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ENERGY USE IN THE TRANSPORTATION SECTOR

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

TO

RECEIVE TESTIMONY REGARDING ENERGY USE IN THE TRANSPORTATION SECTOR

MARCH 6, 2003

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ENERGY USE IN THE TRANSPORTATION SECTOR

THURSDAY, MARCH 6, 2003

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

The committee met, pursuant to notice, at 10:06 a.m., in room SH–216, Hart Senate Office Building, Hon. Craig Thomas presiding.

OPENING STATEMENT OF HON. CRAIG THOMAS, U.S. SENATOR FROM WYOMING

Senator THOMAS. I wonder if we could begin, please. Things are a little disorganized this morning. We are having some votes and all those kinds of things. So we would like to go ahead and then make the changes as we go.

This hearing will take testimony on options to reduce energy use in the transportation sector. The topic is important, obviously. In light of our continuing dependence on imports, the transportation sector accounts for as much as two-thirds of our oil demand. Advanced vehicle technologies, such hybrids, diesels, hydrogen fuel cells and others, offer a great promise for the reduction in demand for foreign oil, although some of it may be some time in the future.

In particular, the committee is interested in the following questions: One, what benefits can hybrid and diesel engine technologies offer conventional internal combustion engines? What fuel efficiency benefits are likely? Two, how can we diversify our fuel supply for use in transportation? Can alternative fuels, like ethanol, biodiesel and natural gas play a role? Three, what is envisioned for the President's FreedomCAR and Hydrogen Fuel Initiatives? What policies, incentives, and funding levels and incentives will be required?

We are pleased to have five witnesses today. The Honorable David Garman, Assistant Secretary of Energy for Energy Efficiency and Renewable Energy, will provide an overview of DOE's vehicle R&D activities, including the President's Hydrogen Fuel Initiative.

The Honorable Emil Frankel, Assistant Secretary of Transportation for Transportation Policy, will discuss how DOT programs can help limit our oil demand.

Mr. Richard Cromwell from Sunline Transit Agency in Thousand Palms, California, will describe the fleet manager's experience with alternative fuel vehicles and our options to diversify our transportation fuel supply.

Mr. Gregory Dana from Alliance of Automobile Manufacturers will address some of the technologies automakers are focusing on today.

And David Friedman from the Union of Concerned Scientists will summarize their recent work, showing that hybrid technologies could dramatically increase fuel economy in a short period of time.

We appreciate the witnesses joining us today to provide an assessment of these new and exciting technologies, what we can expect from cars and trucks in the future.

Before we begin, I would like to inform the members that the record will be open until 6 p.m. today in order to allow members to submit questions. We already have a number of individuals and groups who have submitted statements for the record. I ask at this time to make those part of the record. We have statements from: the Honorable Dave Camp, U.S. Congressman from Michigan; Robert Horton, chairman and CEO of Alchemix Corporation; Stephen Tang, president and CEO of Millennium Cell; Preston Chiaro, president and CEO, U.S. Borax; American Petroleum Association; Jeffrey Serfass, president of National Hydrogen; Phil Lambert, executive director of the National Ethanol Vehicle Coalition; Donald Huberts, CEO, Shell Hydrogen; Anthony Eggert, associate research director, Institute of Transportation Studies, UC Davis. So as you can see there is a great deal of interest and a great deal of collective knowledge in this area.

Senator Bingaman, do you have comments before we begin?

[The prepared statement of Senator Murkowski follows:]

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

Mr. Chairman thank you for calling this hearing today regarding energy use in the transportation sector. The transportation sector is the largest user of petroleum of any other sector. It consumes 69 percent of all oil consumed in the U.S. I look forward to hearing the testimony of the panel.

If we are to reduce our dependence on foreign sources of oil, one of the areas we must address is the efficiency of the energy use in the transportation sector.

This should include supporting new technologies that reduce carbon emissions and improve fuel efficiency. These proposals must be entertained with the idea that the goal we seek is to protect our environment, while not adversely impacting our economy.

In his most recent State of the Union address, President Bush announced a $1.2 billion dollar Hydrogen Fuel Initiative. This is an ambitious proposal, and I look forward to watching it develop.

One of the major challenges of this initiative will be: Where do we get the hydrogen to fuel these new vehicles?

Hydrogen can realistically be produced three ways:

1. The disassociation of water through electrolysis, which requires a great deal of water and electricity;
2. Stripping the methane out of a natural gas stream, and then turning the methane into hydrogen; or
3. Turning coal bed methane into hydrogen.

All of these processes require a great deal of natural resources. I am sure I don't have to remind the members of this committee and the witnesses here today that there is an abundance of natural resources in my State of Alaska.

Just to review: Conservative government estimates indicate that there are between 65 to 314 trillion cubic feet of natural gas and 120 million short tons of known coal reserves in northwest Alaska and another 20 million short tons of coal identified throughout the State. There are almost certainly more reserves that remain unidentified.

Of course there are many obstacles to the production of these resources. Restrictive federal laws and mundane permitting processes make it virtually impossible to extract these resources.

The president's initiative is a step in the right direction, but if we are serious about a hydrogen economy we must talk about how we are going to produce the hydrogen.

It is not likely that we will be able to generate hydrogen with out the use of fossil fuels, and this will only increase the demand for natural gas and other natural resources. This is one other reason this country needs the Alaska natural gas pipeline.

Thank you Mr. Chairman.

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

Senator BINGAMAN. Well, thank you very much, Mr. Chairman. Let me first say that this is a very important issue. I know most of the focus on it, at least in the last month since the State of the Union address, has been about the President's Hydrogen Initiative. And, as I understand that initiative, it is a proposed long-term solution to an immediate problem.

