and of course it will be able to be plugged into a standard 110-volt outlet for recharging. The result will be significantly better fuel economy based on the petroleum consumption of the vehicle and the ability to use diverse energy sources.

No major OEM has built a plug-in hybrid for retail sale because the required battery technology does not yet exist. In fact, given what we know today, it is pretty clear that it will take several years to see if the battery technology will occur and be able to bring it to market. It must meet the expectations of the customers, things like safety, reliability, durability, driving range, recharge time, and affordability.

In this vein, earlier this month we unveiled the Chevrolet concept vehicle the Chevrolet Volt at the Auto Show in Detroit. The Chevrolet Volt is designed to be powered by GM's next generation electric propulsion system, the E-Flex system. The concept Chevrolet Volt can be charged by plugging into the standard 110-volt outlet approximately 6 hours a day. When the advanced lithium ion battery is fully charged, the Volt is expected to deliver 40 city miles of pure electric range.

When the battery pack is close to depletion, the small engine spins at a constant speed to create electricity and replenish the battery pack. To make this concept a reality, we need a low-cost lithium ion battery pack that is proven to be reliable and durable in the many different environments in which our vehicles operate.

There are other types of electrically driven vehicles that we expect to see in the future as well, including hydrogen fuel cell vehicles. As part of a comprehensive deployment plan named Project Driveway, we are building more than 100 next generation fuel cell vehicles that will operate and refuel in California, New York, and Washington, D.C.

So the technology front and the vehicle development and design looks very exciting and promising. As we pursue these technologies and more energy diversity, there are steps the Government can take to help. First, the Government should fund a major effort to strengthen domestic advanced battery capabilities. Governments in other countries are already working on this issue with their own domestic manufacturers. We should do the same. Government funding should increase for R&D in this area and develop new support for domestic manufacturing of advanced batteries.

Second, biofuel production and infrastructure should be significantly expanded. Government should continue incentives for the manufacturer of biofuel capable vehicles, increase in biofuel production, increases for R&D into cellulosic ethanol, and increase support for broad-based infrastructure conversion.

Third, government funding should continue and expand in development and demonstration for hydrogen and fuel cell vehicles. Funding should continue for hydrogen and fuel cell R&D and demonstration activities at the Department of Energy.

Fourth, government purchasing should set an example. The Government should continue to purchase flex-fuel vehicles, demand maximum utilization of E–85 in the Government flex-fuel fleets, use Federal funding to stimulate publicly accessible pumps, provide funding for purchase of electric, plug-in and fuel cell vehicles into Federal fleets as they become available.

Finally, there should be further incentives for advanced automotive technologies so that these technologies may be adopted by consumers in large numbers. Consumer tax credits should be focused on technologies that have the greatest potential to actually reduce petroleum consumption.

In summary, we believe tomorrow's automobiles must be flexible enough to accommodate many different energy sources, from conventional gasoline and diesel fuel to biofuels that can displace them like E–85 and biodiesel, to electricity, whether it is stored or generated on the vehicle, with an internal combustion engine or a hydrogen fuel cell. We see a logical journey from stand-alone largely mechanical automobiles that we have today to vehicles that run on electricity.

Thank you very much.

[The prepared statement of Ms. Lowery follows:]

PREPARED STATEMENT OF ELIZABETH LOWERY, VICE PRESIDENT, ENVIRONMENT AND ENERGY, GENERAL MOTORS CORPORATION

Good afternoon. My name is Elizabeth Lowery and I am Vice President for Environment and Energy at General Motors. I am pleased to be able to speak to you today regarding GM's plans for development and implementation of advanced technologies.

Today's automotive industry provides more in the way of opportunities—and challenges—than we have seen in its entire history. On the challenge side, there are serious concerns about energy supply, energy availability, sustainable growth, the environment, and even national security issues that, collectively, have come to be called "energy security." And the fact of the matter is that it is highly unlikely that oil alone is going to supply all of the world's rapidly growing automotive energy requirements. For the global auto industry, this means that we must—as a business necessity—develop alternative sources of propulsion, based on alternative sources of energy in order to meet the world's growing demand for our products. The key is energy diversity, which can help us displace substantial quantities of oil that are consumed by U.S. vehicles today.

This is a huge assignment. But it's also an extraordinary opportunity. By developing alternative sources of energy and propulsion, we have the chance to mitigate many of the issues surrounding energy availability. We will be able to better cope with future increases in global energy demand. We will minimize the automobile's impact on the environment.

This means that we must continue to improve the efficiency of the internal combustion engine, as we have for decades. But, it also means we need to dramatically intensify our efforts to displace petroleum-based fuels by building more vehicles that run on alternatives, such as E-85 ethanol, and, very importantly, by significantly expanding and accelerating our commitment to the development of electrically driven vehicles.

First let me speak about biofuels. We believe that the biofuel with the greatest potential to displace petroleum-based fuels in the U.S. is ethanol. We have made a major commitment to vehicles that can run on E-85 ethanol. We now have more than 2 million E-85 capable vehicles on the road. Last year, we committed to double our production of vehicles capable of running on renewable fuels by 2010. That's almost one million E-85 capable vehicles a year by the end of the decade—the single largest commitment to renewable fuels in our nation's history. But that's not all. Late last year, we also said that we are prepared to make fully half of our annual vehicle production biofuel—capable by 2012—provided there is ample availability and distribution of E-85, as part of an overall national energy strategy.

But as you know, flex-fuel vehicles alone will not get the job done. Right now, there are about 170,000 gas stations in the United States and only about 1,000 E-85 pumps. So, we are also partnering with government, fuel providers, and fuel retailers across the U.S. to help grow the E-85 ethanol fueling station infrastructure. Since May of 2005, we've helped add 175 E-85 fueling stations in 31 states with more to come.

Now let me turn to potentially the even more exciting opportunity for the future of our products electrification of the automobile. Over the last few months, GM has made several announcements related to our commitment to electrically driven vehicles. The benefits of electricity include the opportunity to diversify fuel sources "upstream" of the vehicle. In other words, the electricity that is used to drive the vehicle can be made from the best local fuel sources—natural gas, coal, nuclear, wind, hydroelectric, and so on. So, before you even start your vehicle, you're working toward energy diversity. Second, electrically driven vehicles—when operated in an all-electric mode—are zero-emission vehicles. And when the electricity itself is made from a renewable source, the entire energy pathway is effectively greenhouse gas emissions free. Third, electrically driven vehicles offer great performance—with extraordinary acceleration, instant torque, and improved driving dynamics.

There is a continuum of electrification of vehicles—and we are working along that entire range. For example, there are what most people think of as "electric vehicles"—pure battery-powered vehicles, such as GM's EV1. The EV1 ran solely on electricity that was generated outside the vehicle and was stored onboard the vehicle, in lead-acid and nickel-metal-hydride batteries.

Then there are gas-electric hybrids—which are not, per se, electric vehicles—but which are, in part, electrically driven. This type of conventional hybrid vehicle has both an internal combustion engine and an electric drive. And, it can be powered by both systems simultaneously or by either system independently. The electric energy in a conventional hybrid vehicle is generated by the vehicle itself and stored onboard in a battery.

We have several kinds of hybrid vehicles, either on the road or under development—from the heavy duty hybrid that is used in more than 550 transit buses—to the Saturn VUE Green Line (which uses our high-value "belt alternator starter" system and gets the highest highway fuel economy of any SUV on the market)—to our advanced "two-mode" hybrid system (which will begin to show up on our full-size SUVs and pickups later this year).

At the Los Angeles auto show, we announced work on another type of hybrid, the Saturn VUE "plug-in hybrid." A plug-in hybrid will be a conventional hybrid vehicle with an important difference—the battery will be much more advanced—storing significantly more energy and, of course, being able to be plugged into a standard outlet to recharge it. The result will be significantly better "fuel economy"—based on the petroleum consumption of the vehicle—and the ability to use diverse energy sources.

No major OEM has built a plug-in hybrid for retail sale because the required battery technology doesn't yet exist. In fact, given what we know today, it's pretty clear that it will take several years to see if the battery technology will occur that will let us bring to market, a plug-in hybrid that will meet the expectations and real-world performance standards that our customers expect—things like safety, reliability, durability, driving range, recharge time, and affordability.

The Saturn VUE plug-in hybrid will use an advanced battery, like lithium-ion. Production timing will depend on battery technology development. But, based on our work with EV1 and our different conventional hybrid-electric vehicles, we already have a lot of experience developing and integrating advanced battery technology into our vehicles, and we're already working today with a number of battery companies to develop the technology necessary to build a plug-in hybrid. The technological hurdles are real, but we believe they're also surmountable. I can't give you a date certain for our plug-in hybrid, but I can tell you that this is a top priority program for GM, given the huge potential it offers for oil consumption improvements.

Earlier this month, we unveiled the Concept Chevrolet Volt at the North American International Auto Show in Detroit. The Chevrolet Volt is designed to be powered by GM's next-generation electric propulsion system, the E-flex System. The E-flex System can be configured to produce electricity for mechanical propulsion from gasoline, ethanol, biodiesel or hydrogen. The Volt uses a large high energy battery pack and a small, one liter turbo gasoline engine to produce electricity.

The Concept Chevrolet Volt can be charged by plugging it into a 110-volt outlet for approximately six hours each day. When the advanced lithium-ion battery pack is fully charged, the Volt is expected to deliver 40 city miles of pure electric vehicle range. When the battery pack is close to depletion, the small engine spins at a constant speed to create electricity and replenish the battery pack.

One technological breakthrough required to make this concept a reality is the large lithium-ion battery pack. This type of electric car, which the technical community calls an "EV range-extender," would require a battery pack that weighs nearly 400 pounds.

There are other types of electrically driven vehicles that we expect to see in the future as well, including hydrogen fuel cell vehicles, such as the Chevrolet Sequel concept vehicle. A hydrogen fuel cell vehicle is, in fact, an electric vehicle. It drives on electricity that is created by the fuel cell. The fuel cell is little more than a battery that stores electricity in the form of hydrogen. The beauty of a fuel cell vehicle like the Sequel is that the electricity is generated onboard the vehicle without using petroleum-based fuel, and without emissions. And like electricity, hydrogen can be made from diverse energy sources before it ever powers a vehicle. As part of a comprehensive deployment plan dubbed Project Driveway, we are building more than 100 next-generation Chevrolet Equinox Fuel Cell vehicles that will operate and refuel with hydrogen in California, New York, and Washington D.C.

GM is developing a prototype fuel cell variant of the Chevy Volt that mirrors the propulsion system in the Chevrolet Sequel (fuel cell vehicle). Instead of a big battery pack and a small engine generator used in the Volt concept vehicle, we would use a fuel cell propulsion system with a small battery to capture energy when the vehicle brakes. Because the Volt is so small and lightweight, we would need only about half of the hydrogen storage as the Sequel to get 300 miles of range. In fact, we continue to make significant progress in this area, and we continue to see fuel cells as the best long-term solution for reducing our dependence on oil.

So, the technology front in automobile development and design looks very exciting. And, as we pursue these technologies—and more energy diversity—there are steps the government can take to help.

- First, the government should fund a major effort to strengthen domestic advanced battery capabilities. Advanced lithium-ion batteries are a key enabler to a number of advanced vehicle technologies—including plug-in hybrids. Government funding should increase R&D in this area and develop new support for domestic manufacturing of advanced batteries.
- Second, biofuels production and infrastructure should be significantly expanded. The market response to renewable fuels is encouraging, but it needs to reach a self sustaining level that is not lessened when gasoline prices fall. Steps to

increase the availability of biofuels should help increase its use. Government should continue incentives for: the manufacture of biofuel-capable flex fuel vehicles; increases in biofuels production; increases for R&D into cellulosic ethanol; and increased support for broad-based infrastructure conversion.

- Third, government funding should continue and expand development and demonstration of hydrogen and fuel cells. Tremendous progress has been made this decade on fulfilling the promise of hydrogen powered fuel cells. The U.S. needs to stay the course on the President's hydrogen program and begin to prepare for the 2010-2015 transition to market phase. Funding should continue for hydrogen and fuel cell R&D and demonstration activities at DOE. The government should also commit to early purchases by government fleets and support for early refueling infrastructure in targeted locals in the 2010-2015 timeframe.
- Fourth, government purchasing should set the example. Government fleets can help lead the way to bringing new automotive technology to market and bringing down the cost of new technologies. 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; provide funding to permit purchase of electric, plug-in and fuel cell vehicles into federal fleets as soon as technology is available.
- Finally, there should be further incentives for advanced automotive technology so that these technologies may be adopted by consumers in large numbers to help address national energy security. Well crafted tax incentives can accelerate adoption of new technologies and strengthen domestic manufacturing. Consumer tax credits should be focused on technologies that have the greatest potential to actually reduce petroleum consumption and provide support for manufacturers/suppliers to build/convert facilities that provide advanced technologies.

In summary, we believe tomorrow's automobiles must be flexible enough to accommodate many different energy sources. And a key part of that flexibility will be enabled by the development of electrically driven cars and trucks. From conventional gasoline and diesel fuel—to biofuels that can displace them, like E85 and biodiesel—to electricity—whether it is stored or generated on the vehicle, with an internal combustion engine or a hydrogen fuel cell—we see a logical journey from standalone, largely mechanical automobiles to vehicles that run on electricity.

The CHAIRMAN. Thank you very much.

Next we have John German, who is the manager of Environmental and Energy Analyses with the Product Regulator Office of American Honda Motor Company in Ann Arbor, Michigan. Thank you for being here.

STATEMENT OF JOHN GERMAN, MANAGER, ENVIRONMENTAL AND ENERGY ANALYSIS, PRODUCT REGULATOR OFFICE, AMERICAN HONDA MOTOR COMPANY, INC.

Mr. GERMAN. Thank you. Good afternoon, Mr. Chairman, members of the committee.

I agree with Beth Lowery that the industry is in a period of unprecedented technology development. This encompasses everything from gasoline engines and transmissions to diesels, hybrid electric vehicles, fuel cells, and alternative fuel vehicles. Since 1987 technology has gone into the fleet at a rate that could have improved fuel economy by almost 1.5 percent per year if it had not gone to other attributes valued more highly by consumers, such as performance, luxury, utility, and safety. There is no reason why this technology trend of improved efficiency should not continue in the future.

This is illustrated by the light duty truck CAFE increases required by NHTSA of about 1.2 percent per year from 2005 to 2011. The challenge is to implement it through fuel economy instead of other customer attributes.

Gasoline technology development is still progressing rapidly. Even with the efficiency improvements of the last 25 years, the energy efficiency of the typical gasoline vehicle is still less than 20 percent during normal driving. My written testimony includes a list of conventional gasoline technologies that have already been introduced into the market and can be spread across other vehicles in the future.

Honda's overall philosophy is to be a company that society wants to exist. This is illustrated by our leadership in vehicle technology, including emission controls, conventional vehicle efficiency, and hybrid vehicle development. For example, Honda pioneered variable valve duration lift and now uses that on all of our vehicles, while penetration in the rest of the vehicle fleet is only a percent or two. Technology leadership is what makes our vehicles more fuel efficient.

Honda has announced plans to introduce two new gasoline engine efficiency technologies within the next 2 years. We will add continuously variable valve lift and timing to our four cylinder i-VTEC technology and we will improve variable cylinder management technology for six cylinder engines. Each technology should improve efficiency by more than 10 percent.

Even longer term are gasoline technologies such as homogeneous charge compression ignition, camless valve actuation, and variable compression ratio. While production time lines are uncertain, these advance technologies offer the potential to increase gasoline engine efficiency to near-diesel levels.

Diesel engines have also seen dramatic improvements in recent years and several manufacturers, including Honda, have announced production plans for diesel vehicles that meet the latest emission standards. Honda's next generation diesel engine features the world's first NOx reduction catalyst that both traps nitrogen oxides and stores and uses ammonia to turn NOx into harmless nitrogen, all without the need for urea.

Honda is the only company that continues to offer a dedicated compressed natural gas vehicle, the third generation Civic GX. We recently introduced a natural gas home refueling system, called Phill, which will expand the market beyond fleets to retail customers. This experience with gaseous home refueling provides the know-how that can help us succeed with distributed hydrogen infrastructure in the long term.

Hybrid electric vehicles are in their second and third generation, with many recent introductions. Honda's latest hybrid, the 2006 Civic hybrid, incorporated significant improvements to the battery, electric motor, and hybrid operating strategy to improve both efficiency and performance. Honda's next step in hybrid vehicle development will be the introduction of an all-new hybrid car to be launched in North America in 2009. This new model will be sold only with a dedicated hybrid power train and will have a target price lower than that of the current Civic hybrid.

Plug-in hybrid vehicles have a lot of promise to displace oil consumption and are being evaluated by a number of manufacturers, including Honda. They need and deserve future research—further research and development. However, there are a number of technology, consumer acceptance, environmental, and cost issues that still need to be addressed.

The principal issue is that the durability of the battery pack must be significantly improved while simultaneously slashing the cost. The American Council for an Energy Efficient Economy recently published a report assessing fuel savings and costs for plug-in hybrids. Even if the battery pack cost is reduced by 80 percent and the durability is also improved to last the life of the vehicle, at $3 per gallon the payback period is still about 6 years compared to a similar conventional vehicle and about 13 years compared to a similar hybrid vehicle.

While some customers value fuel savings more highly, as Dr. Greene will explain, the average new vehicle customer only values the fuel savings for roughly 2 to 3 years. Thus it is difficult to see a substantial market for plug-in hybrids unless fuel shortages occur or there is a genuine breakthrough in energy storage.

Development of all technologies is accelerating in response to growing concerns about energy security and global warming. Fuel cells might be the final solution some day, but hydrogen production, transport, and storage will be extremely challenging. Biofuels are promising and can replace some fuel use, but even development of cellulosic ethanol only has the potential to displace at most about 20 percent of the world's oil demand. Also in order to achieve significant market penetration, any alternative technology must be at least as cost effective as gasoline and diesel engines.

The point is that there is no magic bullet. To achieve energy sustainability we need rapid development and implementation of as many feasible technologies as possible. To put this into context, a 10 percent market penetration for plug-in hybrids would only save as much fuel as a 3 percent increase in CAFE standards.

Different companies are working on different technologies, which is the optimal way. It makes good competition. Technology-specific mandates disrupt this process and are counterproductive. Previous attempts to mandate specific technologies have a poor track record, such as the attempt to promote methanol in the 1990's and the California electric vehicle mandate. The Government should not try to pick winners and losers.

As Honda has previously announced, we believe it is time for the Federal Government to take action to improve vehicle economy. Given the rapid changes in technology, performance-based requirements and incentives are essential to moving the ball forward. For example, the NHTSA already has the authority to regulate vehicle efficiency and Honda has called upon the agency to increase the stringency of the fuel economy requirements. At the same time, Congress should develop a program of broad performance-based incentives to stimulate demand in the market for efficient vehicles.

I appreciate the opportunity to present Honda's views. I would be happy to address any questions you may have.

[The prepared statement of Mr. German follows:]

PREPARED STATEMENT OF JOHN GERMAN, MANAGER, ENVIRONMENTAL AND ENERGY ANALYSIS, PRODUCT REGULATORY OFFICE, AMERICAN HONDA MOTOR COMPANY, INC.

Good afternoon Mr. Chairman and members of the Committee. My name is John German and I am Manager of Environmental and Energy Analysis with American Honda Motor Company. We thank you for the opportunity to provide Honda's views on the subject of transportation sector fuel efficiency and the potential for increased oil savings through technological innovation.

INTRODUCTION

The automotive industry is in a period of unprecedented technology development, encompassing everything from gasoline engines and transmissions to diesels, hybrid-electric vehicles, plug-in hybrids, fuel cells, and vehicles powered by alternative fuels. In part, this is because technology has been steadily improving ever since the first oil crisis in the early 1970s and the easy improvements have already been done. Up until now this new technology has been employed primarily to respond to vehicle attributes demanded by the marketplace, such as performance, luxury, utility, and safety, rather than to increase fuel economy. The figure on the left shows the changes in vehicle weight, performance, and proportion of automatic transmissions since 1980 in the passenger car fleet. Even though weight increased by over 500 pounds from 1987 to 2000, 060 performance improved by about 5 seconds (from just under 15 seconds to under 10 seconds), and the proportion of manual transmissions dropped in half, fuel economy remained relatively constant.

It is clear that technology has been used for vehicle attributes which consumers have demanded or value more highly than fuel economy. The figure on the right compares the actual fuel economy for cars to what the fuel economy would have been if the technology had been used solely for fuel economy instead of performance and other attributes. If the current car fleet were still at 1981 performance, weight, and transmission levels, the passenger car CAFE would be almost 38 mpg instead of the current level of 28.1 mpg. The trend is particularly pronounced since 1987. From 1987 to 2006, technology has gone into the fleet at a rate that could have improved fuel economy by almost 1.5% per year, if it had not gone to other attributes demanded by the marketplace.

There is no reason why this technology trend of improved efficiency should not continue in the future. Even with the efficiency improvements of the last 25 years, the energy efficiency of a typical gasoline vehicle is still less than 20% during typical driving, so there is a lot of room for improvement given sufficient leadtime for technology development. This is supported by the LDT CAFE increases required by NHTSA for the 2005 through 2011 model years of about 2.1% per year. The challenge is to implement it to improve fuel economy instead of attributes valued more highly by consumers.

GASOLINE VEHICLE TECHNOLOGY

Gasoline technology development is still proceeding rapidly. Many of the technologies in the current fleet are only offered on a relatively small portion of vehicles. Following is a list of conventional gasoline vehicle technologies that have already been introduced in the market and can be spread across other vehicles in the future:

- Variable valve timing and lift
- 4-valve per cylinder overhead cam engines
- Reduced engine friction
- Direct injection engines, both with and without turbocharging
- 5-speed, 6-speed, 7-speed, and even 8-speed transmissions
- Continuously variable automatic transmissions (CVT)
- Dual-clutch automated manual transmissions (works like an automatic, but more efficient)
- Lightweight materials
- Low rolling resistance tires
- Improved aerodynamics
- Cylinder deactivation (for example, an 8-cylinder engine shuts off 4 cylinders during cruise conditions)
- Idle-off (the engine stops at idle)
- Improved auxiliary pumps (power steering, water, oil, fuel) and air conditioning systems

Assessing the overall fuel economy improvements from these technologies is a difficult task and is beyond the scope of our comments. However, the 2002 National Academy of Science report on CAFE did a reasonable job of assessing the benefits and costs of most of these technologies and is a useful summary.

Honda has a long history of being a technology and efficiency leader. Our overall philosophy is to be a company that society wants to exist. One of the results of this philosophy is Honda's leadership on vehicle technology, including emission controls, conventional vehicle efficiency, and hybrid vehicle development. For example, while virtually all Honda engines have been aluminum block with overhead camshafts and 4-valves per cylinder since 1988, this technology is still used on less than 70% of the entire vehicle fleet. Another technology pioneered by Honda is variable valve timing and lift (i-VTEC). While Honda is now using variable valve timing and lift in all of our vehicles, penetration in the rest of the vehicle fleet is only a percent or two. Honda is also a leader in the use of high-strength steel. Technology leadership is what makes our vehicles more fuel efficient.

For the future, Honda has announced plans to introduce two new efficiency technologies within the next two years. One is a more advanced version of Honda's four-cylinder i-VTEC technology. Honda has improved its VTEC (Variable Valve Timing and Lift Electronic Control System) technology with the development of the Advanced VTEC engine, which provides high performance along with outstanding fuel economy and lower emissions. The new engine combines continuously variable valve lift and timing control with the continuously variable phase control of VTC (Variable Timing Control) to achieve a world-leading level of performance and a 13% improvement in fuel efficiency versus our current VTEC engine.

The second is a more advanced Variable Cylinder Management (VCM) technology for six-cylinder engines with up to an 11 percent improvement in fuel efficiency.

Even longer term is work on gasoline technologies such as Homogeneous-Charge Compression-Ignition (HCCI), camless valve actuation, and variable compression ratio. HCCI can improve efficiency up to 30%, but control of the self-ignition is very difficult. The self-ignition region needs to be expanded and it may require camless valve actuation, such as electro-magnetic valves.

Camless valves would eliminate throttling losses and significantly improve efficiency. They would enable additional combustion efficiency improvements by switching from HCCI operation at light load to Atkinson cycle at medium load and Otto cycle for maximum performance.

Variable compression ratio increases compression ratio at lighter loads to improve efficiency, while maintaining power by reducing compression ratios at high loads. This technology may be especially effective when combined with turbocharging.

While production timelines are uncertain, these advanced technologies offer the potential to increase gasoline engine efficiency to near-diesel levels.

DIESELS

Diesel engines have seen dramatic improvement in recent years and several manufacturers, including Honda, have announced production plans for diesel vehicles meeting the US Tier 2 bin 5 emission standards. Honda will introduce a 4-cylinder diesel in the U.S. market in 2009. We are also working on the development of V6 diesel engine technology, which is a key development goal for Honda.

Gasoline engines presently employ three-way catalytic converters that offer NOx reduction rates as high as 99 percent, but this performance is possible only at stoichiometric air-fuel ratio. In the oxygen-rich environment of a lean-burn diesel engine, three-way catalytic converters only reduce NOx levels by approximately 10 percent. Honda's next-generation diesel engine employs a revolutionary NOx catalytic converter that efficiently reduces NOx in a lean-bum atmosphere. This catalytic converter features the world's first innovative system using the reductive reaction of ammonia generated within the NOx catalytic converter to "detoxify" nitrogen oxide (NOx) by turning it into harmless nitrogen (N_2).

The new catalytic converter utilizes a two-layer structure: one layer adsorbs NOx from the exhaust gas and converts a portion of it into ammonia, while the other layer adsorbs the resulting ammonia, and uses it later in a reaction that converts the remaining NOx in the exhaust into nitrogen (N_2). Ammonia is a highly effective reagent for reducing NOx into N_2 in an oxygen-rich, lean-bum atmosphere. This ability to generate and store ammonia within the catalytic converter has enabled Honda to create a compact, lightweight NOx reduction system for diesel engines. The system also features enhanced NOx reduction performance at 200-300 °C, the main temperature range of diesel engines.

Honda designed the catalytic converter for use with its 2.2 *i*-CTDi diesel engine, which has earned widespread praise for quiet, clean operation and dynamic performance since its introduction in 2003 on the European Accord model.

By further advancing combustion control, the 2.2 *i*-CTDi delivers cleaner exhaust to the NOx catalytic converter. Honda achieved this by optimizing the combustion chamber configuration, reducing fuel injection time with a 2,000-bar common rail injection system and boosting the efficiency of the EGR (exhaust gas recirculation) system. Thanks to these improvements, Honda has reduced the amount of NOx and soot normally found in engine exhaust, while increasing power output.

Along with developing superior technology for cleaning exhaust gas, Honda plans to address other technical challenges in developing clean diesel engines. Two key challenges are meeting U.S. on-board diagnostic system requirements and the lower cetane number in diesel fuel, which is unique to the U.S.

ALTERNATIVE-FUELED VEHICLES

Honda is the only company that continues to offer a dedicated compressed natural gas vehicle, the third generation Civic GX. We recently co-marketed a natural gas home refueling station, called Phill, which will expand the market beyond fleets to retail customers. Phill is maintenance free, quiet, easy to use, certified for home use with 110 volt, and includes gas detection safety equipment.

Development of battery-electric vehicles continues and they have found a niche in neighborhood vehicles for closed communities.

Honda is strongly supportive of biomass fuel development. Honda has developed an E100 vehicle for sale in Brazil and is evaluating the market for flexible fuel vehicles in the U.S. Also, as we announced last year, Honda has achieved exciting advances in biotechnology research to increase yields in bio-ethanol production by using the stalks and leaves of plants that would normally be discarded. This improves the potential for wider application of ethanol-powered vehicles and for further CO_2 reductions. We plan to maintain this comprehensive focus on both vehicles and fuels in our ongoing research and development.

Honda believes the most optimal use of the ethanol that we are currently producing is to blend it with gasoline at up to 10% levels ("E-10"). All vehicles on the road today are capable of burning E-10 and, unlike E-85, E-10 does not require a new fueling infrastructure or vehicles specially engineered to run on that fuel. If methods are developed to produce ethanol from cellulosic feedstocks with economically viable processes, the investment into infrastructure and vehicles might be a promising course for the nation. Congress has appropriately allocated significant resources for research into the production of ethanol from cellulosic materials.

FUEL CELL VEHICLES

Fuel cells are being heavily researched and developed. Honda was the first company to certify a fuel cell vehicle with the EPA and the first to lease a fuel cell vehicle to an individual customer.

The fully-functional Honda FCX Concept vehicle features a newly developed compact, high-efficiency Honda FC Stack as well as a low-floor, low-riding, short-nose body. Limited marketing of a totally new fuel cell vehicle based on this concept model is to begin in 2008 in Japan and the U.S.

The FCX Concept is equipped with a V Flow fuel cell platform consisting of a compact, high-efficiency fuel cell stack arranged in an innovative center-tunnel layout. This has allowed designers to create an elegant, low-riding, sedan form that would have been difficult to achieve in a conventional vehicle. This new fuel cell stack is smaller, lighter, and more powerful than the current FCX FC Stack. The result is a travel range approximately 30 percent greater than the current FCX with an energy efficiency of around 60 percent—approximately three times that of a gasoline-engine vehicle and twice that of a hybrid vehicle.

The fuel side continues to be challenging. Honda's experience with home refueling for our compressed natural gas vehicle is helping in development of infrastructure technology for hydrogen refueling. Honda's research on the experimental Home Energy Station (HES) is on its third generation of development. This station aims to provide a home-based refueling environment capable of providing sufficient fuel to power a fuel cell vehicle while providing electrical energy needs for an average size home.

HYBRIDS

Hybrid-electric vehicles are in their 2nd generation at Honda and several other manufacturers have also recently introduced hybrid-electric vehicles.

Honda introduced the first hybrid vehicle in the US in 1999, the Honda Insight. This vehicle was designed to showcase the potential of hybrids and advanced technology. The Civic Hybrid, introduced in 2002, was the first hybrid powertrain offered as an option on a mainstream model. The Accord Hybrid was the first V6 hybrid. The 2006 Civic Hybrid incorporated significant improvements to the battery, electric motor, and hybrid operating strategy to improve both efficiency and performance. For example, we added the ability to cruise on the electric motor alone at low speeds, increased the motor output by 50%, increased regenerative braking energy recovery, and reduced the size and weight of the battery pack and power electronics.

Taking what we have learned, Honda's next step in hybrid vehicle development will be the introduction of an all-new hybrid car to be launched in North America in 2009. This new hybrid vehicle will be a dedicated, hybrid-only model with a target price lower than that of the current Civic Hybrid. We are targeting an annual

North American sales volume of 100,000 units, mostly in the United States, and 200,000 units worldwide.

PHEV

Plug-in hybrid vehicles are being evaluated by a number of manufacturers, including Honda. Plug-in hybrids have a lot of promise, especially to displace oil consumption. Before plug-in vehicles can be viable, however, there are a number of technology, consumer acceptance, environmental and cost issues that still need to be addressed. The extra batteries add considerable weight and take up considerable space, which decreases performance and vehicle utility. Systems to plug the vehicle in to the electric grid must be safe and easy to use and the customer needs a garage or secure spot to plug in. Performance must be preserved, which means that either the electric motor and energy storage must provide performance equivalent to the engine; or the engine must be started and used with the electric motor for harder accelerations and higher speeds.

If the engine is not turned on for high accelerations, the vehicle is entirely dependent on the electrical system for acceleration. This requires a much larger electric motor and power electronics, which adds cost and weight and requires more cooling. The high electrical demand during high accelerations also generates high battery temperatures and accelerates battery deterioration, especially when the battery is at a low state of charge. If the engine is turned on only during high accelerations, emissions become an issue because of the difficult in keeping the catalyst at normal operating temperatures.

However, the principal issue is energy storage cost and durability. Some industry analysts have been critical of hybrids because they cost more and the fuel savings are not recoverable in the short term. Although current hybrid vehicles have relatively small battery packs, the battery pack is still the single largest cost of the hybrid system. Further, energy flow in conventional hybrids is carefully monitored and controlled to ensure maximum battery life. High and low battery charge conditions, where more deterioration occurs, are avoided. Battery temperatures are carefully monitored at many points inside the battery pack and system operation is limited when necessary to keep the temperature low and minimize deterioration. Also, the duty cycle of a conventional hybrid is very mild and does not include deep discharges.

The battery pack must be many times larger for a plug-in hybrid, even with just a 20-mile electric range. This adds thousands of dollars to the initial price of the vehicle, not to mention the impact the extra batteries have on weight and interior space. Further, the battery pack is now subjected to deep discharge cycles during electric-only operation and to much higher electrical loads and temperatures to maintain performance. This will cause much more rapid deterioration of the battery pack.

The American Council for an Energy Efficient Economy (ACEEE) recently published a report (September 2006) assessing the annual fuel savings and the short and long term incremental costs for PHEVs. At $3 per gallon, the annual fuel savings for a compact-sized vehicle is only $705 over a comparable conventional vehicle and only $225 over a comparable hybrid vehicle. Even if the Lithium-ion battery can be reduced to $295 per kW-hour and last the life of the vehicle, the payback period is still 6.4 years compared to a similar conventional vehicle and 12.9 years compared to a similar hybrid vehicle. This ignores the tradeoff between electric motor size and emissions, the performance penalty from the additional weight of the batteries, the space needed for the batteries, the increased risk of battery replacement due to the deep discharge cycles, and the cost of safe off-board charging systems.

Customer discounting of fuel savings is another long-term barrier that will also need to be overcome. While some customers value fuel savings more highly, the average new vehicle customer only values the fuel savings for roughly his or her period of ownership. This is supported by a consumer inferred payback period of only 1.5 to 2.5 years, as determined by a May 2004 DOE survey. This means that, even at $3 per gallon, the average new vehicle customer would only value a plug-in hybrid at about $1,500 over a similar conventional vehicle (about two years of fuel savings at $705 per year) or about $500 over a similar hybrid vehicle (about two years of fuel savings at $225 per year).

Certainly there are customers that value fuel savings more highly and other customers that will likely value the ability to recharge from home on electricity. Thus, if lithium-ion battery development meets the long-term targets specified in the ACEEE report ($295 per kW-hour while lasting for the life of the vehicle), a niche market for PHEVs should develop. However, from a mainstream customers' point of view, there is no business case unless fuel prices rises to substantially more than

$3 per gallon, fuel shortages occur, plug-in hybrids are heavily subsidized, or there is a breakthrough in energy storage.

By far the most important action the government can take is research into improved energy storage. The Department of Energy is already developing plans to identify plug-in hybrid research needs and solutions. The Department of Energy held a Workshop on Plug-In Hybrid Electric Vehicles on May 4-5, 2006 to discuss issues and questions on plug-in hybrid research needs. The paper issued in advance of the workshop presented an excellent outline of the advantages of plug-in hybrids, the challenges faced, especially energy storage, the technical gaps, and the questions that need to be answered. The paper is an excellent resource for planning future research and development for plug-in hybrids and should be read by everyone interested in promoting plug-in hybrid vehicles.

The government may also wish to explore ways to incentivize the full useful life savings to manufacturers or customers.

RECOMMENDATIONS

Development of all technologies is accelerating in response to growing concerns about energy security and global warming. Global demand for transportation energy is so immense that no single technology can possibly be the solution. Fuel cells have the most promise to address both climate change and energy sustainability issues in the long term. Honda is making great advancements in fuel cell technology and is working with the Department of Energy, the California Fuel Cell Partnership, and others to help lay the groundwork necessary to move toward commercial deployments. However, the challenges of hydrogen production, transport, and storage will take continued effort to solve and implement, especially on the volume demanded for transportation worldwide. Biofuels are promising and can replace some fuel use, but even development of cellulosic ethanol only has the potential to displace, at most, 10 to 20 percent of the world's oil demand. The point is that there is no magic bullet—we are going to need rapid development and implementation of as many feasible technologies as possible. Honda is developing technology that meets both the needs of our customers and those of society. Thus we are constantly exploring a variety of technologies to achieve energy sustainability.

Different companies are working on different technologies, which is the optimal way and makes good use of competition. Development of specific technologies, including plug-in hybrid vehicles, needs to be viewed within this context. In order to achieve significant market penetration any alternative technology must be able to compete, in terms of cost, performance and utility, with advanced gasoline and diesel engines. With respect to hybrids and, especially, plug-in hybrids, the most important factor is to reduce the cost, size, and weight of the battery pack. We have found that the early hybrid customers are most interested in fuel cost savings. But at this juncture, mainstream customers do not value the fuel savings as highly and hybrid sales represent only about 1.5% of annual sales. Market penetration will increase as the costs are reduced in the future.

As Honda has previously announced, we believe it is time for the Federal government to take action to improve vehicle economy. Given the rapid changes in technology, performance-based incentives are the best way to move the ball forward. It is impossible to predict the pace of technology development and when breakthroughs will or will not occur. Accordingly, technology-specific mandates cannot get us where we need to go. In fact, previous attempts to mandate specific technologies have a poor track record, such as the attempts in the 1990s to promote methanol and the California electric vehicle mandate. The primary effect of technology-specific mandates is to divert precious resources from other development programs that likely are much more promising. If there are to be mandates, they should be stated in terms of performance requirements, with incentives and supported by research and development.

One example would be to increase the CAFE standards. The NHTSA already has the authority to regulate vehicle efficiency and Honda has called upon the agency to increase the stringency of the fuel economy requirements and has supported efforts to reform the passenger car standards. At the same time, Congress should develop a program of broad, performance-based incentives to stimulate demand in the marketplace to purchase vehicles that meet the new requirements.

The other effective action the government can take is research into improved energy storage. The success of electric drive technologies, including hybrids, plug-in hybrids, and fuel cells, depends on our ability to build less expensive, lighter and more robust energy storage devices.

I appreciate the opportunity to present Honda's views and would be happy to address any questions you may have.

The CHAIRMAN. Well, thank you very much.

Next, Dr. Menahem Anderman, president of Advanced Automotive Batteries, from Oregon House, California. Thank you for being here.

STATEMENT OF MENAHEM ANDERMAN, PH.D., PRESIDENT, ADVANCED AUTOMOTIVE BATTERIES, OREGON HOUSE, CA

Dr. ANDERMAN. Good afternoon, Mr. Chairman and members of the committee. My name is Menahem Anderman. I am the president of Advanced Automotive Batteries, a consulting firm specializing in energy-storage technology for advanced vehicles. I was invited by the chairman to brief the committee about the status of battery technology for hybrid electric vehicles, including plug-in hybrid electric vehicles, and much appreciate the opportunity.

Hybrid cars today offer a range of technologies, including micro, mild, moderate, strong, and plug-in hybrids, each characterized broadly by the extent to which electrical power is used for propulsion in the vehicle. In contrast to fuel cell-powered electric vehicles, which are largely at the research stage with no path for high-volume production in sight yet, hybrid electric vehicles are already on the market and their future growth predominantly depends on cost reduction. To date the most successful hybrids on the market are the moderate and strong hybrids.

The debate over the right level of hybridization has recently intensified. Central to the debate is the big box that stores the energy to propel the electric motor, the battery. It is evident that the battery is the key to achieving or failing to achieve technical and commercial success with any of the hybrid architectures. In fact, the battery is responsible for 25 to 75 percent of the increased weight, volume, and cost associated with the various hybrid configurations.

Currently, essentially all moderate and strong hybrids employ a nickel-metal hydride battery as their main electrical energy storage device. Its price is $600 to $3,000 per vehicle. While the nickel-metal hydride is currently the most economical and only proven power source for the application, there is limited potential for cost reduction as production volume increases. Lithium ion batteries offer higher power and energy per unit weight and volume than nickel-metal hydride batteries, making possible the use of smaller and lighter batteries in given applications. However, the reliability of the lithium ion technology for automotive application is not yet proven and its current cost is higher than that of nickel-metal hydride.

At some point in the future, lithium ion is likely to become the battery of choice for most hybrid applications. We expect it to enter the market within the next 3 years. But its growth will depend on a sizable reduction in its costs and on proven reliability in the field.

That is the market of conventional hybrid electric vehicles. Concerning plug-in hybrids and the battery requirements, in the plug-in hybrid application the battery is recharged from an electrical outlet and is designed to propel the vehicle in an all-electric mode for some range. For a 20-mile range and allowing some margin for life, we estimate, perhaps optimistically, that a 10 kilowatt-hour battery would be required. This 10 kilowatt-hour battery would have six times the energy capacity of today's conventional hybrid batteries, which brings out several significant issues.

One, its larger size will essentially fill the trunk of an average sedan. Two, its cost to carmaker using present technology, but assuming much higher volume, would be $5,000 to $7,000 per vehicle. That is three to five times the average cost of today's strong hybrid batteries. Its lifetime in the plug-in application using either technology, nickel-metal hydride or lithium ion, is not known. Since the usage profile in this application is considerably more demanding than that of conventional hybrids, there is a significant risk that the battery in the plug-in hybrid application will not last for the life of the car.

Four, if a lithium ion battery is used there is a potential for hazardous failure, which would be a concern since this large battery would have to be charged in a residential garage.

Items two and three above, that is cost and life, compound each other, making the cost of replacing the battery prohibitive.

It is our opinion, which is shared by many of the leading professionals in the relevant high-volume manufacturing industry, that widespread commercialization of plug-in hybrid with an electrical range of 20 miles or more is only possible if there is a notable improvement in battery performance, proven longevity and reliability, establishing comprehensive lab and field testing over several years, and a significant reduction in battery cost.

Concerning government initiatives, U.S. Government initiatives to promote the growth of the hybrid market through subsidies, incentives, fuel taxation, or tighter fuel efficiency regulation will all encourage further industry investment in fuel efficient transportation. Direct investment in battery development is also likely to advance the technology and in turn the viability of hybrids. Lithium ion battery chemistry is clearly the most promising in terms of supporting future conventional hybrids and approaching the target requirements of plug-in hybrids.

It is also our opinion that as far as electric drive and electrically assisted drive technologies are concerned the conventional hybrid technology is the only one mature enough for its market growth to have an impact on the Nation's energy usage in the next 10 years. Pending significant improvements in battery technology and an increase in fuel costs, plug-in hybrid could possibly start making an impact in about 10 years, while vehicles powered by fuel cells are unlikely to enter the high-volume production in the next 20 years.

Leadership in the development of advanced rechargeable batteries migrated to Japan in the 1980's and has remained there since. Today Japanese suppliers provide about 60 percent of the world lithium ion battery demand, estimated at $5 billion for 2006, and Korean and Chinese suppliers share the vast majority of the remaining 40 percent. While North America and Europe maintain strong competence in battery research, major producers in Japan and more recently Korea have opened a significant gap in advanced battery manufacturing expertise between them and other parts of the world.

To the degree that the U.S. Government is interested in supporting the establishment of a domestic supply of hybrid batteries, thought should be given to addressing how this gap might be bridged.

Thank you for the opportunity to brief the committee. For us in the advanced automotive energy storage field, it is an exciting time. Battery technology has recently advanced enough to start making an impact on the Nation's use of transportation fuel. To speed up this development, it is important that government policies strongly support the technically proven, but barely affordable, conventional hybrid technology, and address the underlying challenges faced by the plug-in version so that in due course they too can impact the Nation's fuel consumption.

I hope that the discussion this afternoon will help in developing such policies. Thank you.

[The prepared statement of Dr. Anderman follows:]

PREPARED STATEMENT OF MENAHEM ANDERMAN, PH.D., PRESIDENT, ADVANCED AUTOMOTIVE BATTERIES, OREGON HOUSE, CA

INTRODUCTION

My name is Menahem Anderman; I have worked in the battery industry for 24 years, with both technology and business management responsibilities. I am the president of Advanced Automotive Batteries, a firm that provides consulting services in the area of energy-storage technology for advanced vehicles. Our activities include—among others—publishing multi-client industry and technology assessment reports, and organizing what is widely regarded as the foremost annual conference in this industry. I was invited by this committee's honorable chairman to brief the committee about the status of battery technology for hybrid electric vehicles, including plug-in hybrid electric vehicles, and am very appreciative of this opportunity.

HYBRID ELECTRIC VEHICLES

Hybrid Electric Vehicles (HEVs) are propelled by combining mechanical power from an internal-combustion engine with electrical power from a battery. Fifteen hybrid car models offered in several vehicle classes are now available in dealerships across the United States, Europe, and Asia. Sales of no less than 350,000 new hybrid electric cars, representing over 0.7% of the total new car[1] production in the world, were reported in 2006, 60% of which were in the U.S. market, accounting for 1.3% of total car sales. Coverage of the hybrid-vehicle technology by the media has increased substantially, and the average Japanese and North American consumer is now well aware of this new breed of vehicle. The technological and commercial success of the 2004 model year Prius—the third generation of this flagship hybrid—combined with the steep rise in oil prices during 2005/2006, the growing concerns about a diminishing world energy supply, and the increased awareness of the relevance of CO_2 emissions from vehicles to the potential for global warming have all intensified the automotive industry's efforts to develop and introduce hybrid electric cars.

As the realization spreads that fuel-cell vehicles are unlikely to enter mass production within the next twenty years or more, and the pressure to reduce vehicle emissions and fuel consumption continues to rise, hybrid electric vehicles seem to offer a timely solution that is both technically proven and economically viable (or almost viable). However, other technologies with some environmental benefits, including ultra-efficient IC engines, clean turbo-diesel engines, ethanol-fueled IC engines, and advanced hydrocarbon fuel technologies, are also evolving. In most cases, these alternative technologies are less expensive and appear less risky to the automakers, which explains their interest in pursuing them in parallel to, or instead of, the hybrid approach. However, in the competitive race to improve drivability, comfort, and safety, while reducing fuel consumption and emissions, automotive engineers are discovering that many of the prospective solutions to these problems will require increased electrical power, which reinforces the desirability of at least some level of vehicular hybridization.

[1] In this report, the term 'car' is used generically to include all types of 'household' vehicles—cars, light trucks, vans, SUVs, etc.

Hybrid cars today cover a range of technologies, each characterized broadly by the extent to which electrical power is used for propulsion in the vehicle. At one end of the spectrum is the 'micro-hybrid', a car that features a "beefed-up" starter, in which fuel is saved during vehicle idle stop, and mechanical energy is captured during braking. At the other end of the range—which also includes mild, moderate, and strong hybrids—is the 'plug-in hybrid', in which a 40- to 100-kW electric motor is capable of propelling the car on its own for, say, 5 to 50 miles, and supplements the power of the internal combustion engine in most acceleration events. To date the most successful hybrids on the market are the strong (sometimes referred to as 'full') hybrids. These vehicles employ a 30 to 70-kW electric motor that is engaged frequently during the drive cycle and is powered by an advanced high-power battery, which is charged on board by the IC Engine and by the kinetic energy captured during deceleration and braking of the vehicle.

The debate over the 'right' level of hybridization has recently intensified. While many automakers are searching for a reduced—although measurably beneficial—level of hybridization (to cut the high incremental cost of the hybrid powertrain), governments, many utility companies, and environmental groups, frequently supported by the media, are pointing in exactly the opposite direction, favoring the introduction of plug-in hybrids that will offer significantly reduced fuel consumption, pollutants, and CO_2 emissions, but with a large price tag and other drawbacks.

HYBRID ELECTRIC VEHICLE BATTERIES

Central to the discussion regarding the relative merits of the various hybrids is the big box that stores the energy to propel the electric motor—the battery. It is evident that the battery is a key to achieving (or failing to achieve) technical and commercial success with any of the various hybrid architectures. In fact, the battery is responsible for 25-75% of the increased weight, volume, and cost associated with the various hybrid configurations. Even more critical are battery life, reliability, and behavior under abuse as they present the largest threat to the commercial success of hybrid technology.

Batteries store electrical energy, which is measured in kWh. Today's mild, moderate, and strong ('full') hybrids on the market utilize batteries with rated capacities of 0.6 to 2 kWh. In general mild hybrids require smaller batteries than do strong hybrids. The rated energy capacity of the battery is dictated by the battery's level of usage (the duty profile), and includes a significant margin for life, to meet the 10-year minimum life requirement of the automotive market. In today's hybrid batteries, only about 10% of the rated battery capacity is used frequently, and up to an additional 30% is accessed under extreme driving conditions. The remaining capacity is in place to ensure adequate service life.

Currently, essentially all hybrids with moderate to significant powertrain hybridization employ a NiMH battery as the main electrical-energy storage device. NiMH batteries are a reliable power source for hybrid cars; their manufacturing base is expanding, and field results suggest long life. However, NiMH batteries are not an ideal energy-storage device for hybrid cars. Their limitations include moderate energy conversion efficiency, which translates to some energy loss and significant heat production in normal usage, reduced life with high depth-of-discharge (DOD) cycling, and unsatisfactory performance at high and low temperatures. NiMH battery packs for HEVs are priced at $900 to $1500 per kWh, which brings the price of today's pack to between $600 and $3,000 per vehicle.

The 2006 NiMH battery market for HEVs is estimated at $600 million. Although NiMH is currently the most economical (and only proven) power source for the application, it has limited potential for cost reduction as production volume further increases, particularly in light of recent substantially higher nickel prices—nickel, in several metallic forms and compounds, being the battery's main component.

Lithium-ion batteries offer higher power and energy per unit weight and volume, and better charge efficiency than NiMH batteries. Thus, if they can maintain performance over life, smaller and lighter batteries can be used in given applications. These attributes allowed them to capture a major part of the portable rechargeable battery market—which requires a battery life of only 2 to 3 years—within a few years of their introduction, and to generate global sales estimated at $5 billion in 2006. Nevertheless, the reliability of lithium-ion technology for automotive applications is not proven—unfriendly failure modes, for example, are a concern—and its current cost is higher than that of NiMH.

Over the last five years, most automakers have started to evaluate the suitability of lithium-ion batteries for HEV applications, and two Japanese automakers even embarked on sizable in-house lithium-ion battery development projects. In the U.S., significant progress has been made under the auspices of the U.S. Advanced Battery

Consortium, a collaborative effort between the U.S. Department of Energy, the auto industry, and battery developers. Sometime in the future, lithium-ion technology is likely to become the battery of choice for most hybrid applications, although the recent reliability problems experienced with lithium-ion batteries in portable devices may delay its acceptance. Nevertheless, following extensive system-verification tests, lithium-ion batteries are still expected to enter the HEV market in 2 to 3 years, and their use to grow thereafter, provided no major negative surprises arise.

Lithium-ion HEV batteries are likely to initially carry a slightly higher price than NiMH batteries but price parity is expected to occur as volume reaches that of the NiMH business. Moreover, they hold better potential for further cost reduction through improvements in technology and economies of scale.

It is useful to note here that world investment in lithium-ion battery technology R&D continues to increase and is estimated at well over $1 billion annually, which is several times the total investment in R&D for all other battery technologies combined. We estimate that there are over a hundred materials, chemicals, and battery companies, several thousand academic researchers, and hundreds of scientists in government-owned laboratories involved in various aspect of lithium-ion battery technology R&D.

PLUG-IN HYBRIDS AND THEIR BATTERY REQUIREMENTS

While the development of plug-in hybrid vehicles by car manufacturers is still at an early stage, industry experience with all-electric vehicles on the one hand, and with conventional hybrid electric vehicles on the other, is sufficient to provide general guidelines for their battery requirements.

In an all-electric vehicle, the battery is the only power source on board and is used in the so-called 'charge-depletion' mode, i.e. the battery is fully charged externally (typically at night) and is depleted at a steady rate during driving. In this case, the battery usually provides only one charge-discharge cycle per day, with the depth of discharge depending on the battery capacity and the driving range. In a conventional HEV, the battery is operated in the so called 'charge-sustaining' mode, i.e. the battery is charged and discharged on board around an intermediate state of charge, typically about half-way between fully charged and fully discharged. In this application, the battery may be called upon to provide hundreds or more shallow cycles per day, never approaching the fully-charged or fully-discharged state.

In a classical plug-in HEV, the battery is fully charged externally, typically on a daily basis. When the vehicle is driven after charging, the battery operates in the charge-depletion mode, just like an EV battery. Later, as the battery reaches some predetermined low state of charge, the vehicle switches to a charge-sustaining mode, in which the battery will be used like that of a conventional HEV. Because of these dual functions the battery's usage profile in a plug-in HEV is considerably more demanding than that of either a full EV battery or a conventional HEV battery, with obvious negative implications for battery longevity.

For a plug-in hybrid electric vehicle the requirement that dictates its battery capacity is the range of electric drive for which the vehicle is designed (Note: some 'plug-in' architectures do not emphasize electric drive, but to keep this discussion simple, we will consider an architecture that requires it). Depending on its weight, aerodynamic design, and driving pattern, a typical mid-size vehicle with an electric motor will utilize 0.2 to 0.4 kWh of energy per mile driven, which means that 1 kWh of energy will propel a car for between 2.5 and 5 miles. For the sake of simplicity we will assume a 3-4 mile range per kWh of used energy. Thus, for a 20-mile range of electric drive, the car will use 5-7 kWh of energy. However, since the duty cycle of the application is considerably more severe than that of HEV or EV batteries, to even stand a chance of meeting life requirements using today's technology it will be necessary to design a battery with 1.5 to 2 times the energy capacity required for the drive. In other words, a plug-in vehicle with a 20-mile range will require a battery with a rated energy capacity of 8 to 14 kWh. Again for the sake of simplicity we will assume a battery capacity of 10kWh for the rest of the analysis.

Since the average capacity of today's strong hybrid batteries is 1.7 kWh, the above calculation shows that the 20-mile plug-in battery will need an energy capacity 6 times higher than that of today's average HEV battery. This brings out several significant issues:

1. The plug-in battery will be about 3 to 5 times the size of today's conventional HEV batteries, essentially filling the cargo space of an average sedan.
2. The weight of this battery will add 200 to 300 lb. to that of the car, which will adversely affect vehicle performance and efficiency.
3. If the plug-in battery vehicle contains a lithium-ion battery, which is to be given a full charge every night in a residential garage, there is a much more

serious concern about hazardous failure than with the smaller batteries of conventional HEVs, which are always kept at an intermediate state of charge.

4. The cost of this plug-in battery (at pack level) to carmakers, using present technology, will be 3 to 5 times the average cost of today's HEV batteries, i.e. around $5,000 to $7,000 per pack.

5. The life of either battery technology, NiMH or lithium ion, in the plug-in application is not known. There is a significant risk that its life will be shorter than that of conventional hybrid-car batteries.

Unfortunately, items 4 and 5 above compound each other, making the cost of replacing the battery prohibitive (should the battery need to be replaced during the life of the car).

It is our opinion that wide-spread commercialization of plug-in hybrids with a range of 20 miles or more is only possible if there is notable improvement in battery performance, proven battery longevity and reliability in well-designed lab and field tests—which, in combination, are likely to require 3 to 5 years—along with a significant reduction in battery cost.

GOVERNMENT INITIATIVES

U.S. government initiatives to promote the growth of the HEV market through subsidies, incentives, taxation, or tighter fuel-efficiency regulations will all encourage further industry investment in fuel-efficient transportation. Because batteries are critical to the potential success of the hybrid-vehicle business, direct investment in battery technology is also likely to advance the technology and in turn the viability of HEVs. Lithium-ion battery chemistry is clearly the most promising in terms of supporting future conventional HEVs as well as in approaching the target requirements of plug-in HEVs. While lithium-ion technology will continue to evolve as a consequence of the large worldwide investment in this technology, U.S. Government regulations that support the growth of the HEV market and/or its funding of lithium-ion battery development would certainly accelerate progress. In our opinion, such enhanced progress could allow lithium-ion battery technology to enter the conventional U.S. HEV market earlier than without it, thereby increasing the attractiveness of these vehicles and stimulating their market growth. In the longer term—perhaps in about 10 years—accelerated progress may gradually close the gap between the targeted battery requirements for plug-in HEV and the state and cost of battery technology, thus facilitating the introduction of plug-in hybrid vehicles as well.

It also is our opinion that as far as electric drive and electric-assist drive technology is concerned, conventional HEV technology is the only one mature enough for its market growth to have an impact on the nation's energy usage in the next 10 years. Pending significant improvements in battery technology, plug-in hybrids could possibly start making an impact in about 10 years, while vehicles powered by fuel cells are unlikely to enter high-volume production in less than 20 years.

OTHER CONSIDERATIONS

Leadership in the development of advanced rechargeable batteries migrated to Japan in the eighties and has remained there since. Today's Japanese suppliers provide over 60% of the world's lithium-ion battery demand, and Korean and Chinese suppliers share the vast majority of the remaining 40%.

Regarding batteries used in today's high-volume hybrids, two Japanese battery producers, Panasonic EV Energy, a joint venture between Toyota Motor Company and Panasonic Batteries, and Sanyo, share over 95% of today's $600 million HEV battery market (currently nearly all NiMH). A single U.S. supplier, Cobasys, supplies NiMH batteries for the 2007 mild-hybrid Saturn Greenliner. Both Japanese battery giants are also developing lithium-ion battery products for the HEV market, where over a dozen additional battery makers from Japan, Korea, and the U.S. intend to compete.

While North America and Europe maintain strong competence in basic battery research, including in materials and electrochemistry, major producers in Japan, and more recently Korea, have opened a significant gap between them and other parts of the world in advanced-battery manufacturing expertise. The manufacturing of high-volume, low-cost, and high-reliability lithium-ion batteries for the portable market is challenging, and established producers have paid dearly to move up the learning curve (and down the cost curve). The manufacturing of low-cost, high-power lithium-ion batteries for HEV is considerably more demanding, when one considers the higher voltage and the larger size of the battery on the one hand, and the long life expectancy and harsh operating environment on the other.

To the degree that the U.S. Government is interested in supporting the establishment of a domestic supply of HEV batteries, thought should be given to addressing this significant gap in high-volume lithium-ion manufacturing expertise between U.S. developers and their Japanese and Korean counterparts, in addition to supporting the development of battery materials and improved cell design.

Thank you for the opportunity to brief the committee. I hope that this presentation will help direct attention to the apparently most promising and affordable technologies for reducing fuel consumption and the impact of vehicles on the environment, yet without sacrificing vehicle functionality and affordability, or threatening human safety.

The CHAIRMAN. Thank you very much.

Our next witness is Mr. William Logue, who is the executive vice president of FedEx Express in Memphis. We are glad to have you here. Thank you.

STATEMENT OF WILLIAM J. LOGUE, EXECUTIVE VICE PRESIDENT, FEDEX EXPRESS

Ms. LOWERY. Mr. Chairman and members of the committee: Thank you for your kind invitation to testify today on the important subject of improving efficiency in the transportation sector.

As executive vice president of Operations and System Support for FedEx Express, my responsibilities encompass our worldwide air operations, our U.S. pickup and delivery oil and gas, our U.S. airport and hub operations, as well as the planning and engineering of our network. I am here today to tell you that this initiative is urgently needed, eminently achievable, and economically viable. Trucks along consume more than 50 billion gallons of fuel per year and aircraft approximately 20 billion gallons. Thus the opportunities of fuel savings and the environmental benefits are enormous.

I commend Chairman Bingaman and this committee for its attention to this very important subject, not only for the well-being of the Nation's energy and environmental resources, but its economic and national security interests.

A few years ago FedEx embarked on an historic project with Environmental Defense to design and build a hybrid truck that would marry our very strict performance standards with extraordinary fuel savings and environmental benefits. The FedEx Opti-Fleet F—excuse me—E700 hybrid electric vehicle operates in several communities across the country today, including here in Washington, D.C., and is shown to increase fuel economy by 40 percent while decreasing particulate emissions by 90 percent and greenhouse gases by more than 25 percent. This shows that significant gains can be made now.

These 93 vehicles, which look identical from the outside to our standard pickup and delivery truck, have traveled more than 840,000 miles in revenue service. We would like nothing more than to put many of these incredible vehicles on the road. However, they are very expensive. The Opti-Fleet E700 costs almost twice as much as a standard pickup and delivery truck and, while we embarked on this program with a rallying call for others in the transportation sector to get on board, very few companies have committed to the technology, and the main reason is cost.

As the committee with jurisdiction over these issues, you have the opportunity to create public policies that improve transportation in the commercial sector. In 2005 the Energy Policy Act tax credits were made available for commercial hybrid vehicles. However, the Department of Treasury has yet to finalize the guidance for claiming the tax credits. I firmly believe that if incentives were available to help reduce the costs more companies like FedEx would embrace this outstanding technology. This would cause manufacturers to produce more vehicles and the competitive realities of the market would kick in. These vehicles could then become a real alternative, much like what you have seen occur in the passenger car sector.

These short-term tax credits could help seed the development and adoption of this technology in the commercial vehicle market. Let me give an example of the benefits we could see with these changes. If 10,000 hybrid electric commercial vehicles were on the road rather than the standard truck, smog-causing emissions would be reduced by 1700 tons annually, the equivalent of taking passenger cars off the streets of New York for 25 days. Carbon dioxide emissions would be reduced by 83,000 tons annually and diesel fuel usage would be reduced by 7.2 million gallons.

While trucks are an enormous component of our operation, we are taking strides in energy conservation and fuel savings in other areas. In August 2005, we opened California's then largest corporate solar electric hub system in our hub in Oakland, California. In the first year it has provided more than one million kilowatt-hours of renewable energy generated by sunlight, thereby avoiding the release of 342 tons of carbon dioxide into the atmosphere.

We are also modernizing our aircraft fleet. Over the next 10 years we are planning to retire our Boeing 727s and replace them with the much more fuel efficient 757. The 757 has a payload grade 20 percent greater, but uses 36 percent less fuel. In addition, the 777 is our long haul freighter for the future, which results in obviously an increased payload as well, but also operates with 18 percent less fuel.

The Nation's energy crisis and finding ways to reduce fuel consumption is so important to FedEx that our chairman, Frederick W. Smith, is co-chairing the Energy Security Leadership Council, an initiative of the nonpartisan organization Securing America's Future Energy, or SAFE. I know this council has met with this committee and has developed an ambitious set of policy recommendations toward reducing U.S. oil dependence.

FedEx is very supportive of the call to raise energy efficiency in commercial vehicles, the need to invest in alternative fuel sources as well, and to make changes in the air traffic control routings which would result in tremendous savings in jet fuel annually.

In conclusion, I would like to offer a few recommendations. No. 1, set fuel efficiency standards annually for medium and light-duty trucks. This would help stimulate the production of hybrid electrics within the medium truck sector, such as our pickup and delivery fleet. It would also drive alternatives for improved fuel efficiency in heavy-duty trucks.

The committee should also look into instructing the Department of the Treasury to finalize the guidance for the hybrid electric commercial vehicle tax credits under the 2005 Energy Policy Act, because nearly 2 years have lapsed, and these tax credits should be retroactive and be extended to 2012.

We also need the FAA to implement improvements in commercial air traffic routing in order to improve aviation efficiencies and reduce fuel consumption.

Finally, provide increased funding to NASA for the research and development of a new aviation engine technology that will reduce emissions, noise, and increase fuel efficiency.

Thank you for this opportunity to come before this committee. I am happy to answer any questions.

[The prepared statement of Mr. Logue follows:]

PREPARED STATEMENT OF WILLIAM J. LOGUE, EXECUTIVE VICE PRESIDENT, FEDEX EXPRESS

Mr. Chairman and Members of the Committee, thank you for your kind invitation to testify today on the important subject of improving efficiency in the transportation sector. I am here today to tell you it is urgently needed, imminently achievable and economically viable. Trucks alone consume more than 50 billion gallons of diesel fuel and gasoline and airlines consume approximately 20 billion gallons of fuel per year, thus the opportunities for fuel savings and environmental benefit are enormous.

I commend Chairman Bingaman and this committee for the attention to this very important subject—not only for the well-being of the nation's energy and environmental resources but its economic and national security interests.

FedEx is part of the fabric of society—we operate in every community across the United States and serve more than 220 countries around the globe. In order to serve 95 percent of the world's GDP in 24-48 hours, it takes a lot of fuel. In fiscal year 2006, FedEx Express consumed more than 1.3 billion gallons of fuel and thanks to some fuel saving initiatives, that figure is actually down 3 percent from the previous two years for vehicle fuels. But this is far from where we want to be.

A few years ago, FedEx embarked on a historic project with Environmental Defense to design and build a hybrid truck that would marry our very strict performance standards with extraordinary fuel saving and environmental benefits. The FedEx Express Opti-Fleet E700 hybrid electric vehicle—operated in several communities across the country, including Washington, DC—increases fuel economy by more than 40 percent while decreasing particulate emissions by 90 percent and green house gases by more than 25 percent. This shows that significant gains can be made now.

These 93 vehicles—which look identical from the outside to our standard FedEx pick up and delivery truck—have traveled more than 840,000 miles in revenue service. We would like nothing more than to put more of these incredible vehicles on the road but they are very expensive.

The Opti-Fleet E700 costs up to twice as much as a standard pick up and delivery truck and while we embarked on this program with a rallying call for others in the transportation sector to get on board—very few companies have committed to the technology. And the main reason is cost.

As the Committee with jurisdiction over these issues, you have the opportunity to devise and instruct public policies that further drive improved transportation in the commercial sector. In the 2005 Energy Policy Act tax credits were made available for commercial hybrid vehicles, however, the Department of Treasury has yet to finalize the guidance for claiming the tax credits. I firmly believe that if incentives were available to help reduce the costs, more companies like FedEx would embrace the technology. If more companies embraced the technology, manufacturers would see the value, the competitive realities of the market would kick in and these vehicles could become a real alternative—much like what you've seen occur in the passenger car sector. Put simply, these short-term tax credits can help seed the development and adoption of this technology in the commercial vehicle market.

For example, if 10,000 hybrid electric commercial vehicles were on the road rather than standard commercial vehicles, substantial reductions in emissions and fuel use would occur annually:

- Smog-causing emissions of nitrogen oxides would be reduced by 1,700 tons annually—the equivalent of taking passenger cars off New York City roads for 25 days.
- Carbon dioxide emissions would be reduced by 83,000 tons annually the equivalent to planting 2 million trees.

- Diesel fuel usage would be reduced by 7.2 million gallons, which requires 1 million barrels of crude oil to produce.

While trucks are an enormous component of our operation, we are taking strides in energy conservation and fuel savings in other areas:

- In August 2005, we opened California's then largest corporate solar electric system at the FedEx Express regional hub in Oakland. In the first year, it has provided more than 1 million kilowatt hours of renewable energy generated by sunlight thereby avoiding the release of 342 tons of carbon dioxide into the atmosphere—equivalent to 96 acres of forest saved or not driving for 850,000 miles.
- We are modernizing our aircraft fleet. Over the next 10 years we have plans to retire the Boeing 727s and replace them with more efficient 757s. The 757 is 20 percent larger but uses 36% less fuel.
- We are also adding the 777 freighter to our fleet for long-haul flights which will result in being able to carry more payload while burning 18% less fuel compared to the aircraft in today's fleet.

The nation's energy crisis and finding ways to reduce fuel consumption is so important to FedEx that our chairman, Frederick W. Smith, is co-chairing the Energy Security Leadership Council, an initiative of the nonpartisan organization Securing America's Future Energy (SAFE). I know the Council has met with this committee and has developed an ambitious set of policy recommendations toward reducing U.S. oil dependence. FedEx is very supportive of the call to raise energy efficiency in commercial vehicles, invest in alternative fuel sources and make changes in Air Traffic Control routings which would result in tremendous savings in jet fuel annually.

Recommendations:

- The Committee should instruct the Department of Treasury to finalize guidance for hybrid electric commercial vehicle tax credits under 2005's Energy Policy Act. Because nearly two years have lapsed these tax credits should be retroactive and be extended to 2012.
- Set fuel efficiency standards annually for medium and heavy-duty vehicles. This would help stimulate the production of hybrid electrics within the medium-duty vehicle sector, such as our pickup and delivery fleet, (Classes 3 through 6) and alternatives for improved fuel efficiency in the heavy-duty vehicles.
- Increase allowable weight to 97,000 lbs. gross vehicle weight for tractor-trailer trucks that have a supplementary sixth axle to improve payload while not compromising safety.
- Allow the Federal Aviation Administration (FAA) to implement improvements within commercial air traffic routing in order to improve aviation efficiencies and reduce fuel consumption.
- Provide increased funding to the NASA for the research and development of new aviation engine technologies that will reduce emissions, noise and increase fuel efficiency.

Thank you for the opportunity to come before this esteemed committee. I am happy to answer any questions.

The CHAIRMAN. Thank you very much for your testimony.

Next is Dr. Walter McManus, who is president of the Automotive Analysis Division at the University of Michigan Transportation Research Institute in Ann Arbor. Thank you for being here.

STATEMENT OF WALTER McMANUS, DIRECTOR, AUTOMOTIVE ANALYSIS DIVISION, UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE, ANN ARBOR, MI

Dr. MCMANUS. Thank you, Mr. Chairman, Senators.

A consensus seems to be emerging around sustainability and reducing gasoline consumption that has not been here for the past several years. I think we all agree now that we need to dramatically reduce our gasoline consumption and head toward a sustainable energy future. The question is how to do it.

There are many proposals that are being considered and that are out there, but I want to make one point very clear today. I believe that Federal leadership is needed to get the kinds of reductions in gasoline consumption that we need. The reason I believe that is that the market for fuel economy has not worked and in the future it will not work to get the kinds of reductions that we are talking about.

Consumers do indeed value fuel economy, and I will be talking about some research that shows that. In the past decade or so, markets failed to work to give them the fuel economy that they wanted. It is not likely to work in the future to dramatically reduce fuel consumption to the extent that we need to have it done.

In the past 6 years, 8 years, the price of gasoline rose 100 percent, but it was not until the last 2 years that people responded by buying different vehicles. Does that mean that it took a tipping point or some number for them to respond? No. They actually did respond well before that, but it was in the form of not having as much demand, and the automakers responded by cutting prices.

At the same time that the fuel prices were going up, vehicles that had lower fuel efficiency were having their prices cut much more than other vehicles. The difference was unprecedented and basically offset all of the reductions in fuel—sorry—all of the increases in fuel costs over the life of the vehicle.

Now, Detroit has consistently failed to recognize new knowledge that comes in the form of new data about the consumer. Just one example. For a long time, for years, the number one complaint about large SUVs has been that they have poor fuel economy. Well, Detroit usually rationalizes that by saying: They knew what they were buying; what did they expect? At the same time, instead of building SUVs with more fuel efficiency in order to improve their compliance with CAFE, they moved trucks into classifications that were not covered, about 8500 pounds, that have even less fuel efficiency.

Most recently, we have done some research on the impact on Detroit and in particular on the Big Three of higher prices. A couple of years ago we predicted that prices at $3.37 would result in the Big Three losing about $11 billion. Well, we have had that now. Prices were close to that for almost a year and a half. And we were wrong. They were much more vulnerable than we thought. They actually have lost now about $25 billion.

So if they had had the vehicles that were fuel efficient in this last few years, they would be in much better financial position than they are. So fuel efficiency is not only important for sustainability and for our national security, it also will contribute to the health, financial health, of the auto industry and of the communities that rely on them.

In the future, the market is also not likely to do it again. I say that because Detroit failed to sense and then to respond to changes in consumer demand. I worked in the industry for about 15 years and it is common to discount any evidence that consumers valued fuel economy, because we know better than the consumer does what they want.

In addition, Toyota and Nissan—some people say, well, leave it to Toyota and Nissan to provide our fuel efficient vehicles. But they are today moving rapidly into the same large SUVs and pickup trucks that got the Big Three in trouble.

So in conclusion, I just want to say that of all the multiple proposals that are out there—there really is no shortage of proposals—we would like to assist in understanding them and helping to understand the impact on greenhouse gas emissions, sustainability, and the auto industry and the employment in the United States.

Thank you.

[The prepared statement of Dr. McManus follows:]

PREPARED STATEMENT OF WALTER MCMANUS, PH.D., DIRECTOR, AUTOMOTIVE ANALYSIS DIVISION, UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE, ANN ARBOR, MI

A year ago President Bush declared that America is addicted to oil—an addiction that poses great risks to our nation's security, economy and environment. In this year's State of the Union, he outlined a plan to reduce our projected gasoline consumption in 2017. With the new Congress, there is an opportunity to devise an effective and rational national policy on automotive fuel economy that can do more than just decrease our future projected increase in gasoline consumption. A smart set of policies can dramatically reduce our national addiction to oil, while putting Detroit automakers on more solid financial ground and Americans on the path to a safer, cleaner future.

There are many who say we should just let the market take care of it. Carmakers only make what consumers want to buy and until now consumers have not wanted fuel economy. As gasoline prices rise, consumers will move to more fuel-efficient cars, as they have over the last year.

Research and analysis conducted by the University of Michigan's Transportation Research Institute Automotive Analysis division reveals why the market has not worked over the last decade, why the market did not give consumers as much fuel economy as they were willing to buy and why the market will not push fuel economy to the extent it needs to go to significantly decrease our nation's gasoline consumption or stop the financial freefall for Detroit.

WHY THE MARKET DIDN'T WORK

Judging from recent public statements, advertisements, and some concept cars at this year's auto shows, it would seem that Detroit automakers now understand consumers want fuel economy. Hurricane Katrina, Rita and other oil supply disruptions sent the price of gasoline skyrocketing in the last year. Consumers reacted and stopped buying fuel inefficient SUVS and pickups. So the market works.

But the price of gasoline has risen by over 102% since 1998. Why did it take the spike in 2005 to change demand? It didn't. Our research shows for almost a decade consumers have placed a much higher value on fuel economy than Detroit automakers has given it. But Detroit automakers ignored even their own data.

Since the 1990s, the reigning conventional wisdom in Detroit has been that consumers would not pay for fuel economy and this view dominated Detroit's thinking about its customers so thoroughly, that any evidence that challenged it was rationalized away or ignored, even when the contradictory evidence came from Detroit's consumers themselves.

Detroit automakers spend many millions of dollars collecting data and building models of their customers' needs and wants so they can design products their customers want and build them in quantities that are profitable. To develop predictions about future market conditions that product decision makers can act upon, a market forecaster analyzes patterns in historical data and develops models and forms opinions about how the market works. New useful knowledge has only two sources: from observing new data or from thinking about historical data in new ways.

With respect to the consumer value of fuel economy, Detroit failed to recognize new knowledge of both types that it should have, and that could have helped Detroit avoid the dismal financial results of the last two years.

Detroit failed to recognize new knowledge in the form of new data about the consumer value of fuel economy.

When asked what they liked and disliked about their new vehicles, more buyers of large SUVs have said they disliked the vehicle's poor fuel economy than said they disliked any other feature. (J.D. Power and Associates, APEAL Study 1996-2005). Instead of addressing their customers' top complaint by improving the fuel economy of large SUVs, the automakers dismissed the complaint since it contradicted the conventional wisdom ("they bought a large SUV, what did they expect?"). At the same time automakers expanded their offerings of super-heavy SUVs to take advantage of a gap in CAFE (SUVs weighing over 8,500 lb do not count toward CAFE compliance until MY2011).

As a forecaster, I know that forecasting is as much an art as it is a science. The art of forecasting is what guides forecasters as they adjust the raw output from a statistical analysis to make better predictions. In nearly all of Detroit's internal and external market research studies, the raw output would imply that consumers put a fairly high value on fuel economy. However, the conventional wisdom is so strong that these raw estimates are nearly always adjusted downward.

Detroit also failed to recognize new knowledge in the form of novel patterns in historical data in the relationship between gasoline prices and vehicle sales.

By 2005 gasoline prices had been steadily rising for several years. From 1998 to 2006, the average price per gallon of regular gasoline rose from $1.27 (adjusted for inflation) to $2.57—a 102% increase over eight years. For comparison, the first oil shock, which led Congress to create CAFE standards, involved a 73% increase over eight years in the price regular gasoline. (Adjusted for inflation, a gallon of regular gasoline cost $1.76 in 1973 and $3.06 in 1981.)

The duration and magnitude of the rise in gasoline prices make the apparent lack of a consumer response until 2005 puzzling. In the face of steadily rising gasoline prices, why did consumers not change their new vehicle choices before 2005 and 2006? Is there a "tipping point" that gasoline prices must pass before consumers respond?

We addressed these questions in a research study we recently completed (forthcoming in *Business Economics,* Jan 2007). We examined the impact of the rise in gasoline prices on consumer demand for fuel economy using data on the sales, actual transaction prices, and attributes of all vehicles sold in the U.S. for the years 2002 through 2005. We used a statistical methodology called hedonic regression that models the real price paid for a vehicle as a function of the real price of gasoline, fuel economy, and other factors.

Our study found that the consumer value of fuel economy rose each year in direct proportion to the rise in the real price of gasoline. Without some action to offset this trend, demand would have shifted away from large SUVs as early as 2003. What Detroit did (starting immediately after 9/11) was cut their vehicles' prices, and the least fuel-efficient vehicles had the biggest price cuts. These cuts in prices offset the fall in what consumers would pay for their vehicles as gasoline prices rose. Consumers would have switched earlier, but Detroit kept making better and better offers they could not refuse as gasoline prices rose from 2002 to 2005. And, as a result, while sales continued to look good, Detroit was experiencing a massive erosion of profits.

Hurricanes Katrina and Rita sent regular gasoline prices shooting over $3 per gallon (nominal) in 2005 and the expectation of other supply disruptions kept the price high (nominal, year over year) for much of 2006. This time Detroit could not offer enough discounts and incentives to prevent a dramatic and sudden shift of American new-vehicle buyers from gas guzzling SUVs and large cars to fuel-efficient cars, crossover vehicles, and hybrids. For the first time since 1981, the truck share of sales fell in 2005 and 2006. (From 1981 to 2004 the truck share grew from 19% to 56%. The truck share fell to 55% in 2005 and to 52% in 2006.) More significantly, for the first time since 1991, the actual number of trucks sold fell in 2005 (by 79 thousand units) and again in 2006 (by nearly 2 million units).

This began a financial freefall for Detroit that has implications for the entire U.S. economy. Less than two years ago, UMTRI released a study that focused on Detroit's vulnerability to rising fuel prices. Both the industry and the media dismissed our findings. We predicted that if gasoline were to hit $3.37 per gallon it would cause $11 billion in losses for Detroit. We underestimated Detroit's vulnerability—so far the gasoline price spike has cost close to $25 billion in losses, along with thousands of jobs.

WHY THE MARKET WILL NOT WORK TO MEET AMERICA'S FUEL ECONOMY NEEDS

In theory, we could let the market simply continue replacing American vehicles with fuel-efficient foreign vehicles. There are several reasons why this theory will not lead to the kind of reductions in fuel consumption our nation needs to achieve in the time we have to achieve it.

In America, we have 240 million passenger cars and light trucks on the road which we drive 2.9 trillion miles in a year. Every car and truck produced is part of our fleet for 15 years or more. Automakers are making decisions today about the cars and trucks that will roll off the assembly line five years from today.

Detroit failed to sense and respond to the change in consumer demand before and there is a danger Detroit still doesn't understand how much consumers value fuel economy. Recently, as gas prices have drifted down, Detroit automakers have worried out loud that consumers will not want fuel-efficient vehicles. Foreign automakers may make similar mistakes about American consumers. Toyota and Nissan have been selling large SUVs and trucks in the U.S. for a number of years, and Toyota is currently launching their largest and least fuel-efficient American-assembled trucks.

Each new vehicle represents an investment of at least a billion dollars and five years of development before the first unit ("job one") rolls off the assembly line. While technologies that are under the hood today could dramatically increase fuel economy if deployed fleet wide, Detroit simply does not have the capital it needs to implement such a deployment. In the meantime, Detroit automakers are continuing to produce another generation of gas-guzzlers that will hamper efforts to reduce gasoline consumption for years to come.

Finally, if Americans import (or buy from foreign-owned automakers) advanced technology vehicles, we would just trade oil dependence for technology dependence. The national security implications of this would need to be examined to determine whether we would be more or less safe.

This fall we released a study that showed proactive fuel economy increases would strengthen Detroit financial footing and America's economic, energy and environmental future. From a greenhouse gas emissions consideration alone, there is an urgent need to reduce American fuel consumption quickly. Today it is my opinion that this cannot happen without federal leadership.

There are multiple fuel economy proposals on the table but a dearth of solid analysis on which to base sound policy decisions. The University of Michigan will be conducting this analysis in the coming months. We look forward to assisting you as you craft a powerful legacy for future generations.

The CHAIRMAN. Thank you very much.

Our final witness here is Mr. David Greene, who is with the National Transportation Research Center at Oak Ridge National Laboratory in Knoxville. Thank you very much for being here.

STATEMENT OF DAVID L. GREENE, CORPORATE FELLOW, ENGINEERING SCIENCE AND TECHNOLOGY DIVISION, OAK RIDGE, TN

Dr. GREENE. Thank you, Senator. Thank you for inviting me to discuss the need to formulate effective policies to increase motor vehicle fuel economy. I will try to summarize my testimony and will refer to a couple of illustrations contained in it. Of course, the views I offer today are my own and not necessarily those of Oak Ridge National Laboratory or the Department of Energy.

New passenger car and light truck fuel economy has not increased in 20 years. At the same time, technology that could have increased fuel economy has instead been used to increase horsepower by 85 percent and vehicle mass by 25 percent. In large part this is because the marketplace does not fully value fuel economy.

How do I know that is so? First consumers say so. In response to survey questions, consumers indicate they require payback periods for fuel economy improvements of about 2 years, far less than the full savings over the life of the vehicle. Second, manufacturers say so. Auto manufacturers generally say that consumers are willing to pay for fuel economy improvements that will repay their initial investment in 2 to 4 years. Third, scientific research says so. Researchers at the University of California at Davis interviewed 57 California households about their entire history of car ownership. Not one had ever calculated the value of future fuel savings. Most did not even consider fuel economy in their car purchases.

The economist's ideal consumer, comparing the discounted present value of fuel savings to its cost, was simply nowhere to be found.

It is not that consumers are irrational or uninformed. It is the nature of the problem. First, the rational consumer is interested in the net value of higher fuel economy, the discounted present value of future fuel savings minus the increased vehicle price. In fact, the net value of higher fuel economy generally varies little over a wide range of miles per gallon.

Figures 2 and 3 in my written testimony use the data and assumptions of the National Research Council Committee on the CAFE Standards to illustrate this point. At $2 a gallon, there is little difference in net value between a car getting 31 miles per gallon and higher MPG numbers all the way up to 41 miles per gallon. The difference is about $100, on a par I would say with floor mats. The same applies at $1.50 a gallon.

Second, the car buyer is faced with great uncertainty. What will the future price of gasoline be? How many miles per gallon will I really get with this car? What am I actually paying for this better fuel economy? Indeed, it would be surprising if the market for fuel economy did function efficiently.

But although higher fuel economy may not be a high priority for consumers, the benefits in reduced greenhouse gas emissions and increased energy security are of great value to society. So what can we do? What policies will work? Fuel economy standards, for one. We have the CAFE standards. The European Union has a voluntary greenhouse gas emissions agreement. Japan and China have weight-based standards and indeed Japan just established successful weight-based standards for medium and heavy trucks, as Mr. Logue has recommended today.

Australia and Canada also have standards. Nearly every major economy does. They work.

But there is always room for improvement and I believe the footprint-based reforms implemented by NHTSA for light trucks are potentially a major improvement. However, I wish NHTSA had had a thorough engineering analysis of possible unintended consequences. I think that analysis still needs to be done, although I think it will prove that the standards will work.

Feebates also an work. Feebates are a market-based policy that circumvents the failure of the market economy by levying fees on low fuel economy vehicles and providing rebates to high fuel economy vehicles at the time of purchase. We have an incomplete feebates system in the form of gas guzzler taxes, which strangely apply only to passenger cars and not light trucks.

The chief advantage of feebates is that, unlike fuel economy standards, they provide a continuing incentive to adopt the latest technology and apply it to improve fuel economy, perhaps another way around the gridlock that Senator Domenici referred to.

And yes, there is raising the tax on gasoline. Now, this is an unpopular proposal, but raising the tax on gasoline sends a consistent signal to consumers that reducing petroleum consumption is important, and it offsets the very small tendency for vehicle travel to increase as fuel economy is increased. It can be phased in as fleet fuel economy improves, having the added advantage therefore of maintaining the funding for our highway system.

Finally, there is research, development, and demonstration. As amazing as today's technologies are, they are still not up to the challenge of climate change or of achieving sustainable energy for the world's growing mobility demands. Even greater energy efficiency and the ability to effectively use abundant, clean energy sources are needed.

I thank you for your attention and look forward to questions.

[The prepared statement of Mr. Greene follows:]

PREPARED STATEMENT OF DR. DAVID L. GREENE, CORPORATE FELLOW, ENGINEERING SCIENCE AND TECHNOLOGY DIVISION, OAK RIDGE NATIONAL LABORATORY

Good afternoon. Thank you for inviting me to discuss the need to formulate effective policies to significantly increase motor vehicle fuel economy. The views I express today will be entirely my own and do not necessarily reflect the views of Oak Ridge National Laboratory or the Department of Energy.

Our transportation system consumes more petroleum than any other country in the world, on average 6,300 gallons of oil per second. It produces more climate changing carbon dioxide emissions than any other country in the world except China. There is good reason to be concerned about the sustainability of conventional petroleum as a source of energy for the world's transportation system. More than one fourth of all the petroleum consumed in all of human history was consumed in the past ten years. Both the International Energy Agency (IEA, 2006) and the ExxonMobil Corporation have predicted that by 2010 conventional oil production outside of OPEC nations will peak or reach a plateau. If we continue on our present path, only OPEC or more carbon intensive unconventional fossil energy sources will be able to supply the world's growing demand for liquid fuels.

WHY DO WE NEED FUEL ECONOMY POLICY?

For too long we have ignored the urgent need to reduce our petroleum dependence, protect the global climate and chart a course toward a sustainable energy system. For the past twenty years we have spent the technology that could have been used to raise fuel economy to instead increase horsepower and vehicle mass. Since 1987 horsepower is up 85% and mass over 25%. In part, this is because consumers value acceleration and speed. But it is also because car buyers undervalue fuel economy. Raising the fuel economy of passenger cars and light trucks will not by itself solve our energy dependence, greenhouse gas emissions and sustainable energy problems. But significantly increasing vehicle efficiency is an essential component of any meaningful strategy to address these important goals.

How do we know that consumers undervalue fuel economy? Consumers say so.

Consumers' responses to survey questions indicate a willingness to pay for only about 2 years of fuel savings. Half of a random sample of U.S. households was asked how much they were willing to pay for a fuel economy improvement that would save them $400 per year in fuel costs. The other half was asked how much money they would have to save each year in fuel costs to justify a $1,200 increase in the price of a vehicle. The average payback periods implied by consumers' answers to these questions were roughly 2-2.5 years, regardless of which way the question was posed. The published literature on consumer payback periods for fuel economy improvements is almost non-existent. However, such short payback periods are entirely consistent with the larger literature on consumers' preferences for other energy-using durable goods.

Figure 1.* Consumers Inferred Payback Periods for Fuel Economy Improvements Source: Opinion Research Corporation, Caravan Survey for the U.S. Department of Energy, May 20, 2004.

Manufacturers say so. Some say that consumers consider only the first 50,000 miles of fuel savings. Other manufacturers have told me they believe payback periods of 2-4 years accurately reflect consumers' willingness to pay. I have yet to find a manufacturer who believes that consumers value the discounted present value of fuel savings over the full lifetime of a vehicle. What manufacturers think consumers are willing to pay is important because it is they who make the decisions about vehicle design and the use of fuel economy technologies.

Scientific research says so. What little scientific research has been done on the subject provides strong evidence that the simple model of an economically optimizing consumer who compares the cost of improved fuel economy to the discounted present value of fuel savings does not apply to consumers' decisions about fuel economy. Detailed interviews of 57 vehicle-owning households in California covering the

*Figures 1-3 have been retained in committee files.

complete histories of their car-buying decisions found not one that did any comparison of the value of fuel savings versus its cost. The U.C. Davis researchers concluded: "When consumers buy a vehicle, they have neither the motivation nor the basic building blocks of knowledge to make a calculated decision about fuel costs." (Turrentine and Kurani, 2004, p. 2)

It's not that consumers are irrational or uninformed. In fact, there is relatively little net gain (or loss) for consumers from increased fuel economy over a wide range of higher fuel economy levels. The National Research Council (NRC, 2002) Committee's estimates of the cost of increasing the fuel economy of an average passenger car, together with the present value of future fuel savings are plotted in figures 2 and 3 for gasoline prices of $1.50 and $2.00 per gallon (constant 2000 $). The economically rational consumer is concerned with the net value of the fuel economy improvement: the present value of fuel savings minus the increased vehicle price. If the price of gasoline is $2/gallon, as shown in Figure 2, almost $500 in net value can be gained by increasing miles per gallon from 28 to 32. But there is very little difference in net value between 32 and 41 mpg, about $100 or so. Figure 3 shows the same calculations at $1.50 per gallon. There is perhaps a difference of $250 in net value between 28 and 40 miles per gallon. Of course, the consumer doesn't know what the future price of gasoline will be any more than I do.

Figure 2. Net Value of Fuel Economy Improvement to Car Buyer Using the NRC 2002 Fuel Economy Cost Estimates and Assuming Gasoline Costs $2.00 (Constant 2000 $).

Figure 3. Net Value of Fuel Economy Improvement to Car Buyer Using the NRC 2002 Fuel Economy Cost Estimates and Assuming Gasoline Costs $1.50 (Constant 2000 $).

In addition, it is rare that a consumer finds a clear trade-off between fuel economy and cost. Higher fuel economy may come with a smaller engine, a manual transmission, or a completely different model. It's up to the consumer to infer what the price of higher fuel economy really is. Finally there is substantial uncertainty about the actual fuel economy a car will get on the road. Even if the EPA estimate is accurate on average, any given motorist might get 7 mpg less or 7 mpg more in actual use.

From the manufacturer's perspective, moving from a sales-weighted average of 28 to 40 miles per gallon would require completely redesigning all product lines, a project that would take 8-10 years and billion of dollars for engineering and retooling; all for a fuel economy increase about which individual car buyers are likely to be indifferent.

The NRC (2002) fuel economy study considered the undervaluing of fuel economy in their cost-efficient fuel economy calculations. (A fuel economy increase was considered cost-efficient if the marginal cost of the increase was less than or equal to the marginal benefit in fuel savings to the consumer). In estimating the cost-efficient levels of fuel economy achievable by near-term technologies, the NRC report considered two alternative ways consumers might value fuel economy. One assumed that car buyers compare the discounted present value of fuel savings over the full life of a vehicle to increased cost of fuel economy technologies needed to achieve it. The other assumed car buyers were willing to pay for technologies with a simple payback period of three years or less. Using the full lifetime method and assuming gasoline priced at $1.50 (constant 2000 $) per gallon, the NRC Committee estimated that fuel economy improvements of 12% to 27% were cost-efficient for passenger cars, and from 25% to 42% for light trucks; the larger the vehicle, the larger the estimate percent fuel economy improvement. However, using the simple 3-year payback rule, the cost-efficient fuel economy changes ranged from –3% to +3% for cars and 2% to 15% for light trucks. Valuing fuel economy as both consumers and manufacturers say they do, little or no improvement was justified.

In June of 2006, at the request of Senators Biden, Lugar and Obama, I recalculated cost-efficient fuel economy levels using the NRC Committee's spreadsheet model but assuming gasoline prices of $2.50 and $3.05 (current $) per gallon and accounting for the discounted present value of fuel savings over the full lifetime of a vehicle. At these prices, the overall cost-efficient fuel economy improvements for the light-duty vehicle fleet were 41% and 50%, respectively.

Finally, the consumption of oil produces additional costs that are of great significance to us as a nation but are generally not considered by individuals in their car purchase decisions:

1. Economic costs of oil dependence
2. Military, strategic and foreign policy costs of oil dependence
3. Climate change impacts of carbon dioxide emissions
4. Other environmental impacts

By my estimates, the economic costs of oil dependence alone exceeded $300 billion last year. Military and foreign policy costs are extremely difficult to measure in dollars but in my opinion they are at least as great a problem for our nation. All of these additional costs of oil use are what economists call public goods (or bads). In general, consumers give them little or no weight in their individual purchase decisions. Such problems must be addressed by public policy if they are to be solved.

WHAT POLICIES WILL WORK?

While there are many policies that can reduce transportation petroleum consumption and greenhouse gas emissions, I will focus on those that can have the greatest impact on new vehicle fuel economy: fuel economy regulation, fuel economy fees and rebates ("feebates"), the price of gasoline, and research and development of new automotive technologies.

If the market for fuel economy were efficient, taxing gasoline would be an efficient solution. Since the market for fuel economy is not efficient, many governments have chosen to adopt fuel economy standards. The European Union, Japan, China, Canada, Australia, South Korea and the United States all have fuel economy standards for light-duty vehicles (An and Sauer, 2004). Japan has also recently successfully implemented fuel economy standards for heavy trucks. In many of these countries gasoline prices exceeded $4 and even $5 per gallon last year (EIA, 2006, table 11.8). Yet fuel economy standards are still needed because of the inefficiency of the market for fuel economy and because markets are not concerned with the public goods, such as energy security and preserving the global climate. Raising gasoline taxes is a less effective way to increase fuel economy than standards or feebates. Nevertheless, higher fuel taxes are an important complementary policy because they send a consistent message to consumers that reducing fuel consumption is important, they mitigate against the very small increase in driving that fuel economy increases would otherwise produce, and they can be used to offset the loss of revenues to maintain and improve transportation infrastructure that would otherwise occur.

Fuel economy and greenhouse gas emissions standards can take many forms. Japan and China's fuel economy standards vary with vehicle weight. The EU's greenhouse gas standards are a voluntary agreement on an industry-wide target between the government and industry. The U.S. Corporate Average Fuel Economy Standards require the sales weighted harmonic mean fuel economy of a manufacturer's imported and domestic passenger car fleets to meet a single fuel economy target. The target is the same for all manufacturers regardless of the types of vehicles they sell. The newly reformed light truck fuel economy standard assigns each manufacturer a different target depending on the "footprint" (wheelbase time track width) of the trucks it sells. The new reformed standard is likely, in my opinion, to prove to be an important and valuable innovation that could be extended to include the passenger car standards in a unified system. Unfortunately, the NHTSA did not do a thorough study of how vehicle designs might change under the new reformed standards and what the consequences of such changes might be. This study still needs to be done if we are to be confident that the new reformed system will not have significant unintended consequences.

Feebates are a market-based policy that circumvents the market failure of undervaluing fuel economy. A feebate system imposes fees on high fuel consumption vehicles and gives rebates to low fuel consumption vehicles. Fees increase in proportion to the gallons per mile by which a vehicle exceeds a target value and rebates increase in proportion to the gallons per mile by which a vehicle's fuel consumption is below the target value. Because the market signal is given at the time of vehicle purchase, feebates avoid the market failure that makes gasoline taxes relatively ineffective in promoting fuel economy. Today we have a partial feebate system in the form of gas-guzzler taxes that apply only to passenger cars.

Feebates have certain advantages over fuel economy standards. Because a fee avoided or a rebate gained is always valuable, there is a continuing incentive for manufacturers to adopt the latest technologies and apply them to improving fuel economy. Published studies show that feebates, like fuel economy standards, will work almost entirely through the adoption of fuel economy technology rather than by shifting the mix of vehicles sold. Feebate systems can be designed to be revenue neutral, revenue enhancing or a net cost to the government and net subsidy to industry and consumers. An appropriately designed feebate system can actually increase the sales revenues of vehicle manufacturers.

Feebates have the disadvantage that the quantity of fuel economy improvement is not certain, as it is with a fuel economy standard. Also, depending on how the feebate system is designed, some manufacturers will be net receivers of rebates while others will be net payers of fees. Such effects can be reduced by designing attribute based feebate systems, in the same way that the current light-truck fuel economy standards are adjusted according to the sizes of light trucks.

Future technological advances will expand the possibilities for efficiency improvement and substitution of clean alternative energy sources if industry, academia and government aggressively pursue research and development. I will not dwell on the importance of research and development of advanced automotive technologies but simply note that continued technological progress is essential. The technologies available today are amazing improvements over technologies available three decades ago. Still, they are not up to the task of reducing transportation's greenhouse gas emissions to acceptable levels nor of achieving sustainable, secure energy for transportation in the 21st century. To accomplish these goals we will need advanced vehicle and fuel technologies, and the sooner the better.

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The CHAIRMAN. Thank you very much.

Why don't we do 5-minute rounds, and then if people still have questions we will do another 5-minute round.

Let me get started. Dr. Anderman, you in your testimony make reference to this U.S. Advanced Battery Consortium, and I think also urge that the Government, the Federal Government, do much more to promote battery, advanced battery development for use in vehicles. What has been the problem with getting that, making the necessary progress? You indicate that we are behind Japan, we are behind Korea, and we are behind these other countries. Is it just a lack of Federal funds that are going into this or is there some other failure that is a little harder to get to?

Dr. ANDERMAN. I will start saying that under the U.S. Advanced Battery Consortium significant advances have been made with lithium ion battery technology. I also said that at the cell level chemistry U.S. and European expertise is quite high, and Canadian. The problem here is that there is really no high-volume manufacturing of lithium ion batteries in the United States. It does not exist. And the step to go from a cell chemistry to competitive high-volume manufacturing of lithium ion batteries is a very big step. Nobody has done it in the United States yet.

So the funds have been used well and there has been significant improvement. Companies that received some of the funds made significant steps forward. The car companies increased their understanding of how the technology works. But we still do not have U.S. manufacturing.

The other comment I will make is that the difference between the requirement to make a conventional hybrid work and a plug-in hybrid work is very large, and I think we are right on the edge of having lithium ion being a viable technology for conventional lithium ion. That is not the case for plug-in.

The CHAIRMAN. Thank you.

Mr. Logue, let me ask you. You say, one of your recommendations is that the Congress should set fuel efficiency standards annually for medium and heavy-duty vehicles. You are essentially embracing something akin to CAFE, where we say this is the standard and we are not giving the administration discretion to change it or anything else, but to implement it.

Mr. LOGUE. Absolutely. What we are looking for is to set the efficiency standards for both emissions as well as the fuel economy, because what we have seen recently in the past years is as the efficiencies have improved on emissions it has come out of the fuel economy. So we are looking for both. We want to have regulations that require not only continued emissions improvement, but also fuel economy improvement at the same time, which will require and drive a lot of change towards the hybrids and so forth, which can turn that product around.

At the same time, on the large trucks the reality is hybrids at this point here on large trucks are not out there. We are looking on the large to try to find a way to continue to improve emissions on the large trucks and fuel economy, which will drive alternate solutions going forward on the large trucks.

The major focus for us is on that medium truck, which is our pickup and delivery type, and try to find ways to keep both going up, because it will cost us more. We understand that from a capital perspective. But ideally, operating costs will come down as you improve your mile per hour and so forth. And that improvement comes right back to us on our stops per hour and so forth.

The CHAIRMAN. Let me ask Ms. Lowery and any of the rest of you that want to comment. California is working to develop what they are calling a low carbon fuel standard, which is a new concept to me, but seems to try to get at the emissions issue, but also I believe would have a substantial impact on vehicle fuel efficiency. Are you familiar with that proposal and if so do you think it makes sense as a way to begin regulating this if CAFE is not the right way to go?

Ms. LOWERY. I am familiar with it. The executive order was pretty broad and general, so we will look for further details. They are sending it back to the agencies to look at what could be accomplished there. But when you focus on fuels it is very helpful, just like the discussion we have had here on renewables fuels. If we really want to look at energy diversity as a country, we do have to look at both fuels and the technology on the vehicles. So directionally it makes a lot of sense to try to create momentum around renewable fuels, which is what the low carbon focus would do.

The CHAIRMAN. Do you think it would also result in significant vehicle fuel efficiency?

Ms. LOWERY. Well, it certainly would reduce greenhouse gases, and it would also displace petroleum because of the low carbon content, that you would have more E–85, biodiesel, E–10. You would have a lot more diversity in the fuels for transportation sector. So how it all plays out with respect to the specific fuel efficiency, we would have to see the details of that.

The CHAIRMAN. Anyone else want to comment on that? Yes, Dr. Greene?

Mr. GREENE. I think first of all it is a good approach because it is a performance-based standard and it allows the fuel suppliers to figure out what the best way to do it is. To the extent that the low carbon fuels added or blended with petroleum fuels are alcohols like ethanol, it will actually decrease fuel economy on a volume basis somewhat because of the lower energy content of alcohols.

The CHAIRMAN. Thank you very much.

My time is up.

Senator Domenici.

Senator DOMENICI. Thank you very much, Mr. Chairman. Might I say that, for those who really want to pay attention and follow up, this is an extraordinary record. I compliment you for the quality of the witnesses. I contributed a couple of thoughts, but most of them were thought up by you and your staff, and they are terrific. I think what has gone on record should just be the beginning. We could use them a little more. I am sure they would be glad to have that happen if they saw it being worthwhile.

Ms. Lowery, your testimony says that the automobile industry is in need of some tax credits of some type so they can move ahead in the battery area. What are you talking about? Does General Motors need some tax incentives that we are unaware of to move ahead in this, in the field of battery, the growth of new kinds of batteries and getting them operative into the American market?

Ms. LOWERY. There are actually a couple pieces of incentives necessary. So we need government incentives with respect to the battery research and development as well as manufacturing, which is critical because, as the testimony shows, it is based in China, Japan, and Korea right now.

Senator DOMENICI. What is?

Ms. LOWERY. Battery development——

Senator DOMENICI. All right, battery development.

Ms. LOWERY [continuing]. With respect to actual high-volume manufacturing. The chemical work is going on here through U.S. ABC and a number of the fine companies that are working very hard on lithium ion. But more research and more incentives for manufacturing of the supplier of batteries is very important for the energy storage type of battery for plug-in and for——

Senator DOMENICI. Would you stop right there?

Have you submitted this kind of request to some part of the U.S. Government before today so that they are working on this? Or where are we in terms of USA versus General Motors communication, communicating with reference to this problem?

Ms. LOWERY. Sure. Ford, General Motors, and DCX have been working through the U.S. ABC Consortium and looking where funding could be used to develop batteries and do the manufacturing piece. There was a submittal to Mr. Al Hubbard that gave some information with respect to what would be helpful in R&D and manufacturing. Then there was additional discussion among the companies to what would be the best use of those funds.

Senator DOMENICI. Now, has anything come of that discussion?

Ms. LOWERY. Not that I am aware of.

Senator DOMENICI. How long ago was the discussion? I hate to sound like a cross-examining attorney, but did you give it to Hubbard a few months ago?

Ms. LOWERY. I believe it was a few months ago. I would have to check on the exact date. I was not part of the submittal process.

Senator DOMENICI. Well, ma'am, let me suggest on behalf of this committee, if the chairman does not think this is untoward, you ought to submit it to us.

Ms. LOWERY. Absolutely.

Senator DOMENICI. We are going to have to pass it. We do not find very much volunteerism on the part of this administration when it comes to incentives. We have to write them and pass them with precision or we never get them used. So just an idea of what we are up against. If you are talking about tax credits, it takes forever to get out of OMB. They have a propensity, for some reason, to find it extraordinarily appropriate to sit on their butts when we ask them for something to do with tax credits. We cannot find them. Senator, they are busy.

But we are going to—we have to find them because we do not have any money going into where it should be going. Here is another area that we have not heard about.

Now, John—how do you say your last name?

Mr. GERMAN. "JERR-man," just like the people.

Senator DOMENICI. German. That is a good name, right?

Mr. GERMAN. My father thought so.

Senator DOMENICI. Did you say something in your testimony about the Federal Government putting some incentives forth in this area?

Mr. GERMAN. There is a lot of potential ways to do incentives. The devil is in the details. It really depends on what you want to accomplish. Certainly advanced batteries, advanced energy storage, are going to help not just plug-ins, but also fuel cells and conventional hybrids. It is certainly an area of high priority.

Senator DOMENICI. Well, we are having a hearing today. We have all of you here and the whole purpose of the chairman calling it is to find out how we can do a better job of getting more miles per gallon in automobiles and trucks, in our transportation sector. The purpose of bringing you here is to ask you how to do that, what we should do.

Mr. GERMAN. In terms of battery research, the Department of Energy held a workshop last year outlining the needs. They did, in our view, they did an excellent job of defining the challenges and what should be done, and I think Congress simply needs to support them.

Senator DOMENICI. Well, I guess we, Mr. Chairman, ought to find out what that is. I do not know what they are doing, but that does not mean they are not doing something very wonderful.

I will wait and do mine later after you have given them a round.

The CHAIRMAN. All right, thank you.

Senator Menendez is next.

Senator MENENDEZ. Thank you, Mr. Chairman. I want to thank all the panelists for their testimony.

Ms. Lowery, I notice that your testimony does not say anything about CAFE standards and I wanted to know what GM's position is on the Government raising fuel economy standards?

Ms. LOWERY. Actually, I do mention that we have a strong commitment to improving the internal combustion engine fuel efficiency, which the men and women at General Motors, engineers, are working hard on that all the time.

With respect to CAFE, it is a very complex subject and it is very difficult to just pick a number. But with respect to what has been discussed so far, we do think that the truck reform was a very extensive rulemaking, which we did get into this attribute-based, which we think is a much fairer system, and that we would be willing to look at reform of car CAFE as well.

Senator MENENDEZ. So does that mean that GM supports the possibility of raising CAFE standards or opposes it?

Ms. LOWERY. We do not have a specific number with respect to where we think we should go. We think that in order to reduce petroleum consumption we need to look at all of the various aspects of the vehicle. So we have some limitations with CAFE, given some of the inequities that have been in the system for some time with respect to a full line manufacturer such as General Motors.

Senator MENENDEZ. You know, I always am concerned because I read the administration's initiatives. I think the *New York Times* today called it a "faith-based fuel initiative." That basically I think describes it pretty well. In the past, I've looked at some of the testimony that has been offered here and it seems that we call upon the Government to fund major efforts in battery and fuel cell research, we want them to expand biofuel infrastructures, and do a whole host of other things. But it seems that we are expected to do so without very much in return in the form of higher efficiency standards by the industry, and I think this is a shared responsibility.

I hope we do not hear that it is a consequence to the industry. The last time we heard those statements, we actually had an industry that, notwithstanding an increase in fuel efficiencies, cars kept getting bigger and heavier and heavier, and at the end of the day in some respects the industry when it was challenged had a rebirth. Your industry can do amazing things when it is challenged. But when it is not challenged it seems not to pursue it. So we would love to continue to pursue that conversation with you and others in the industry as well.

I have a question particularly on the hydrogen versus the plug-in hybrid efficiencies. For those who may have some expertise in this, maybe you can elucidate it for me. Has anyone looked at the overall efficiencies of fuel cells versus plug-in hybrids? It seems to me that if we do not use fossil fuels, fuel cells require taking electricity, using it to split water into hydrogen, compressing and transporting the hydrogen, then using the hydrogen to generate electricity on the back end. And each part of those steps obviously involves some loss of energy, not to mention the costs of developing a hydrogen fueling infrastructure.

So with plug-in hybrids you generate electricity, you transmit it over existing lines, and you bring it straight into the car. There is some transmission loss, but it seems to me like that is a more efficient process overall. So has anyone looked at the overall costs and efficiencies of the two processes head to head?

Mr. GERMAN. Not that I am aware of. But keep in mind that the transmission losses in electricity generation can be very large. In some cases only about a third of the energy actually gets to the end. But as you correctly pointed out, both the plug-in hybrid vehicle itself and the hydrogen vehicle, the vehicles are highly efficient. Fuel cells are 60 percent efficient. There is not that much loss in the end. It is the upstream, what does it cost to make it, transport it, is the real issue.

So if you are looking in terms of simply global warming or total energy, there is not necessarily a lot of savings to them, but what you do get is a lot of fuel displacement. It is using something besides oil to provide the energy. That is the primary benefit.

Senator MENENDEZ. Dr. Anderman.

Dr. ANDERMAN. There is work in the national labs both in Argonne National Lab and the National Renewable Energy Laboratory in Colorado looking at that. The complexity here is it depends what is the source of electricity and it depends how you make hydrogen. So it is impossible to give a single answer.

I will just say that ballpark the efficiency when you look at the total system, depending on what is the source of electricity and what is the source of hydrogen, they are very similar. If you consider the considerable investment, risk, infrastructure, unknown in fuel cell compared to plug-in hybrid, it is definitely less likely to help our energy security in the next 20 years.

Senator MENENDEZ. Thank you, Mr. Chairman. I hope that we will look at this issue before we go down the path of spending a lot of money on something that, unless we have the comparison to get a real hold of understanding what is most efficient and pursuing this, we can spend a lot of money and find out that we are not necessarily headed in the best direction.

Thank you.

The CHAIRMAN. I think you make a very good point.

Senator Smith.

Senator SMITH. Thank you, Mr. Chairman.

Ladies and gentlemen, thank you for being here. You answered a number of my questions already with your testimony, but, Dr. McManus, I wonder if you have researched the cost of owning and maintaining advanced technology vehicles over the life of the vehicle? Dr. Anderman indicated that some of these technologies will not last the life of the car. What does that mean in practical dollars and cents terms to a consumer?

Dr. MCMANUS. Well, I have not done that kind of research on what the costs could be. But there is speculation about batteries in particular costing a lot to replace. I do not know that we have actually had that happen with the current generation of hybrids that are out there, that they have actually been replaced. John German might be able to answer that if they have.

But there is an uncertainty about what the costs are going to be. For example, the Automotive Lease Guide Company would not put a residual for the Prius because they were not sure; it was a new technology. However, research that we did when I was at J.D. Power and Associates suggested that the residual for the Prius was about 2 to 3 percent higher than the residual for a Camry, and that is quite significant. But it was the—it actually had a better residual in the used vehicle market. I think that is an indicator of the value and how long people think it will last.

Senator SMITH. Well, you know, to Senator Menendez's question, another one that I have been asking myself in listening to you relates to infrastructure, whether it is hydrogen or electricity, and perhaps the age of plug-in vehicles. There are large regions of this country as we speak right now that are always on the edge of blackouts, and I do not know if anyone has put a pencil to what it means in terms of power loads that will be necessary to get us to being able to support this kind of thing.

I mean, everyone wants energy at an affordable price, but nobody wants it produced near them. So we have a heck of a time getting the infrastructure in terms of power. Shoot, they are even talking about tearing out hydroelectric dams in my part of the world.

Do any of you know of any research on what is out there in terms of what we are going to have to do as a Congress to get this infrastructure? Dr. Greene, do you?

Mr. GREENE. Yes, this has been addressed recently in studies by the University of California-Berkeley and the Electric Power Research Institute. Both presented papers at the recent Transportation Research Board meeting. It depends entirely on when the customer chooses to recharge the vehicle.

Senator SMITH. You probably have to do it at night.

Mr. GREENE. If you recharge at night, then there is plenty of capacity. If you recharge during the peak periods, then you have to build new capacity.

Senator SMITH. Dr. Greene, you say that consumers generally do not consider fuel efficiency when they buy a car, which probably argues why the Federal Government ought to be pushing the industry to increase technology.

To your point, Dr. McManus, you discuss the financial problems the Big Three are in right now. I wonder what kind of financial health other companies are that do produce fuel efficient vehicles. How does GM compare to Toyota right now?

Dr. MCMANUS. Not very favorably.

Senator SMITH. So have we done them backhanded harm by not pushing CAFE standards or some other mix of incentives to get them—are there not a lot of auto workers in Detroit who would be employed today if we had done this?

Dr. MCMANUS. Well, I do not know if it is that simple, but they would be better off if they were making more fuel efficient vehicles now. I think the down side of having fuel efficient vehicles in your fleet is less serious than the down side of having inefficient vehicles in your fleet, and especially when you look at the fact that the large SUVs that are the biggest gas guzzlers are produced here and they really only have a market here. So when the market here slows down a little bit with the fuel price, we are hit very hard. Communities and workers are hit hard, whereas other companies can move vehicles or can source vehicles from other countries. We cannot sell those vehicles in other countries in large enough numbers. We are very inflexible here in terms of what we make, and that is not healthy.

But I do not know if that can be addressed just by looking at their health now.

Senator SMITH. Well, it probably can not. It is probably more complex than that and I probably ought to give Beth Lowery and John German a chance to answer that, because it does seem to me that maybe we need to help you help yourselves by pushing this, these standards in some new mix. I know CAFE is a very blunt instrument, but it surely seems to me that we are not helping you by backing off from pushing you.

Ms. LOWERY. Well, certainly we have had our challenges at General Motors. We are in the midst of a major turnaround addressing a number of issues. It is important with respect to the record we have on fuel economy. We have more models that get 30 miles per gallon on the highway than any other manufacturer. We are a broad portfolio of vehicles. So we have from a small vehicle to very large vehicles.

So we tend to get painted as someone that does not understand fuel efficiency. We understand it very much. We have people that are working very hard every day to improve the internal combustion engine and transmissions and putting large investments in all the advanced technologies, including what we can do today.

But it is not as simple as that. CAFE is the mix of what is sold in the market. Certainly people have valued functionality, safety, performance, and markets are a very difficult thing to predict and certainly when the high price of gasoline happened there was a major shift very quickly. You know, in our industry it is not easy to turn very quickly to a totally different portfolio.

But certainly we do have the focus on fuel efficiency. Again, the issues that we have been dealing with are not simply about whether General Motors is selling fuel efficient vehicles or not. We certainly have issues of legacy costs, health care, the currency issues, the trade imbalances. There is a whole list of issues that we are addressing one by one and obviously, with help from government, are making progress on a number of those as well, and we look forward to continuing to work together.

But we need to make sure we stay close to the market and close to what the U.S. consumer is interested in.

The CHAIRMAN. Mr. German, did you wish to make a comment?

Mr. GERMAN. From Honda's point of view, we just have a culture of being a technology leader. We are consistently 20, 25 percent over the CAFE standards. We are not affected by them. Even if you adjust for size, if you look at the NHTSA's reformed light truck standard for 2011, our 2006 light truck fleet essentially meets that size-adjusted 2011 standard. So that is just our philosophy, is to be a technology leader.

The CHAIRMAN. Senator Salazar.

Senator SALAZAR. Thank you very much, Chairman Bingaman. Thank you for holding this hearing on this important subject.

Let me first ask a question to Mr. Logue. For me, when I look at all this energy debate that we have had here for the last several years and maybe the energy debate in the last 30 years, there are a lot of ideas and sometimes people would say a lot of hot air and sometimes a lot of inaction that takes place.

Let me commend your company because with the 100 hybrid vehicles that you have out on the road—I was reading the information that was given to me. You have these vehicles, 42 percent better fuel economy, 30 percent reduction in CO_2 emissions, 96 percent reduction in particulate matter. So I think you are leading the way.

I am disappointed, frankly, as even though we try to work as well as we can on a bipartisan basis—the 2005 Energy Policy Act came out of this committee I think with only one no vote and a bipartisan vote coming out of the Senate, I think with 82 votes. And yet, 2 years later we do not have a Department of Transportation that has moved forward with the promulgation of the rules that would implement the tax credit for commercial vehicles so that you can buy hybrids, so we can further penetrate that market.

So it seems to me that what we have here is an Executive Branch agency that essentially is thumbing its nose at what this committee did and what this Senate did. How would these Federal tax credits, if they were available to FedEx, how would they incentivize your company to do more of the good things that you are doing?

Mr. LOGUE. Well, I think first of all, I understand they are in the final stages of getting that approved, which is encouraging. The important thing here is that it is an incentive that would allow us to go out there and participate in the market. But also, I think we also look at it as a way to stimulate the market if we had the tax credits. It is very difficult for companies our size and anybody in the medium truck range to go out there and buy at the rates that these hybrid trucks, the costs that they are today.

So it is twofold: One, I think it incents us to go out and want to participate and buy more. At the same time, we are really looking forward to make a market that is going to incent the manufacturers to want to go out there and obviously participate in that market. I also believe that the manufacturers will need some sort of support as well, tax incentive or whatever, to also get into that, into the market. That is why I tied it to the issue that we also need to make sure we are raising the fuel economy regulations as well as the emissions, because as you do that you cannot get fuel economy when you are trying to take the—when you are driving your emissions performance up by taking out of the fuel economy as a way of getting there.

So we need to make sure that we put it on both, and then from there with the tax credits it would allow us to go out there and participate more. Again, we look at it on both sides of the coin. We want the manufacturers to be incented to buy them, because again at today's prices it is not cost effective for a company to go out there and purchase those trucks at that level.

We did it to make sure that we understood, could these trucks work for us, are they really that efficient, and more or less be a proving ground to validate. We have done that, and we believe now it is time to make sure that we have the support to change the industry. The numbers speak for themselves. They do work and we need to make sure that we are driving—we view our role to be the catalyst driving that behind it, and again we look for your support.

I think this committee here, it is a great opportunity for you to really make a difference I think in this part of the industry. Again, we are very small in the scheme of things compared to the automotive, but at the end of the day we do burn a lot of fuel and there is an opportunity to make some significant savings with today's technology.

Senator SALAZAR. Thank you very much, Mr. Logue.

I know we have another round of questions that I hope we end up getting to. But there are a number of bills that have been introduced in this Senate by a whole host of people. Many members of this committee are co-sponsors with Senator Bingaman of legislation that came out of an effort called Set America Free and it is S. 339, which essentially helps incentivize the renewable fuels and the distribution of renewable fuels as well as higher efficiencies with vehicles, and it includes a broad measure of the Senators from Republican to Democrats, conservatives to progressives.

I would like each of you, if you can in one or two sentences, because I do not have much time, to tell me what it is you think we as a Congress could do to most achieve the objectives of enhancing renewable fuels and their use as well as fuel efficiency? You do not have much time, so one sentence each, basically. Beth?

Ms. LOWERY. Support for renewable fuels I think is the most important thing for displacing petroleum and really making a difference in getting a diversity of supply for transportation.

Senator SALAZAR. John.

Mr. GERMAN. Honda is on record as supporting increases in the CAFE standards. We think this is the most effective way to reduce fuel use. On the fuel side, we are certainly supportive of renewable fuels, but until we see how development of cellulosic material goes that is limited, so it is something that we need to watch and could be effective, but is not nearly as certain as CAFE.

Senator SALAZAR. May I have 1 more minute, Mr. Chairman?

The CHAIRMAN. Yes.

Senator SALAZAR. The question to you, Mr. Anderman, the same question.

Dr. ANDERMAN. Incentivize the growth of the hybrid vehicles market so we can actually get to the level where we have an impact on energy security in the next 10 years, and build the understanding of the technologies that possibly from there we can go to plug-in as well, because the best incentive you can give for plug-in is create the industry by moving the lithium ion into the regular hybrid market. This will get the capital out there looking at that if there is a lithium ion market and we invest and then you can move to plug-in.

Senator SALAZAR. Mr. Logue.

Mr. LOGUE. Set fuel efficiency standards for the medium and heavy-duty trucks, continue to push the tax credits that are out there for us so that we can make sure these medium trucks become cost competitive.

Senator SALAZAR. Mr. McManus.

Dr. MCMANUS. I think the most important thing that can be done is to provide incentives for supplier companies to develop the technologies, because that is where it is going to be developed and they are—they then can sell anywhere, to any manufacturer.

Senator SALAZAR. Mr. Greene or Dr. Greene.

Mr. GREENE. I think the first thing would be higher fuel economy standards, maybe 30 to 50 percent improvement by 2017, hopefully with a unified car and truck system based on the footprint approach. But as I said, a study needs to be done to make sure that there is not stretching of the wheelbase and track width with unintended consequences.

I also think we should go for fuel economy standards for medium and heavy trucks, at least as much as the Japanese have done with their weight-based standards, which is 15 percent.

An alternative to all of that is a feebate system, which I agree is less likely because it is untested.

Senator SALAZAR. Thank you, Dr. Greene.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman.

Thank you to all the panelists today. Some very interesting discussion and positive and constructive proposals out there, which I think it is fair to say we greatly appreciate.

Mr. McManus, I want to ask my first question of you. You had indicated, I think you said, that it is common to discount the evidence that the consumers want fuel economy standards. Good discussion raised by Senator Smith in that vein. Everyone is talking about increased CAFE right now. The President mentioned it in his speech last week. I am a co-sponsor of legislation that would increase the passenger car standard to 40 miles per gallon by 2017.

Is this doable? Is this too aggressive? Is this—is it going to do damage to the industry? Will they produce vehicles that the public will not accept? Just give me in your experience whether this is a doable goal?

Dr. MCMANUS. Well, I am not sure about the specific number and if it applies to cars and trucks.

Senator MURKOWSKI. Cars.

Dr. MCMANUS. Just cars.

Senator MURKOWSKI. What we are looking at is a study for the——

Dr. MCMANUS. Right, the passenger cars. Then I think that is certainly attainable and it would actually help make the domestic industry more competitive worldwide.

Senator MURKOWSKI. What about the safety issues that could be raised? I think, Mr. Greene, you kind of hinted in your last response there that we must look to that aspect of it, of course. Dr. McManus, if we move to the 40 mile per gallon standard do we suffer anything from the safety perspective in your opinion?

Dr. MCMANUS. Well, I think it depends on what happens on the truck side, too, because what is deadly is variance in the weight when vehicles interact. So if the trucks stay bigger and the cars get smaller, that—that is where the concern over safety arises. So I think it has to be comprehensive. You have to look at both cars and trucks, fuel economy and safety together.

Senator MURKOWSKI. Mr. German, you mentioned that Honda does support increased CAFE. Have they said—have they set a standard? Is 40 miles per gallon attainable from their perspective?

Mr. GERMAN. What we have said is that the standard should be set by an expert agency like NHTSA. They are the ones who can evaluate the tradeoffs between—the rate of technology development is very unpredictable. They can see how it is going. They can assess that. Lead time is extremely important. All these can be balanced off against the safety and the need for the Nation to conserve energy and all that.

But the issues are so complicated that it really takes an expert agency like NHTSA to sort them out. And they change over time as well.

Senator MURKOWSKI. Let me ask you, Mr. Logue, because you mentioned very clearly your support for a CAFE standard for the commercial trucks in your testimony. I am glad that there are folks here that are bragging on your company. I was noting in your testimony your vehicle fuel usage declined by 3 percent from fiscal year 2004 from last year. Knowing how many trucks you have out on the road, you guys are certainly figuring it out and we want to recognize that.

I have introduced a bill that would require NHTSA to report back to Congress within 2 years on the benefits and the costs of imposing such a standard. Do you agree with that approach or do you think we just need to move ahead with imposing the standard on the trucks?

Mr. LOGUE. I think without doubt we need to put standards in for the medium and large trucks. We need to set specific objectives so that the manufacturers have that objective to go out there and meet as we work on their efficiency well. The emissions are very important. We all agree with that 100 percent. But we have got to make sure that it is not a tradeoff.

So we firmly believe that we will not get where we need to be unless we set the standards on both sides, which then in our opinion will drive the hybrid performance. In hybrid trucks it will drive the performance that we all need in the production as well as the limitations of the emissions.

Senator MURKOWSKI. One last question and this is for you, Mr. German. This is more of a technical question as it relates to ethanol. I understand that it provides less power than gasoline. Somewhere between 20, 28 percent more ethanol fuel is required to produce as much power as gasoline. My question is whether or not that is, my understanding, is correct? And if it is correct, is this—does this hold true for cellulosic as well? Does it also suffer—buzzers are going crazy here.

I mean, that is going to make a difference to a consumer if they think that they have got to fill up more or they are not going to be getting as much power from this cellulosic powered vehicle.

Mr. GERMAN. We need to separate the feedstock from the end product. Corn, cellulosic material, sugar cane, those are all feedstocks, and they can be made into a variety of end products, of which ethanol is only one of the end products. Another one, British Petroleum and Dupont are building a plant in England that will produce nutonal from sugar beets instead of ethanol.

So ethanol, it does not matter what you make it out of. Ethanol is ethanol. It has 28 percent lower energy content than gasoline, E–85 has 28 percent lower energy content. Ethanol has 33 percent lower. This means 28 percent lower fuel economy. It means 40 percent more trips to the fuel station.

Honda is very supportive of biomass development. We even announced that we are working with an independent company on developing cellulosic processes. But we are puzzled by the rush to judgment on E–85. There are a lot of potential end products. Butanol can be shipped through pipelines, ethanol cannot. Butanol has higher energy content. It may prove to be a much better fuel in the long run, and for the time being, if you look at ethanol from corn, we can easily absorb that into 10 percent ethanol blends, E–10. There is no need to rush into E–85 infrastructure right now.

So what our recommendation is is that the current production of ethanol go into E–10 and that we evaluate the process of cellulosic development, which would produce a lot more fuels that we need to now go into higher blends, but also the process of other possible end products such as butanol, which would have significant advantages.

Senator MURKOWSKI. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much.

We have been informed we have two votes starting up here right away. So Senator Sessions has indicated he does not have questions right now. I will call on Senator Cantwell for her questions and then we will adjourn this hearing, and we appreciate all of you being here.

Senator CANTWELL. Thank you, Mr. Chairman. I am sorry my colleague from Oregon left because I know that we have had a lot of discussion about the electricity grid and about plug-ins, and I just want to point out that the Pacific Northwest Lab just recently released a report saying that the current electricity grid capacity could provide capacity for 70 percent of our fleet of cars, pickup trucks, vans, and sport utilities. So that is a pretty amazing number when you think about it. It could basically amount to about the equivalent of 50 percent of our imported oil and cut greenhouse gas emissions by an estimated 20 percent. Using the current electric capacity that is already out there, that is unused. So I think that that speaks to, obviously, what we have tried to do before on plug-ins and maybe where we can go in the future.

Mr. McManus, you were pretty direct with your testimony. I would like to ask you something even more direct. Do you think the difference in profitability between Honda and GM had to do with these companies' focuses on the choices in car manufacturing that they have pursued?

Dr. MCMANUS. I think there are a lot of factors that make them different. It is—right to start, Honda is not as full a line manufacturer as GM is. So there is a big difference there. However, it was those vehicles that Honda does not make that provided GM with most of its profit for a long time, and they were the ones that were the most vulnerable.

So if you look at the different companies in terms of who is vulnerable to fluctuations in fuel prices, Honda is probably the least vulnerable to highs and lows of fuel prices. They will make money and profits during—no matter what happens to fuel price. GM and Ford are probably the most vulnerable to fuel prices.

Senator CANTWELL. Because they did not, because they did not manufacture a line of hybrid cars or alternatives for the consumer?

Dr. MCMANUS. Well, not that. It is because they are manufacturing the SUVs, the big SUVs, that have no other market in the world than here, and they have very poor fuel economy.

Senator CANTWELL. So just poor fuel economy choices led to the two different paths that we are seeing here?

Dr. MCMANUS. Yes, it was part of it certainly.

Senator CANTWELL. I have a question about composites. We did not talk about composites much. The 787 Boeing plane is a lighter weight material, 60 percent of the design with lighter weight materials, making it much more fuel efficient. I do not know if any of the panelists want to talk about this—I thought I saw something at Detroit where somebody was coming out with a model that might have integrated with some composites.

I think the Rocky Mountain Institute said that alternative fuels and lighter weight materials were key to our getting off of foreign oil. Does anybody want to speak to this?

Ms. LOWERY. Sure. I would mention, I think the vehicle you are referring to was our Chevrolet Volt concept vehicle. We worked with GE Plastics on some new lightweight materials that they have in research and development to really make it a lightweight vehicle, which obviously does improve fuel economy.

There is a big difference between the airplanes and use of composites and the everyday robustness of our cars and trucks on the road. But certainly Rocky Mountain Institute and a number of people are doing some research on lightweight materials, and certainly at General Motors we have a commitment looking at the lightweight materials and how they could be incorporated over a period of time into vehicles to improve the mass and efficiencies of the vehicle.

Senator CANTWELL. So what is the plan for that car, the concept car that you put out?

Ms. LOWERY. The Volt concept car right now is, we are doing the product development while the battery development is under way. So the lithium ion battery development we have talked about so much today is a very important part of that, and as that development is taking place we are also doing the product engineering. We do not have a specific time frame because of the battery development.

Senator CANTWELL. Wal-Mart is committed to increasing its efficiency in the truck fleet by 25 percent over the next 3 years. I think you were talking about something on a larger horizon. So are they ahead of you?

Ms. LOWERY. No, we are actually—hybrid vehicles are the ones that are showing that, the type of performance that I quoted in my earlier statements. They have 90 percent more—fewer particulates and 40 percent improvement in the fuel efficiency and so forth. Those are the hybrids. We are trying to get to—we are trying to go out there and stimulate the environment to go out there and move.

We have like 98 hybrids today. We are trying to move so that the manufacturer will produce them, because right now they are very cost-ineffective and bottom line is if we can continue to stimulate that. We know the performance is there and we show on these trucks that we can get that type of performance.

Senator CANTWELL. Mr. German, since you have the mantra above you to continue to be the technology leader, and you in your testimony had some comments about diesel engines, what do you see for the biodiesel fuel market? I think at one point in time we did in the past administration have an agenda on diesel technology that was cancelled when this administration took over.

Do you think we have missed something there? Is Honda ready to invest in that line of car investment?

Mr. GERMAN. As far as the diesel——

The CHAIRMAN. Mr. German, why do you not go ahead and answer that question. Then Senator Sessions did indicate he has thought of some questions, and we have started the vote. So we will give him just a few minutes to ask his questions, too.

Go ahead.

Mr. GERMAN. Just as far as the diesel vehicles, we will be bringing out a four-cylinder diesel in about 2 years. We have also announced development plans for a V–6 diesel which will go into some of our light trucks. We are very optimistic that there is a viable diesel market in the United States.

The biodiesel I am not sure we have time to get into right now. I can try if you want.

Senator CANTWELL. Maybe I will follow up.

Senator SESSIONS. You can use my time on that because I was going to ask about diesels also. Briefly on the biodiesel?

Mr. GERMAN. The advantages of biodiesel is that they can be blended into higher concentrations than ethanol can be into gasoline. The down side right now of biodiesels is that there is no standards for the fuel quality of the biomaterial. So that is one thing that is needed.

There is also a potential concern in that all the feedstocks are moving to ethanol, and so right now the potential to produce a lot of biodiesel just is not there.

Senator CANTWELL. Could I just put for the record, Mr. Chairman, since we broke ground in Washington State—there was not 100 million gallons produced in the country, but this facility will produce 100 million gallons of biodiesel this year. So I think the market is changing and I am glad to hear that we need standards because maybe that is something we could do.

The CHAIRMAN. Thank you very much.

Senator Sessions, go ahead.

Senator SESSIONS. Well, on biodiesel, I visited an Alabama plant. Another one is about to start. The plant that exists has I think grown fourfold in the last 3 or 4 years in production. But I think you are right, there is a limit to how far that can go.

But on the question of diesel, Ms. Lowery and Mr. German, I understand that Europe is now 50 percent diesel and that the new diesel engines that the Europeans are using are 25 to 40 percent more efficient. So how do you respond to that, and maybe if there is any legal impediments in the United States that slows our ability to utilize more diesel?

Ms. LOWERY. Diesels are a very important technology for addressing CO_2, and in Europe there is a balance between the emissions requirements and the CO_2 requirements that encouraged the production of diesel. There is also policies with respect to diesel fuel on the pricing. So there was very much an incentive to have diesels in the marketplace and you see the results of that.

Here in the United States, we have the challenging emission requirements and so the diesel market is slow to grow here. But certainly if we are going to address CO_2 emissions in this country, it is a technology that needs to be given a fair shake with respect to incentives and making sure we are doing the right balance on emissions requirements and the CO_2 piece.

Senator SESSIONS. You mentioned the CO_2, but it would also reduce presumably imports of oil, which would reduce our dependency, a national security question. It would also help by reducing the amount of wealth transferred out to purchase this oil. It would help our economy also, would it not?

Ms. LOWERY. Right, and our diesels are certified for 5 percent biodiesel and we are working on the standards for the 20 percent biodiesel. So that would be something that would certainly help the development of biodiesel in this country as well. A very important piece of the fuel picture.

Senator SESSIONS. With any legal impediments or problems?

Mr. GERMAN. I just wanted to add quickly on what she said. Diesel fuel in Europe is cheaper than gasoline is in Europe; differential taxation. So a lot of people buying diesels in Europe are buying them to get to the cheaper fuel.

The other thing that happened is that the emissions standards for diesels in Europe are less stringent, and that has also helped. Here the standards are the same.

One other comment——

Senator SESSIONS. Is it the particulate emissions that are the problem?

Mr. GERMAN. Actually, the particulate emissions problems has been largely solved by the particulate traps. It is NOx, that is the problem.

The other thing that has happened, though, is that this huge buildup in light duty diesels in Europe has led to a refinery imbalance and Europe now has refined gasoline that nobody wants. They ship it to the United States, and that is why gasoline in the United States is now cheaper than diesel fuel here is. So unless that——

Senator SESSIONS. And we are shipping diesel fuel to Europe, I understand.

Mr. GERMAN. Not much.

Senator SESSIONS. Not much.

Mr. GERMAN. It is primarily the influx. So there is actually an inversion of the prices of the fuels and that is going to make it more difficult to introduce diesels in the United States as well. We are still optimistic, but the kind of situations that created this huge market in Europe do not exist here.

Senator SESSIONS. I see the Washington, DC buses running on clean natural gas. I understand that natural gas does burn much cleaner even as to CO_2, produces a lot less CO than oil does. That is a domestically produced item that does not require an importation and a purchase by the American consumer from a foreign source. And it sort of has irritated me that we are utilizing so much natural gas for electricity. It seems to me since—does natural gas—I will just say it this way: Does natural gas have a future in fleets like city buses in Washington, DC, and could that reduce some of our problems if we did that?

Mr. GERMAN. You are certainly correct, natural gas has a higher proportion of hydrogen in it, which means that there is less CO_2 emissions from it. It also burns extremely clean. It is cleaner than gasoline. So there is two major advantages.

The problem you have with it is that you do need central refueling stations, you do need expensive storage tanks. Fleets, buses, are a great application. But Honda is not in that business, so I cannot really respond to why more of it is not happening.

Ms. LOWERY. I would just mention that hybrid electric buses, we have Allison Transmission, who has been doing a hybrid, diesel hybrid, which has great performance as well. So that is another alternative to CNG buses that would be helpful to reduce dependence on petroleum.

Senator SESSIONS. Mr. Chairman, thank you.

The CHAIRMAN. Let me thank all of you. This has been very useful testimony. We will try to follow up on some of your excellent recommendations.

Thank you, and that will end the hearing.

[Whereupon, at 4:22 p.m., the hearing was adjourned.]

APPENDIX

Responses to Additional Questions

Responses of Walter McManus to Questions From Senator Sanders

Question 1. You assert that Detroit ignored consumer demand for more fuel efficient vehicles, to their financial detriment, and to our national detriment, in terms of jobs, national security and the environment. You conclude that higher prices for fuel caused consumers to want more efficient vehicles, but Detroit officials were in denial that fuel efficiency is important to consumers, just as they used to assert that safety would never sell. Then Detroit cut the prices of their least efficient SUVs to maintain the market for these gas guzzlers. Do you think their $25 billion in losses will make Detroit come to their senses in time to prevent economic, environmental catastrophe? Do currently lower fuel prices make them think that they can ride out this rough spot and keep selling gas hogs'?

Answer. The industry seems much more willing to accept that fuel economy is important than in the past, so the $25 billion in losses have had some effect. Whether this means they would and could act in time to prevent a catastrophe is impossible to tell. There has indeed been some backsliding because of lower fuel prices, but it has been focused more on concern that consumers may not buy hybrids and other fuel-efficient vehicles than on whether the industry can continue business as usual.

Question 2. Please respond to Senator Menendez' excellent question regarding the relative efficiencies of fuel cell electric vehicles versus plug in hybrid electric cars. That is, how much original electricity from a solar panel on the roof of an American home is lost in delivering power to split water to make hydrogen, to compress this hydrogen and make a fuel cell vehicle run versus the same electricity delivered to a plug in hybrid electric vehicle?

Answer. I hope you have asked this question of Mr. German of Honda. I am an economist not an engineer, and am afraid I am unable to answer.

Responses of Walter McManus to Questions From Senator Cantwell

Question 1. Mr. Green and McManus, has any of your research calculated the current levels of subsidies for fuel or feedstock producers, expressed as $ per gallon, for both bio diesel and ethanol fuels? And given the intrinsic advantages of diesel engines in fuel economy and the "refinery mix" constraints mentioned in testimony does this suggest to you that we need to look at refinery constraints as a limiting factor on fuel economy in mid to long term?

Answer. My research has not addressed the first question on subsidies for bio fuels.

The refinery mix constraints are significant and must be taken into account in fuel economy improvements that can be derived from diesel fuels. The mix constraint is intrinsic and so would affect long term gains.

Responses of Walter McManus to Questions From Senator Bingaman

Question 1. You make the case that domestic manufacturers are more vulnerable economically due to their—in your view—under-emphasis on fuel efficiency. which is much more in demand in the international marketplace. Have you done any analysis on the competitive position of domestic manufacturers regarding advanced fuel efficiency technologies? If the U.S. marketplace were to place greater emphasis on fuel efficiency, either through consumer choice or regulation, would U.S. automakers be competitive?

Answer. Our study, "Can Proactive Fuel Economy Strategies help Automakers Mitigate Fuel Price Risks?", which we provided to the Committee, directly addresses these questions. For your convenience, I reproduce the executive summary below.

EXECUTIVE SUMMARY

The high oil and gasoline prices we have experienced over the past two years have dramatically increased the attention paid to vehicle fuel economy by drivers, new car buyers, and the government. Detroit automakers, who have long depended on the least fuel-efficient vehicles to provide most of their profits (and some of who have argued that fuel economy did not matter very much to their customers) are seeing their sales and profits evaporate, as new vehicle buyers switch to more fuel-efficient vehicles. Management apparently assumed that (1) fuel prices would stay low forever, and/or that (2) their customers would not change their vehicle choices because of high fuel prices.

Events of the past two years have demolished both assumptions. The price of gasoline soared in 2005 and again in 2006, but more importantly the real price of gasoline has been rising at a 10% annual pace since 1999, and at a faster 16% annual rate since 2002. The price of gasoline ($2.70/gallon average so far in 2006) is 98% above what it was in 1999 and 83% above what it was in 2002. By lowering vehicle purchase prices (in cash, zero or low interest-rate loans, employee pricing for all), Detroit managed to maintain the sales of their profitable SUVs and pickups in units, if not revenue or profit. By the last quarter of 2005, the automakers' ability (or willingness) to cut prices again and again simply to sell the same number of units collapsed. Since then, consumers have migrated to more fuel-efficient options, primarily at the expense of Detroit automakers' share and profits.

In this study, we examine the economic viability of improving fuel economy as a strategy to mitigate the risk of high fuel prices and to gain a competitive advantage.

By adopting a "game theory" approach to representing the competitive interactions among the automakers and using different scenarios to represent the risks automakers face with respect to fuel prices and consumer demand, we are able to identify which strategies maximize profits for the automakers and support U.S. auto industry employment.

Rising fuel prices are a primary contributing factor to rapid erosion of Detroit automaker market share, profits and jobs.

- While GM, Ford, and DaimlerChrysler have significant cost disadvantages compared to their Japan-based competitors, some of which can be attributed to issues beyond the control of current management (exchange rates, health care and pension costs), poor fuel economy decisions by management have contributed significantly to their situation.
- Automakers that are highly leveraged in truck-based products (truck-based SUVs and pickups) are especially vulnerable to higher fuel prices since these products are less fuel-efficient.
- Detroit automakers have earned a high portion of their profits from truck-based products. In 2004, Ford earned 62% (GM 61%, DaimlerChrysler 44%) of variable profits from trucks and SUVs, versus 36% for Nissan and 28% for Toyota (Honda 0%). Consequently, when higher fuel prices restricted truck-based product prices and profits, Detroit automaker profits were disproportionately affected.
- Since January 1999, fuel prices have been rising, and the ability of automakers to maintain prices and profits of trucks has steadily declined. However, since Detroit automakers were heavily committed to trucks, and switching production from trucks to cars is costly, they accepted lower profits rather than lower unit sales of trucks.
- In 2005, the price of gasoline rose 19% above its 2004 level, and the share of variable profits from pickups and SUVs fell 4.0 percentage points for both Ford and GM. This profit erosion continued in the first half of 2006—GM's share of variable profits from pickups and SUVs fell an additional 5.0 percentage points (Ford's fell 1.0 percentage point). The cash cows are rapidly dying off.
- New-vehicle dealers, because they are closer to the retail market than the automakers are, have more accurately read the market's shift away from gas-guzzlers than have the automakers. Dealers have only indirect influence on the new products they get from the automakers, but they directly control the mix of used vehicles that they sell alongside the new vehicles. They obtain used vehicles to sell from wholesale auctions. Prices at wholesale auctions reflect dealers' collective judgment about what consumers are willing to pay (before adding a competitive mark up). Since January 2000, the auction price of used full-size SUVs has fallen from 185% of the average auction price of all vehicles to 133% (June 2006)—a 52-percentage point dropwhile the real price of gasoline rose 88% from $1.55/gallon to $2.92/gallon. The implied relationship is strong: a 1.0% increase in the real price of gasoline is associated with a 7 percentage-

point reduction in the wholesale auction price of full-size SUVs versus the average auction price of all vehicles.

- GM and Ford's dependence on truck-based products is eroding their market share. Larger Japan-based automakers (Toyota, Honda, and Nissan) are seeing share and profit growth, and are increasing their North American capacity because they have a larger selection of fuel-efficient vehicles that are attractive to Americans. However, because both GM and Ford committed to rolling out new large SUVs more than four years ago, they are not significantly cutting their capacity to produce these gas-guzzlers. Instead as their operations contract due to declining sales, they are cutting capacity to produce mid-size and smaller vehicles.

Technological Options

What options do automakers have to improve fuel economy by 2010? In this study, we assume that the basic product portfolio of any manufacturer is mostly fixed. However, within the fixed product portfolio, a manufacturer has the option of improving the fuel economy of its vehicle models by adopting improved engine, transmission, and other fuel saving technologies.

For simplicity, we analyze two distinct fuel economy strategies, "Business as Usual" (BAU) and "Proactive" (PROA). An automaker following the BAU strategy is assumed to make only those improvements in fuel economy that would be necessary for future CAFE standards. An automaker following the PROA strategy is assumed to make those fuel economy improvements beyond CAFE that consumers would value (and pay for). Developing these scenarios requires an engineering assessment of what fuel economy technologies are available and a detailed forecast of each manufacturer's future product plans including when individual models would have an opportunity to integrate new technology.[1]

Our data include 1,145 separate make, model, engine, transmission, and body style configurations in 2010. Of these, 154 configurations (13%) are expected to have new engines by 2010 that are potentially eligible for the advanced or moderate fuel-saving packages and 931 configurations with carry-over engines are eligible for foregoing projected improvements in horsepower downsizing.[2] Since the automakers understandably protect information about the future products and powertrains, our base assumptions for 2010 come from a forecast by The Planning Edge. It is possible that some automakers have already decided to implement some of the improvements we apply in the PROA strategy. However, since our base average fuel economy for Detroit automakers in 2010 is equal to what CAFE will require of them, and since the fuel economy of the Detroit automakers has historically not exceeded the requirement, Detroit automakers are not likely to have decided to implement our complete PROA packages.

Based on this assessment, we determined that if all automakers were to follow a PROA fuel economy improvement strategy and implement the fuel-saving packages we identified:

- Overall fuel economy would increase 6.0% above baseline 2010 fuel economy or 7.4% above model year 2005 estimated fuel economy of 24.5 mpg (EPA 2005). The 7.4% increase over today's level is consistent with the 4.0%-8.2% range we derived from a review of other studies and amounts to a modest 1.5% annual increase between 2006 and 2010
- Ford has the greatest opportunity to apply advanced technologies (34% of its base 2010 sales). DaimlerChrysler can apply advanced technologies to entries accounting for 30% of its sales and GM can apply advanced technologies to entries accounting for 19% of its sales. The Detroit automakers have more opportunity to improve the fuel economy of their vehicles than do Nissan (16%), Toyota (8%), and Honda (6%).

Methodology & Scenario Analysis

The impact of alternative fuel economy strategies and fuel prices on total sales by the industry is estimated using a simplified model of the total market demand for vehicles. To assess the change in market share for individual vehicle models under different fuel economy strategies and fuel price scenarios, we use an econometric model of discrete choice along with estimates of consumers' willingness-to-pay for attributes of vehicles. Discrete choice models match the intuitive notion that

[1] We derive these strategies by combining a detailed baseline 2010 sales forecast by manufacturer, model, engine, transmission, and body style from The Planning Edge) with an engineering analysis by Dr. Feng An (an expert in fuel economy technologies).

[2] We excluded as ineligible for improvement hybrids, diesels, and a few gasoline engines (60 configurations in all).

a vehicle is a bundle of attributes and that the vehicle's value to a consumer is derived from the value the consumer places on the attributes. The demand for vehicles is seen as a derived demand arising from the demand for vehicle attributes.

In this study we enhanced the model we used previously (McManus et al. [2005]), by incorporating measures of the key vehicle attributes of performance and size, along with the attributes examined in that study, fuel economy and retail purchase price. We updated our estimates of the model's parameters with 2005 data, using econometric techniques that exploit the correlation between vehicle price and vehicle attributes to derive data-based estimates of consumers' willingness to pay for fuel economy, performance, and size.

We used scenario analysis to compare automaker profits in four market-demand scenarios defined by fuel prices ($2.00/gallon and $3.10/gallon) and consumer discount rates (0% and 7%). The consumer discount rate measures the rate at which consumers discount future operating savings and costs to make them comparable to today's purchase price. Technically, the discount rate equals the prevailing market rate of interest minus the rate of expected inflation in fuel prices, and can be positive or negative (if consumers expected 14% annual percent inflation in fuel prices and the market interest rate were 7%, then the discount rate should be –7%). The lower the discount rate, the more value future savings of fuel are worth. We limited the lower bound on the discount rates in our simulations to 0% to be conservative.

We assume that automakers aim to maximize profits and decide whether to pursue PROA increases in fuel economy with that aim in focus as well as in light of uncertainties regarding future fuel economy standards, fuel price, and other automakers' fuel economy strategies. CAFE standards put a lower limit on each automaker's average fuel economy, but do not prevent any automaker from exceeding the standard.

To identify each automaker's optimal strategy under these uncertainties, we adopt a "game theory" approach. We model five automaker-competitors (individual Detroit, Japanese Big Three, and other), and we assume that each must choose either an aggressive or a BAU fuel economy strategy. An outcome in the simulation, of which there are 128, is defined by the fuel price, the consumer discount rate, and the choices of each of the five competitors. Letting this process run until it results in a stable outcome in which no automaker could gain by switching strategies given what the other automakers choose (Nash equilibrium), we find that the optimal strategy for each automaker is to pursue PROA improvements in fuel economy. This conclusion is quite robust; it holds when neither fuel price nor consumer discount rates are known; and it also holds when fuel price and consumer discount rates are known (among the four demand scenarios).

Another way to find the solution of the simulation is to apply the maximin principle of game theory (choose the strategy that maximizes the worst case one can expect). Four market demand scenarios, five competitors, and two strategies yield 128 possible outcomes, 32 outcomes in each of the four market demand scenarios. The maximin principle reaches the same solution; all automakers should choose PROA.

Results: Increasing Fuel Economy Performance Increases Expected Profits

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The surprising conclusion of our analysis is:

> Each automaker should pursue proactive improvements in fuel economy that exceed what CAFE requires, regardless of the fuel economy strategies of other automakers, for fuel prices between $2.00/gallon and $3.10/gallon consumer discount rates between 0% and 7%.

Detroit Automakers' Profits are Highly Sensitive to Fuel Prices under Business-As-Usual Fuel Economy Scenarios

- Detroit automakers' profits are much more sensitive to fuel prices than the Japanese automakers. These results are consistent with the findings in McManus et al. [2005]. Detroit automakers lose $3.1-$3.6 billion in variable profits when fuel costs $3.10/gallon compared to $2.30/gallon, accounting for 72-77% of the total industry losses. In contrast, the three biggest Japanese manufacturers (Toyota, Honda, and Nissan) also see a reduction in variable profits, but at a much lower level, $0.8 billion.
- Conversely, if fuel prices drop to $2.00/gallon, Detroit automakers do better than the Japanese automakers. Detroit's variable profits increase by $1.2 to $1.4 billion when fuel costs $2.00/gallon compared to $2.30/gallon. In contrast, the three biggest Japanese manufacturers only gain a total of $0.3 billion.

- The differences in Detroit's profits between high and low consumer discount rates are small compared to the differences generated by fuel prices. The variable profits of the three largest Japan-based automakers (Toyota, Honda, and Nissan) are much less sensitive to both fuel prices and consumer discount rates than Detroit's are.
- These results are driven by two critical factors. First, if fuel prices increase to $3.10/gallon, overall sales decline by 3.5%. At $2.00/gallon, overall sales increase by 1.3%. Second, higher fuel prices decrease consumer demand for fuel-inefficient products, especially truck-based SUVs, and increase demand for more fuel-efficient options, including crossovers, minivans, and cars. At lower fuel prices, the reverse is true. Consequently, since Detroit automakers sell a much larger fraction of less efficient truck-based vehicle products, they are much more vulnerable to variable fuel prices than the Japan-based automakers are.

Proactively Increasing Fuel Economy would Benefit Detroit Automakers

The results of our simulations were surprising, even to us. In all four market-demand situations we evaluated (defined by fuel price and consumer rate of time discount), proactively increasing fuel economy would be the optimal strategy for all automakers, in that it would result in the highest variable profit that each automaker could be assured of earning, no matter what price of fuel (between $2.00-$3.10/gallon), consumer rate of time discount (between 0%-7%), or actions by its competitors were realized.

What was especially surprising was that the Detroit automakers (GM, Ford, and DaimlerChrysler) have more to gain from pursuing the aggressive fuel economy improvement strategy than do the three largest Japan-based automakers (Toyota, Honda, and Nissan). This is because the Detroit automakers face more risk (are more vulnerable) if they pursue BAU than the Japan automakers do. The Detroit automakers also have more opportunities for improvement, since Detroit automakers currently have lower average fuel economy than the Japan automakers do.

- Detroit automakers would benefit from raising the fuel economy of their vehicles regardless of fuel prices and consumer discount rates. Our results show that a PROA, industry-wide program to increase fuel economy performance would increase the profits of Detroit automakers by $0.8-$2.0 billion per year (depending on the market-demand situation).
- While the gains are greatest in the case of high fuel prices with low consumer discount rate and smallest in the case with low fuel prices and high consumer discount rate, the gains are nevertheless positive in all four potential market-demand situations we evaluated.
- Ford stands to gain the most in annual profits, more than twice as much as GM or DCX, by proactively pursuing fuel economy performance. Ford's gains are from $0.5-$1.4 billion, depending on the market-demand situation. GM's gains are from $0.2-$0.5 billion, depending on the market-demand situation. DCX's gains are $0.1 billion (There are differences in DCX's gains between market-demand situations, but not sufficient to register at this level).
- On the other hand, the three largest Japan-based automakers show very different results from those of Detroit. The Japan-based manufacturers actually see a reduction in their profits of $0.1-$0.6 billion. In large part this is due to the fact that the Japan-based automakers have more fuel-efficient fleets than the Detroit automakers have, and therefore have less room for improvement. Under a PROA fuel economy strategy, Detroit-based manufacturers narrow the gap in fuel economy performance between their fleets and the fleets of the three largest Japan-based automakers.

These surprising results are driven by the following factors:

- The higher fuel economy level of the fleet helps to insulate total industry sales from declining under the high fuel price scenarios. That is, the entire industry makes more profit under high fuel prices if fuel economy levels are higher, ($1.2-$1.4 billion). More surprising is our prediction that under low fuel prices, total industry profits are higher by $0.8-$0.9 billion if all automakers following PROA. This is because at $2.00/gallon, some of the fuel economy technologies are still cost-effective. This assessment is consistent with recent National Research Council findings on fuel economy (NRC [2002]).
- The key factor that explains the advantages to Detroit-based automakers of adoption of a PROA fuel economy strategy is opportunity—the Detroit-based automakers have lower fuel economy than the three largest Japan-based automakers and thus have more room for improvement. In the technological options section of this report we identified a larger set of improvement opportunities (for both new and carry-over powertrains) for the Detroit-based than for the

three largest Japan-based automakers. (We excluded improvements that were not valued by consumers, and such technically possible but not valued improvements were more likely to be excluded for the Japan-based than for the Detroit-based automakers.)

- The three largest Japan-based automakers could, in principle, maintain their fuel economy advantage by applying more technologies to more vehicles, but they would do so at the cost of profits. It is important to note that, while the Detroit automakers could narrow their fuel economy disadvantage relative to the Japan 3 automakers through a proactive fuel economy strategy, the Japan 3 automakers would still have an advantage.
- Our study concludes that the Detroit automakers would benefit from pursuing PROA fuel economy improvements above what CAFE requires. This does not imply that raising CAFE requirements would benefit the Detroit automakers. That question was not directly addressed in the study, and it is important to understand that when we speak of an industry-wide or market-wide proactive fuel economy improvement strategy, we do not mean a higher CAFE standard, we mean the situation in which all automakers have chosen the PROA fuel economy strategy.

Proactively Increasing Fuel Economy would Protect American Jobs

We estimated the impact of strategic choices by automakers on U.S. employment using the well-known model developed and maintained by Regional Economic Models, Inc. (REMI). The REMI model takes the latest national input-output coefficients, which show how much each industry buys from every other industry, and tunes them to particular geographies using trade-flow data generated from the US Census of Transportation.

- Under high fuel prices, a market-wide PROA fuel economy improvement strategy would create 15,000-35,000 new jobs (throughout the whole economy) due to increased production by Detroit automakers. Decreased production by foreign-owned transplants would offset 10,000-19,000 jobs, for a net increase of 5,000-16,000 new jobs.
- Under low fuel prices, but with low consumer discount rates as well, the net gain in new jobs is smaller (168 net new jobs), as 11,000 new jobs due to increased production by Detroit automakers are nearly fully offset by reduced production by foreign-owned transplants.
- Only in the case with low fuel prices and high consumer discount rate would the market-wide proactive fuel economy increases result in job losses.

PUBLIC POLICY IMPLICATIONS

In light of our conclusion that the optimal strategy for all automakers is aggressive fuel economy improvement, even with $2.00/gallon fuel, why has it taken a steadily rising fuel price for five years, billions in lost profit, and tens of thousands of job losses to stimulate action by the Detroit automakers? What are the barriers to implementing the optimal strategy?

Deploying new technologies takes time and money to accomplish, and time and money are in short supply in Detroit. The cumulative effects of declining market share, rising fuel prices, and uncompetitive product development are forcing drastic and costly changes at Ford, GM, and DaimlerChrysler. For the first time in more than 20 years, their survival is in doubt. GM and Ford may have just enough cash for one cycle of product development to bring new versions of their full product lines to market. Items seen as important but secondary to new vehicle designs are not getting funded.

Public policy actions that will be accepted by Detroit automakers in the current situation will be actions that enhance their ability to respond to changing market conditions. Our research shows that increased fuel economy has the potential to enhance their flexibility, but pressing concern about what are seen as bigger issues make achieving progress challenging.

To adequately address public policy concerns about fuel economy in the current economic environment requires the active, direct involvement of industry, labor, government, and other organizations in the search for policies that are generally acceptable to all interested parties and, more importantly, that work. New policies are inevitable. If industry leaders do not become engaged with other stakeholders, it is very likely that the new policies will be more onerous.

Improving the fuel economy of America's light vehicle fleet would help reduce our dependence on oil (much of which is in the hands of unstable or hostile regimes) and contribute significantly to reducing emissions of pollutants and greenhouse gases. Our research indicates that improving the fuel economy of Detroit automakers' fleets would also reduce the risks to profits and American jobs of volatility in fuel prices. Reducing fuel consumption has become a national priority for leaders from both political parties. An emerging consensus sees reducing fuel consumption as a means to enhance national security, increase the market flexibility of American workers and communities, and help address climate change.

There are four areas that a formal coalition of stakeholders with a federal mandate to develop policies should address: improving fuel economy, enhancing regulatory rationality and certainty, supporting the development of advanced technologies, and building a domestic supply chain for advanced technology fuel-efficient vehicles. These need to be considered in conjunction with the key policy leverage points at which interventions can have significant effects: the decision by consumers to purchase a vehicle, the decision by automakers of the range of vehicles with different attributes to produce, and the decision by suppliers of which technologies to develop and provide to the automakers.

No one would question the importance of purchase price (capital cost) in consumers' vehicle choices. Tax incentives to encourage consumers to purchase fuel-efficient vehicles are already part of our policy environment, as are tax incentives to purchase inefficient SUVs and trucks. Most observers believe that an increase in the federal excise tax on motor fuels would not find sufficient support in Congress, yet the recent experience with higher fuel prices has demonstrated the power of raising operating costs to influence consumers' vehicle choices and thereby improve aggregate fuel economy.

However it is difficult for consumer-focused instruments alone (incentives and/or fuel taxes) to achieve dramatic improvements in fuel economy. Automakers cannot radically alter their product mix very rapidly, nor do all consumers switch from one type of vehicle to another overnight. We have seen significant evidence of the beginning of a move from SUVs to cars by consumers, and some automakers have acknowledged it, but the present composition of the fleet is not going to change radically in the near term. Encouraging the development of technologies that improve the fuel economy all vehicle segments across the entire market, are needed to produce significant improvements in fuel economy.

Encouraging advanced technologies across the entire fleet of vehicles calls for instruments that increase the portfolio of fuel-saving technologies available, make the technologies now or soon to be in the portfolio more attractive to automakers, and/or enhance the ability of suppliers to develop and commercialize new technologies.

Question 2. As someone who has looked at the effectiveness of CAFE standards and other systems for increasing fuel efficiency, do you have an opinion about which types of policy would be most effective in pushing the technological envelope on fuel economy?

Answer. I suggest the following as options that ought to be considered:

1. Tax credits for suppliers of technologies to convert facilities in the U.S. would ensure that we own the technologies rather than be required to import them. American suppliers could sell advanced technologies globally and help with the trade deficit.
2. Taxes on fuels or taxes on carbon. I know these are unpopular, but they would be effective because they would make consumers demand more efficient vehicles.
3. Carbon (or fuel) cap and trade programs would define the total economy-wide reduction in carbon and then let markets allocate them to make the reductions in the most efficient manner possible.
4. Feebates would pay rebates to consumers buying efficient vehicles and charge fees to consumers buying inefficient vehicles. A feebate system could be self-financing, with the buyers of inefficient vehicles paying into a fund that would be used for the rebates. It would also be more effective in changing buying patterns than rebates alone and would enlist all consumers in demanding more fuel-efficient vehicles.

RESPONSES OF WILLIAM LOGUE TO QUESTIONS FROM SENATOR SANDERS

Question 1. Please respond to Senator Menendez' excellent question regarding the relative efficiencies of fuel cell electric vehicles versus plug in hybrid electric cars. That is, how much original electricity from a solar panel on the roof of an American home is lost in delivering power to split water to make hydrogen, to compress this hydrogen and make a fuel cell vehicle run versus the same electricity delivered to a plug in hybrid electric vehicle?

Answer. FedEx has not been made aware of the relative total cycle energy efficiency of either fuel cell or plug-in hybrid electric vehicles primarily because neither technology will be commercially available for our fleet applications in the foreseeable future. We have utilized both technologies—several years ago we operated a fuel cell vehicle in Tokyo, Japan for one year, and we have been operating a plug-in hybrid electric vehicle in Paris, France for the past few months. Neither technology has been available for purchase.

Unfortunately, we seem to be in a situation where the nation is forgoing improvement now while waiting on new technologies, such as plug-in hybrid electric and fuel cell vehicles. In reality, there will always be tempting technologies for which we as a nation could wait. And, these ambitious long-term technological goals are important, but near-term technological and operational solutions are necessary now. These near-term solutions can include both hybrid electric vehicles and increased fuel economy for the range of on-road vehicles, from passenger vehicles through commercial Class 8 heavy trucks.

Question 2. Please tell me more about your fleet of hybrid electric trucks. You say that it gets 40% better fuel efficiency but costs twice as much as your regular trucks—but given that the fuel savings will more than pay for the upfront costs of the vehicle over its lifetime, why in your opinion, aren't other companies making similar investments?

Answer. FedEx Express and Environmental Defense initially believed that market demand for more fuel efficient hybrid electric vehicles would act to spur the development and production of these vehicles. It did spur the development of them, as our 93 hybrid electrics in revenue service demonstrate. However, it has not been sufficient to drive the full production of them. Reasons are complex: (1) commercial vehicle sales' volumes are lower than passenger vehicle sales, so there is less potential return for research and development into new technologies; (2) competition among commercial vehicle manufacturers is not as broad as the passenger vehicle market, given only a handful of commercial vehicle manufacturers; (3) the market has become more vertically integrated, yet the innovations in these areas come from other companies (for example, the hybrid power train FedEx uses comes from Eaton Corporation, who does not produce vehicles themselves); (4) commercial vehicle manufacturers must meet very stringent vehicle emission standards that are ramping down significantly through 2010; (5) and, as importantly, commercial vehicle manufacturers are simply not required to produce vehicles that meet any fuel economy goals or standards. In fact, commercial vehicle manufacturers receive no regulatory benefit in increasing fuel economy of their vehicles, given the U.S. EPA emission measurement: grams/brake horsepower—hour. To explain, under U.S. EPA regulations, a vehicle with 10 miles per gallon (MPG) in fuel economy is viewed as identical to one that uses the same engine with 20 MPG in fuel economy—even though the 20 MPG vehicle would emit only 50 percent of the carbon as the 10 MPG vehicle.

Simply put, market pressures from fleet operators are not sufficiently strong to counter the intense pressure commercial vehicles manufacturers are under to meet federal emission standards. As such, they are sacrificing fuel economy to meet vehicle emission standards, and not focusing upon new technologies that can increase fuel economy.

RESPONSE OF WILLIAM LOGUE TO QUESTION FROM SENATOR BINGAMAN

Question 1. With the costs of hybrid trucks running so much more than the standard vehicle, how much do tax credits have to be to give sufficient incentive for significant purchases? Would a strong CAFE standard achieve the same goal?

Answer. FedEx believes that both tax incentives and fuel economy standards for commercial vehicles are necessary. The fuel economy standards are necessary to drive commercial vehicle manufacturers to innovate and bring new, more fuel-efficient vehicles to market. However, these vehicles will inevitably carry a higher purchase price. As such, operators willing to act as early adopters for these technologies in the formative years of development and integration should benefit by the receipt of tax incentives to offset higher capital costs. The nation spends billions of dollars in R&D for new technologies, but needs to do better in transitioning new, promising vehicle technologies from the laboratory to the road. Tax incentives can help do this.

RESPONSE OF DAVID GREENE TO QUESTION FROM SENATOR SANDERS

Question 1. Please respond to Senator Menendez excellent question regarding the relative efficiencies of fuel cell electric vehicles versus plug in hybrid electric cars. That is, how much original electricity from a solar panel on the roof of an American home is lost in delivering power to split water to make hydrogen, to compress this hydrogen and make a fuel cell vehicle run versus the same electricity delivered to a plug in hybrid electric vehicle?

Answer. Dr. Anderman can provide a more expert opinion than I about the current and potential future efficiencies of electrolysis and fuel cells. Undoubtedly, it would be far more energy efficient to store the electricity from a solar cell directly in a battery and use that to power a vehicle via an electric motor than to uses the electricity to electrolyze hydrogen, convert the hydrogen back into electricity via a fuel cell and then use it to power an electric drive. The difference in efficiency would be on the order of a factor of two.

Of course, there are other, more efficient ways to produce hydrogen. A comparison of the overall energy cycle efficiency of hydrogen made from natural gas, coal or biomass to electricity generated from the same sources would put the fuel cell vehicle in a much more favorable light.

Response of David Greene to Question From Senator Cantwell

Question 1. Mr. Greene and McManus has any of your research calculated the current revels of subsidies fir fuel or feedstock producers. expressed as $ per gallon for both bio diesel and ethanol fuels? And given the intrinsic advantages of diesel engines in fuel economy and the "refiner mix" constraints mentioned in testimony, does this suggest to you that we need to look at refiner constraints as a limiting factor on fuel econony in mid to long term?

Answer. I have not done research calculating the levels of subsidies being given to producers of feedstocks for biodiesel and ethanol for use as a motor fuel.

While it is true that diesel engines have an inherent fuel economy advantage over gasoline engines, I do not believe that refinery constraints will pose a serious problem for more widespread adoption of diesel engines in U.S. light-duty vehicles in the mid-to long-term. I believe that diesels will find a sizable market segment to occupy in the U.S. but will not become as dominant as they are now in the European Union. Given time to respond, the global refinery system will very likely be able to accommodate any resulting increase in U.S. diesel demand.

Diesel vehicles will be more expensive than conventional gasoline vehicles, chiefly due to their high-pressure fuel injection systems and partly due to the more costly emissions control equipment that our Tier II standards require of them. This will limit their share of the market. There will also be strong competition from gasoline hybrid electric vehicles which will likely offer even better fuel economy at a slightly higher price. Advanced conventional gasoline vehicles with turbo-charged direct injection engines will offer a smaller fuel economy improvement but will also be less costly.

Diesels will have an inherent advantage in market segments that favor torque for towing and for heavy-duty applications. Hybrids will have an advantage in urban stop and go driving. Advanced gasoline internal combustion engines will have an advantage with cost-conscious car buyers. In my view, we will see a light-duty market with diverse power trains serving different needs, not a market dominated by diesel engines. This will require some adjustment by refiners but not likely one that will constrain the market in the mid- to long term.

Responses of David Greene to Questions From Senator Bingaman

Question 1. Both you and Dr. McManus point to the market failure that has led to an under valuation of fuel economy in the car and truck marketplace. You further point out that gas taxes are less economically efficient than other approaches due to the dynamics of the U.S. market. In your view, what is the most economically efficient way to repair this market failure?

Answer. In my opinion, the problem with the market for fuel economy stems from a failure by consumers to consider the full value of future fuel savings when vehicles in their purchase decisions. As a consequence, manufacturers fail to incorporate into vehicles all the fuel economy that is cost-effective. Raising the price of fuel by means of a tax on gasoline or petroleum would increase consumer interest in fuel economy and undoubtedly raise fuel economy levels somewhat. However, it is not likely that it would correct the failure to adequately consider the full lifetime value of fuel savings. Fuel economy standards circumvent the problem by requiring manufacturers to achieve certain fuel economy levels regardless of consumer demand. Feebates are an interesting market-based alternative that circumvent the problem by putting the economic incentive to increase fuel economy on the price of the vehicle rather than on future fuel savings. Feebates provide progressively larger rebates for vehicles with lower rates of fuel consumption per mile and progressively larger fees for vehicles with higher fuel consumption rates. Like NHTSA's reformed CAFE standards for light trucks, feebates can be tied to attributes like a vehicle's footprint. Unlike fuel economy standards feebates do not guarantee the achievement of a certain level of fuel economy. Rather, they provide manufacturers with an additional economic incentive to make vehicles more fuel efficient. An advantage of feebates is that they provide a continuing incentive to adopt new fuel economy technologies as they are developed. Both fuel economy standards and feebates can be economically efficient. With fuel economy standards, efficiency depends on choosing the right level of fuel economy and the right form of the standard. Allowing trading of fuel economy credits within manufacturers' product lines and across manufacturers enhances the economic efficiency of fuel economy standards. With feebates, efficiency depends on choosing the right feebate rate, in dollars per gallon per mile (the inverse of miles per gallon).

Question 2. As someone who has looked at the effectiveness of CAFE standards and other systems for increasing fuel efficiency, do you have an opinion about which types of policy would be most effective in "pushing the technological envelope" on fuel economy?

Answer. Fuel economy standards will require the adoption of fuel economy technologies up to the point at which the standards are met. Beyond that point, there is no incentive for manufacturers to implement advanced technologies to improve fuel economy. Fuel economy standards send manufacturers a mixed message about inventing new fuel economy technologies. If manufacturers are convinced that fuel economy standards will be raised in the future, they will carry out research and development to be prepared for the higher standards to come. On the other hand, manufacturers may fear that if they invent a new technology it would only inspire regulators to adopt more stringent standards. Feebates, on the other hand, send a clear and consistent signal. If a new fuel economy technology can gain a rebate or avoid a fee cost-effectively, it will be adopted. Inflation indexed feebates would provide a consistent and continuing incentive both to invent and adopt advanced technologies to improve fuel economy. In this sense, they should be more effective at "pushing the technology envelope" on fuel economy.

RESPONSES OF JOHN GERMAN TO QUESTIONS FROM SENATOR SANDERS

Question 1. The bill I recently introduced with Sen. Boxer and 9 other of my colleagues to combat global warming—S. 309—includes CO_2 emissions standards for vehicles, the same standards already in place in California. Can you please comment on what your company is doing to meet these requirements or to fight these requirements?

Answer. Climate change is an issue that requires serious attention throughout the economy and in that context, motor vehicle manufacturers must do their share to address the issue. Because there is a direct relationship between the amount of greenhouse gas emissions and fuel economy, Honda has been an advocate for higher fuel economy standards (CAFE). It supported higher CAFE standards for light trucks and has urged the National Highway Traffic Safety Administration to increase the standards for passenger cars as well. Honda believes that greenhouse gas regulation can only be successful if it is addressed at the federal, rather than the state, level.

Honda's fleet of vehicles achieves the highest fuel economy of any major manufacturer. It has adopted its own target to reduce greenhouse gas emissions from its products worldwide—10% grams/km between 2000 and 2010.

Question 2. Please respond to Senator Menendez' excellent question regarding the relative efficiencies of fuel cell electric vehicles versus plug in hybrid electric cars. That is, how much original electricity from a solar panel on the roof of an American home is lost in delivering power to split water to make hydrogen, to compress this hydrogen and make a fuel cell vehicle run versus the same electricity delivered to a plug in hybrid electric vehicle?

Answer. If one assumes that the energy for both fuel cell vehicles and electric vehicles comes from electricity available at the home, it is true that losses in splitting water to make hydrogen, compressing the hydrogen, and fuel cell operation are somewhat higher than the losses in charging a battery pack and electric motor operation. However, this is not the right way to compare the technologies, as it is only part of the story:

- A fuel cell vehicle only operates on hydrogen, while a plug-in hybrid has limited all electric range and, thus, will operate much of the time on gasoline.
- The plug-in hybrid vehicle must be at home and plugged in during the day, which is not typical, in order for the batteries to be recharged with renewable energy from the solar panel. Hydrogen can be produced from the solar panel even when the vehicle is not present.

- Hydrogen can be used in a co-generation system to provide very high efficiency electricity and heat for the home.
- Hydrogen can also be produced from natural gas or even biogas, with similar or even higher full-cycle efficiency, and lower GHG per mile in a Fuel Cell Vehicle, versus the use of the national electric grid (using coal and natural gas fueled power plants) to charge an electric vehicle battery and drive it the same distance.

We believe that fuel cell electric vehicles have the most promise to address both climate change and energy sustainability issues in the long term.

RESPONSE OF JOHN GERMAN TO QUESTION FROM SENATOR CANTWELL

Question 1. There seems to be a spread of opinion on the maturity of Lithium-ion batteries suitable for plug-in hybrid use. Mr. German's testimony suggested that we need to wait ten years, building a market for the technology via the conventional hybrid market before plug-in hybrid battery technology is mature enough for market. I have several questions relative to this context:

Ms. Lowery, Mr. German, and Dr. Anderman, a recent study by Pacific Northwest National Laboratory showed that the existing U.S. electrical system has sufficient excess capacity to provide charge to a plug-in hybrid fleet that could save a very significant fraction of our oil imports. Calculations based on this study also showed that the cost of the electricity that would be used in charging would the equivalent of about $1.00 per gallon gasoline. Given that plug-in hybrids have this strong of comparative advantage versus gasoline, do you believe that current targets for plug-in battery performance might be relaxed somewhat, thus accelerating delivery to the market?

Answer. We agree that the existing U.S. electrical system has sufficient excess capacity to provide charge to a significant plug-in hybrid fleet. We also agree that the cost of the electricity would be the equivalent of about $1.00 per gallon gasoline. However, the targets for plug-in battery performance already reflect these factors.

Key targets for PHEV battery technology include usable energy density (size and weight), durability, safety, and cost. Most customers will only pay for a few years of fuel savings, so the incremental cost of the system must be reasonable. More importantly, customers that pay for mobility expect an operating life comparable to today's alternatives. Relaxing any of the battery targets would damage the reputation of the new technology and market acceptance.

RESPONSES OF JOHN GERMAN TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. You believe a battery does not yet exist for a "plug-in hybrid" that can meet the performance criteria you need and is affordable for the consumer. Is there a specific ratio of power and energy to price at which plug-ins become viable?

Answer. Currently, conventional hybrids carry a price premium of roughly $2000 to $4000 over a conventional vehicle. The market has demonstrated that this price premium is too large relative to the fuel savings for most customers. The conventional hybrid market is currently about 1.5% of the entire new vehicle market and is unlikely to increase to more than 3% or so without significant cost reductions.

According to ACEEE's September 2006 report on plug-in hybrid vehicles, at $3.00 per gallon a hybrid vehicle saves about $480 per year in fuel over a comparable conventional vehicle. By comparison, a plug-in hybrid vehicle only saves an additional $225 per year over a comparable hybrid vehicle—less than half the fuel cost saved with a conventional hybrid. This suggests that the price premium for a plug-in hybrid vehicle over a conventional hybrid must be less than half the price premium for a hybrid over a conventional vehicle.

Based on experience with conventional hybrids and the relative fuel savings, slashing battery costs by about 80%, to less than $300 per kW-hour, and increasing durability to last the life of the vehicle should enable a niche market for plug-in hybrids. Keep in mind that battery improvements will also reduce the cost of conventional hybrids. Very few customers will compare plug-in hybrids to conventional vehicles—customers considering plug-in hybrids will be comparing them to the improved, cheaper conventional hybrids.

For plug-in hybrids to supplant conventional hybrids and go mainstream requires either energy storage to drop to something less than $100 per kW-hour (roughly 95% reduction from current levels) or fuel shortages. Many customers will pay a substantial premium for utility and convenience, as demonstrated by the strong demand for four-wheel drive vehicles. If sustained fuel shortages occur, home refueling will become a highly-valued feature, with plug-in hybrids competing with compressed natural gas and fuel cell vehicles.

Question 2. You've outlined some of the technological challenges to bringing advanced technology vehicles to U.S. consumers. What market challenges do you see to mainstreaming fuel-efficient vehicles and what can be done at the federal level to address these challenges?

Answer. There are two primary challenges to mainstreaming fuel efficient vehicles—competition and leadtime.

The first challenge is the nature of market competition. The vehicle market is extremely competitive and is becoming more competitive every year. Every manufacturer looks to find competitive advantages in the market, such as reduced cost, better reliability, better quality, distinctive designs, more utility, more luxury, better performance, better safety, and better fuel economy. Engineering resources are limited and expensive, as is tooling and design. Thus, every manufacturer tries to spend their engineering time and tooling/design budget on the features that will matter most to customers. If one manufacturer focuses on mainstreaming fuel efficient vehicles, this reduces the resources available to work on other attributes. If their competitors use their resources instead to offer features more highly valued by most new vehicle customers, such as improved performance and more luxury, the manufacturer that focused on fuel efficient vehicles will be at a competitive disadvantage.

This is precisely why CAFE standards and/or a feebate program are necessary. A CAFE program removes the competitive disadvantage from mainstreaming fuel efficient vehicles, as all manufacturers would be required to invest resources in efficiency technologies. A feebate program works directly by providing monetary incentives to manufacturers who develop and use efficiency technologies. Either system can effectively bring efficiency technologies to the market.

Increasing the price of fuel is another effective way to reduce fuel use. CAFE and feebates work primarily by spreading efficiency technologies throughout the fleet. Higher fuel prices promote customer acceptance of the efficiency technologies, as well as reductions in vehicle travel and the type of vehicle selected by purchasers. While directly raising fuel taxes is politically difficult, it could be more acceptable if presented with an off-setting tax reduction or as a cost shift. Examples include a reduction in income taxes or pay-at-the-pump vehicle insurance. The later would reduce vehicle insurance premiums and collect the difference at the gas pump. This would also have the advantage of collecting money at the pump from drivers operating a vehicle without insurance, which would further reduce insurance premiums.

The second challenge to mainstreaming fuel-efficient vehicles is leadtime. Due to the competitive nature of the market, there are huge risks to widespread adoption of new technologies. If a manufacturer invests in a technology that ultimately proves to be more expensive, they will be put at a cost disadvantage compared to their competitors. Even worse is widespread adoption of a technology that does not meet the customer expectations for performance and reliability. Not only does this hurt the manufacturer's reputation, it can also set back acceptance of the technology for all manufacturers. Thus, it is extremely important to implement new technology on normal development cycles. To ensure quality and reliability, new technologies go through a rigorous product development process and are put into production initially on a limited number of vehicles. This not only allows proof of quality and durability, it is also necessary for cost considerations. The cost of new technologies always goes down with higher volumes and additional development. However, the rate of the cost reduction is highly variable. One technology may drop dramatically in cost with high volume production and further development, while another may prove to be far more difficult to reduce costs. An orderly development process is needed to adjust technology deployment in response to learning.

Costs also increase dramatically if normal development cycles are not followed. Most products are on a 5-year development cycle and some are considerably longer. Forced development and implementation of new technologies on a faster timeline is extremely disruptive and greatly increases development costs, tooling costs, and the risk of mistakes.

Question 3. As someone who has looked at the effectiveness of the CAFE standards and other systems for increasing fuel efficiency, do you have an opinion about what types of policy would be most effective in "pushing the technological envelope" on fuel economy?

Answer. As discussed in our response to question 2, the only policies that would be effective in "pushing the technology envelope" on fuel economy are CAFE and feebates. Feebates have an advantage in that they automatically address the leadtime constraints—technologies will be developed and implemented as soon as they are cost effective, but implementation of technologies that are not ready or cost effective would not be required. The downside is that the ultimate amount of fuel economy increase is not certain under a feebate system.

CAFE can also effectively bring fuel economy technology into the fleet. The major problem with CAFE is that the rate of technology development cannot be forecasted. There are times when technology development progresses rapidly and other times where promising technologies do not pan out. This is why it is important for an expert agency, such as NHTSA, to monitor technology progress. When technology breakthroughs occur, NHTSA should increase the CAFE standards to compel more rapid implementation of the technology breakthroughs. Should technology development hit unexpected problems, NHTSA should adjust the CAFE standards to prevent unintended market and competitive problems. Congress should specify the criteria used by NHTSA to make CAFE adjustments, but a rational adjustment mechanism is needed in order to implement technology at the maximum feasible rate without market disruptions. NHTSA has the technical expertise and experience to make these judgments.

Mandates for specific technologies rarely work in pushing the technology envelope. There are a vast multitude of possible technologies in development at any time, all with highly uncertain costs and other attributes. In fact, most technologies never make it into high volume production, either because they do not work out as anticipated or because they wind up being replaced by even better technologies. Thus, mandates have two risks. The first is that they require massive amounts of engineering resources and money to be spent on a technology that doesn't work out as anticipated. The second is that they divert resources and money away from the development of even better technology. It is difficult even for manufacturers to assess which technologies deserve development and resources—and we constantly reassess and change technology development and implementation. If manufacturers, whose very existence depends on making the right decisions, have difficultly determining the most promising technologies, the chance that Congress can pick the right technology to mandate is very poor. This is demonstrated by past failures in California to mandate methanol and electric vehicles. Congress needs to establish performance requirements or incentives and let the experts develop the best mix of technologies to meet society's needs.

There are two other points that should be kept in mind with respect to mandates. One is that no technology reduces fuel consumption much unless it can be spread across most of the fleet. For example, a 10% market penetration for plug-in hybrids would only save as much fuel as a 3% increase in CAFE standards and would have less GHG benefit. There is no magic bullet—we need development of a wide range of technologies as rapidly as possible.

The second point is that there is also nothing magical about energy switching. Using electric to power vehicles instead of gasoline reduces oil imports. But improving the efficiency of a gasoline vehicle also reduces oil imports—and does it without the need to increase other kinds of power generation. Vehicle efficiency improvements are the best way to reduce oil consumption and GHG emissions. Performance requirements or incentives are the best way to bring efficiency improvements into the fleet.

RESPONSES OF BETH LOWERY TO QUESTIONS FROM SENATOR SANDERS

Question 1. While it is gratifying to see that GM plans to build 100 fuel cell vehicles as part of Project Driveway, when will this happen? And when will we do the same for plug-in hybrids like GM's Chevy Volt, which I saw at the DC Auto Show last Friday (January 26th)?

Answer. GM will build more than 100 Chevrolet Equinox Fuel Cell vehicles and will begin placing them with customers in the fall of 2007, as part of a comprehensive deployment plan dubbed "Project Driveway." Designed to gain comprehensive learnings on all aspects of the customer experience, Project Driveway constitutes the first meaningful market test of fuel cell vehicles anywhere. A variety of drivers—in differing driving environments—will operate these vehicles and refuel with hydrogen in three geographic areas: California, the New York metropolitan area and Washington D.C.

As for the Chevy Volt, one of the key enablers for plug-in hybrid vehicles is the advanced battery pack that can provide all of the energy and power needs of such vehicles. We need advanced battery packs that are proven to be durable, reliable, and cost effective, as well as providing the expected driving ranges. Battery technology is maturing quickly. Consequently, we are accelerating engineering development of the E-Flex technology, which will enable us to take advantage of advances in batteries as they occur. When the battery is ready, we plan to be too. In the meantime, we are producing a driveable version of the Volt using existing battery technology. This will allow us to gain valuable experience with the packaging of the technology in a more limited range vehicle, while we wait for the battery packs that will allow the vehicles to achieve the targets we envision for it.

Given what we know today, it will take several years to bring a plug-in hybrid to market that will meet the expectations and real-world performance standards that our customers expect. The government can help by increasing R&D in this area and developing new support for domestic manufacturing of advanced batteries.

Finally, advanced automotive technologies will not address national energy security issues unless they are adopted by large numbers of consumers. Well crafted tax incentives can accelerate adoption of new technologies and strengthen domestic manufacturing. The government can focus consumer tax credits on technologies that reduce petroleum consumption and provide support for manufacturers/suppliers to build/convert facilities that provide advanced technologies.

Question 2. You also called for the government to support new technologies by purchasing these vehicles to create a market and jump start new technologies. When can we expect the Chevy Volt to be available to purchase so that the federal government can buy them?

Answer. We are unable to predict when the Chevrolet Volt will come to market. Battery technology is maturing quickly. We are accelerating engineering development of the E-Flex technology, which will enable us to take advantage of advances in batteries as they occur. When the battery is ready, we plan to be too.

Government purchasing should set the example for advanced technologies currently available as well. Government should continue to purchase flex fuel vehicles and hybrids, and demand maximum utilization of E85 in the government flex fuel fleets. Federal fueling can also stimulate development of publicly accessible pumps, and provide adequate funding to permit purchase of electric, plug in and fuel cell vehicles in federal fleets as soon as technology is available.

Question 3. The bill I recently introduced with Sen. Boxer and nine of my colleagues to combat global warming—S. 309—includes CO_2 emissions standards for vehicles, the same standards already in place in California. Can you please comment on what your company is doing to meet these requirements or to fight these requirements?

Answer. The California CO_2 requirements for vehicles are in conflict with federal law and are excessive. The automotive industry has said as much during the entire process of the passage of the California law and the development of the regulatory program to implement those requirements. The California matter is currently stayed indefinitely, pending resolution of other cases/administrative proceedings.

As to any current or new CO_2 emission requirements for vehicles, the auto industry has been subject to CO_2 constraints for over 30 years under the Corporate Average Fuel Economy (CAFE) program. The miles per gallon standards for the CAFE program and any CO_2 limits on gasoline vehicles are exactly the same thing, because the emissions of CO_2 are directly related to the consumption of gasoline in such vehicles. In effect, "CO_2 emissions requirements" are just another way of saying "fuel economy."

Over the years, we have attempted to balance the consumer expectations for improved safety, comfort, utility, performance, etc., with improvements in energy efficiency. Simply setting arbitrary fuel economy or CO_2 emission targets is not consistent with this goal of meeting American consumer needs. It is also not consistent with the technological and economic realities of vehicle design, engineering, certification and production. Instead, policies that displace petroleum with low-carbon biofuels and electricity can more effectively address the growth of energy consumption in the U.S. (which is primarily due to growing population and increased driving)—and avoid creating undue economic limitations and competitive impacts among manufacturers.

Question 4. Please respond to Sen. Menendez' excellent question regarding the relative efficiencies of fuel cell electric vehicles versus plug in hybrid electric cars. That is, how much original electricity from a solar panel of the roof on an American home is lost in delivering power to split water to make hydrogen, to compress this hydrogen and make a fuel cell vehicle run versus the same electricity delivered to a plug in hybrid electric vehicle?

Answer. One of the goals of developing advanced technology and alternative fuel vehicles is to help displace or reduce the gasoline consumption in the U.S. We believe that pursuing a variety of different paths will help us develop greater energy diversity.

Some people believe that focusing on hybrid electric and plug-in hybrid electric vehicles are the best steps to accomplish this. Unfortunately, these hybrids are still dependent on gasoline usage to some degree. And, given the driving patterns of many Americans, consumption of gasoline in hybrid and plug-in hybrid vehicles will remain high.

Fuel cell hybrid vehicles powered by hydrogen offer yet another choice. The hydrogen does require energy to create, but future sources of hydrogen production may be able to rely even less on oil than simply focusing on hybrid and plug-in hybrid vehicle technology. Wind, solar, renewables and even nuclear power can be used to produce the hydrogen.

We hope that all of these technology options can be developed to the point that we can see how large and how effective a role they can play.

RESPONSES OF BETH LOWERY TO QUESTIONS FROM SENATOR CANTWELL

Question 1. What do you believe is the expected time to have a viable plug-in hybrid vehicle assuming a $3000 per vehicle tax credits are passed soon to incentivize the market? Would greater incentives serve to accelerate this time frame?

Answer. This is a priority program for GM, given the potential it offers for fuel economy improvement. Given what we know today about advanced battery availability, it will take several years or more to bring a plug-in hybrid to market that will meet the expectations and real-world performance standards that our customers expect . . . things like safety, durability, driving range, recharge time, operating temperature range, and affordability.

Advanced lithium-ion batteries are a key enabler. The government can help by increasing R&D in this area and develop new support for domestic manufacturing of advanced batteries.

Regarding incentives, advanced automotive technologies will not address national energy securities issues unless adopted by large numbers of consumers. A consumer tax incentive of $3000 will certainly help advance the prospects of plug-in hybrids. But, a much greater incentive may be needed to overcome the expected high initial costs of the battery packs and advanced electronics needed in these vehicles. Incentives that are 2-3 times the current levels for advanced hybrid vehicles may be needed to really accelerate the early growth of plug-in hybrid vehicles.

Question 2. A recent study by Pacific Northwest National Laboratory showed that the existing U.S. electrical system has sufficient excess capacity to provide charge to a plug-in hybrid fleet that could save a very significant fraction of our oil imports. Calculations based on this study also showed that the cost of the electricity that would be used in charging would have the equivalent of about $1.00 per gallon gasoline. Given that plug-in hybrids have this strong of comparative advantage versus gasoline, do you believe that current targets for plug-in battery performance might be relaxed somewhat, thus accelerating delivery to market?

Answer. One of the conceptual flaws of many studies regarding the availability of electricity for use in vehicles is that there is ample excess capacity at a low cost. The “excess capacity” is usually off-peak power (i.e., night time). But owners of electric and plug-in electric hybrid vehicles are not going to only plug in these vehicles at night. They will look to keep the batteries charged to a high level by plugging in the vehicles whenever and wherever they can. So, realistically, as the volume of these vehicles increases, the electricity demand associated with charging them will be at all times—on-peak as well as off-peak. More analysis needs to be done, and the infrastructure and energy providers should be encouraged to continue this type of research.

Regarding the desirability of relaxing the targets for plug-in vehicle performance (notably driving range on electric drive only), that may well be worth considering as we see how advanced battery development and production are progressing.

RESPONSES OF BETH LOWERY TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. You believe a battery does not yet exist for a “plug-in hybrid” that can meet the performance criteria you need and is affordable for the consumer. Is there a specific ratio of power and energy to price at which plug-ins become viable?

Answer. Due to the early state of the development of the battery pack that would be used in a plug-in hybrid, we have not yet set a power and energy to price ratio. Early cost estimates of the battery pack show it to be very expensive, but as the production volume of lithium-ion battery packs increases, there will be a reduction in the cost of the pack.

Advanced batteries are the key enabler to a whole array of future advanced technology vehicles that we would like to be able to produce—vehicles that will use little to no gasoline in routine driving and which will produce even lower levels of tailpipe and greenhouse gas emissions. Development of reliable, durable, cost effective advanced batteries—like the lithium-ion batteries that are being explored in all of the major auto producing countries of the world—should be accelerated if possible, and the U.S. should look to make sure adequate supplies of these batteries are produced in the U.S. It would be unfortunate for the U.S. to trade our dependence on foreign oil for a dependence on foreign supplies of a new critical component of future vehicles.

The US Advanced Battery Consortium (USABC) is helping direct the research needed to develop battery packs for vehicle applications and the government needs to start now to determine what incentives will be most effective in encouraging U.S. production of these batteries.

Question 2. You and other automakers have advocated for a significant federal investment in battery technology to get us to the next step in efficiency. As we have heard here, real advances in efficiency have been made in the past, but they have been applied to increase power rather than to save fuel. How do you recommend we ensure the taxpayers get a fair return in fuel savings on their investment in advanced vehicle technologies?

Answer. Automobile design is a matter of striking the right balance of maximizing the fuel efficiency as well as all the other attributes customers expect from each vehicle in our product portfolio. As with past advancements in technology, various automakers have used them in different ways to create the vehicles they believe consumers will want while making improvements in fuel efficiency and safety. As a result, there is a wide array of hybrid vehicles in the market, both in the light-duty market as well as in the transit bus market. The auto companies aggressively compete with each other to provide the best balance of these attributes. Ultimately, our customers decide who has done the best job and they pick the winners by their purchase decisions. We expect that providing improved fuel efficiency will be valued by consumers. We urge the government to rely on market forces, competition and consumer purchase decisions to guide the proper application of the technologies that are developed using government funding.

RESPONSES OF MENAHEM ANDERMAN TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. You indicated that in order to make the leap from today's hybrids to a plug-in hybrid requires a technological advance in power density (actually in energy density—comment from M. Anderman) and a significant reduction in cost. Where are we technologically? Do technologies exist that have yet to be sufficiently field tested or are we still awaiting fundamental breakthroughs in the lab?

Answer. I do not believe that any technology exists, at any state of development, which can support the present commercialization of PHEVs. Battery volume (energy density) and battery cost (even assuming very large PHEV volumes) are clearly inadequate. Battery life, reliability, and safety are also significant challenges.

Question 2. Regarding costs: I understand the component cost of nickel may limit how cheaply a NiMH ("nickel-metal-hydride") battery can be produced. Do lithium ion batteries face the same inherent cost problem, or is the problem there one of not yet having sufficient production facilities to drive down costs? How much cost reduction can we reasonably expect from large-scale manufacturing?

Answer. The cost barrier for Li-Ion batteries is large but somewhat different than for NiMH batteries. The former is generally driven by the technology's requirement for very pure processed materials and very tight manufacturing tolerances and controls. However, cell manufacturing for the portable battery business is already at very high volume (over 1 billion cells per year) and consumes very large amounts of those materials. The Japanese/Korean Li-Ion battery industry has gone through the steep part of the learning curve and we expect a slow continuous cost reduction in the future. The pricing of $500 to $700 per kWh, which I have used in my briefing, is based on today's technology but at PHEV battery pack volumes of hundreds of thousand packs per year.

Li-Ion technology is evolving—regardless of the particular automotive application—with new materials being introduced into commercial products. However, there are multiple drivers for new materials, including increasing energy content, reducing cost, supporting longer life, and improving safety and reliability. While notable improvement in one or two of the four parameters above is quite possible, it is unlikely that materials that will significantly improve all four parameters—which is what will be required to change the value equation for the PHEV application—will be developed in less than ten years, and it often happens that improvement in one parameter, such as cost for example, comes at the expense of another, such as energy density or/and life.

As a reference, notebook computer battery packs are sold at volumes on the order of 50 million packs per year at a current high-volume OEM pack pricing of around $500/kWh. My estimate of $500 to $700 per kWh for the PHEV battery may still be somewhat optimistic, considering that many of the material cost drivers in computer cells and HEV or PHEV cells are the same, but that the higher power, more demanding duty cycle, and longer life requirement of the PHEV application will put upward pressure on battery cost per kWh.

RESPONSE OF MENAHEM ANDERMAN TO QUESTION FROM SENATOR SANDERS

Question 1. Please respond to Senator Menendez' excellent questions regarding the relative efficiencies of fuel cell electric vehicles versus plug-in electric cars. That is, how much original electricity from the solar panel on the roof of an American home is lost in delivering power to split water to make hydrogen, to compress this hydrogen and make a fuel cell vehicle run versus the same electricity delivered to a plug-in electric vehicle?

Answer. The grid to electric motor efficiency through making H2 in electrolysis and powering a fuel-cell vehicle with this hydrogen is only about 25 to 30%.

A typical breakdown of the various steps includes:

i) Water electrolysis at about 65%,

ii) Compressing the hydrogen at about 85% to an accumulative efficiency of 55%,

iii) Losses in powering ancillary fuel-cell pumps: about 15% to an accumulated efficiency of 47%, and

iv) Fuel cell hydrogen to electricity efficiency of 60%, to an accumulated efficiency of 28%.

The efficiency of charging a Li-Ion battery and outputting it to an electrical motor is in the range of 80%. Thus the efficiency advantage of storing the electricity in a battery versus using H2 is two to three times, or more significantly, the losses associated with the FC compressed hydrogen route of 70 to 75% are about three times the losses associated with the battery route of about 20%. Both schemes will have similar additional losses upfront for electrical energy generation and final losses related to converting the electrical energy to mechanical torque in the vehicle.

RESPONSES OF MENAHEM ANDERMAN TO QUESTIONS FROM SENATOR CANTWELL

Question 1. Ms. Lowery and Dr. Anderman, what do you expect is the expected time to have a viable plug-in hybrid vehicle assuming a $3000 per vehicle tax credit are passed soon to incentivize the market? Would greater incentives serve to accelerate this market?

Answer. I do not believe PHEVs are viable for mass commercialization at the current technological status and fuel pricing, and tax incentives of $3,000 will not do nearly enough to effect a genuine change. My estimate—in line with that of many technologists from the relevant high-volume manufacturing industry—is that the cost-based pricing of PHEVs with a 20-mile electric range is about $10,000 to $15,000 higher than that of strong hybrids (this difference would be even higher for a PHEV with a higher electric range). The incremental initial cost of the former over that of the latter is on the order of $6,000. In addition, the net present value of at least one battery replacement will have to be added to the price of the PHEV (at about 1.5 times the OEM battery price), since no battery company will provide a warranty for PHEV applications covering the useful life of the car (or even a significant fraction of it).

The net present value of the fuel savings to the customer over the life of the car versus the cost in fuel of operating a strong hybrid such as the Toyota Prius, evaluated—for PHEVs with a 33-mile range—by the very same Northwest National Laboratory study quoted by Senator Cantwell in the next question,[1] is estimated at between zero and $1,000 (at $2.50/gallon of fuel and electricity priced at $0.08/kWh to $0.12/kWh). Thus, the fuel savings above contribute but little to overcoming the cost disadvantage noted in the prior paragraph.

PHEVs should be looked upon as a potential long-term solution that is more technologically and commercially feasible than fuel-cell vehicles and offers equivalent or better energy savings and emission benefits. PHEVs could support a reduction in the nation's petroleum consumption when the value of saving a gallon of petroleum is three or more times the current U.S. gasoline pricing.

Question 2. Ms. Lowery, Mr. German, and Dr. Anderman, a recent study by Pacific Northwest National Laboratory showed that the existing U.S. electrical system has sufficient excess capacity to provide charge to a plug-in hybrid fleet that could save a very significant fraction of our oil imports. Calculations based on this study

[1] Michael J. Scott, Michael Kintner-Meyer, Douglas B. Elliot, and William M. Warwick, Pacific Northwest National Laboratory, "Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids: Part 2: Economic Assessment".

also showed that the cost of the electricity that would be used in charging would the equivalent of about $1.00 per gallon gasoline. Given that plug-in hybrids have this strong of comparative advantage versus gasoline, do you believe that current targets for plug-in battery performance might be somewhat relaxed, thus accelerating delivery to the market?

Answer. I believe that targeting the initial entry of PHEVs into the market with a moderate 10-mile range or so may be somewhat beneficial as it would allow the introduction of PHEVs on existing platforms—although at the current price of fuel it still would not work. For PHEVs with a range beyond 10 miles, automakers will have to design a new vehicle platform from the ground up—to accommodate the much larger battery—as is proposed by GM for the Chevrolet Volt. The associated engineering and tooling cost of having to build a dedicated platform for a vehicle that does not currently have a sustainable business case adds an additional barrier to commercialization.

The commercial barrier to developing electrical transportation, be it EV or PHEV (rather than electrically-assisted transportation, as with strong hybrids) is that the savings in fuel are considerably smaller than the cost of depreciating the battery over its useful life. Note that the annual fuel cost savings provided by a PHEV with a 10-mile range against the fuel cost of operating a Toyota Prius—at today's typical gasoline pricing ($2.5/gallon) and electricity pricing ($0.10/kWh)—will only amount to $100 or less. Such marginal savings are too small to outweigh the numerous disadvantages and generate customer interest.

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