It is something that clearly I would like to see us move ahead with. But it does not hold out any real promise for dealing with the issue which is the subject of today's hearing; that is, reducing the need for additional oil for our transportation sector. It does not hold out any promise of dealing with that for at least 15 or 20 years.

So, I would like to have some discussion today from the witnesses about what is planned for the immediate and the near term. Is there anything that can be done or should be done? The obvious options that come to mind are an increase in CAFE standards, which we have debated here extensively in the Congress. And, I would be interested in seeing particularly what the Administration witness's view on that is at this particular time.

Another option that is urged, particularly by economists, is raising the gasoline tax. I assume that is not something the administration is endorsing this morning. But I would be interested in knowing what is being proposed to deal with the immediate problem that we have of growing imports of oil to meet our need for petroleum in the transportation sector.

I also have some issues, some questions that I look forward to asking, related to the Hydrogen Initiative the President has come up with.

So thank you very much for having this hearing, Mr. Chairman.

Senator THOMAS. Thank you.

Gentlemen, we will have statements, if you would like, then the questioning time, if that is satisfactory. If you want to hold your statements to some sort of a little shorter time, why, the total statements will be in the record.

So, Assistant Secretary Garman, welcome back to the Hill.

STATEMENT OF DAVID K. GARMAN, ASSISTANT SECRETARY, ENERGY EFFICIENCY AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY

Mr. GARMAN. Thank you, Mr. Chairman. Mr. Chairman, members of the committee, I appreciate the opportunity to testify before you today on energy use in the transportation sector. As the chart behind me shows, there is an imbalance between domestic oil production and transportation's demand for petroleum. That imbalance, now about 11 million barrels a day, is projected to keep growing. And we will not close this imbalance—if we are really honest with ourselves, we will not close that gap with regulation, new domestic production, or even both.

Although promoting efficiency in the use of oil and finding new domestic sources of oil are important short-term undertakings, over the long term a petroleum-free option is eventually required. We ultimately want a petroleum system, a transportation system that is free of dependence on foreign energy supplies and free of all harmful emissions.

We also want to preserve the freedom of consumers to purchase the kind of vehicles they want to have. And that is the concept between the FreedomCAR partnership and the President's Hydrogen Fuel Initiative, which are designed to help develop the technologies necessary for hydrogen fuel cell vehicles and the infrastructure to support them.

A transportation system based on hydrogen provides several advantages. Hydrogen can be produced from diverse domestic resources, freeing us from a reliance on foreign imports. Hydrogen can fuel ultra-clean internal combustion engines, which would reduce auto emissions by more than 99 percent. And when hydrogen is used to power fuel cell vehicles, the combination results in more than twice the efficiency of today's gasoline engines with none of the harmful air emissions. In fact, fuel cells' only byproducts are pure water and waste heat.

But to bring about the mass market penetration of hydrogen vehicles, government needs to partner with the private sector to conduct the R&D needed to advance investment in a hydrogen fuel infrastructure that performs as well as the petroleum-based infrastructure we now have. And that is going to be difficult.

Our current gasoline infrastructure has been forged over the last century in a competitive market. It is incredibly efficient. And it can deliver refined petroleum products that began as crude oil a half a world away to your neighborhood for less than the cost of milk, drinking water, or any other liquid product you can buy in the supermarket.

We are currently bound to a petroleum infrastructure. And before drivers will purchase a fuel cell vehicle, they have to have confidence in a hydrogen refueling infrastructure. That is why the President, in his State of the Union address, made a new national commitment backed over the next 5 years by $1.7 billion for the FreedomCAR partnership and Hydrogen Fuel Initiative.

Government is not going to build the hydrogen infrastructure. The private sector will do that, as the business case becomes clear. But as we develop the technologies needed for the fuel cell vehicles, we also want to develop the technologies required by the infrastructure to support them.

But some of those technology challenges are daunting. For example, we have to lower the cost of producing and delivering hydrogen by at least a factor of four. We have to develop more compact, lightweight, low cost hydrogen storage systems, so vehicles will get the kind of range that consumers demand. We have to lower by a factor of at least ten the cost of materials for fuel cells themselves.

But fortunately, we are not starting from scratch. Beginning back in November 2001, the Department of Energy began working with industry, academia, and stakeholders on a comprehensive technology road map. We have achieved a remarkable consensus on what needs to be done.

And as important as hydrogen is for the long term, we have maintained a robust R&D program in the non-hydrogen transportation technologies. Under the FreedomCAR partnership, we have proposed a funding increase in fiscal year 2004 for our hybrid technology program, as well for increases in materials technology programs. Many of these technologies will deliver fuel savings both prior to and after the introduction of fuel cell vehicles, since lightweight materials and hybrid technologies will be incorporated into the fuel cell vehicles, as well as the conventional and hybrid models that precede them.

And automakers are starting to introduce technologies that have resulted in part from DOE's work in this area. At the recent Detroit auto show, the major U.S. automakers announced that they will have a variety of new hybrid gasoline-electric models entering the market in the 2004 to 2008 time frame. Of course, hybrid vehicles are more expensive compared to conventional vehicles, which is why the President proposed a tax credit for hybrid vehicles in the national energy plan and in subsequent budget submissions. And we urge that Congress adopt this important incentive for more efficient vehicles.

And DOE is also going to continue its Clean Cities Program, which is a unique voluntary approach supporting alternative fuel vehicles. And we also strongly support a renewable fuel standard that will increase the use of clean, domestically produced renewable fuel, such as ethanol and biodiesel.

But as important as the renewable fuel standard and the Clean Cities program are, their goals really illustrate the challenges we face. Taken together, the renewable fuel standard and Clean Cities are expected to offset about 4 billion gallons of gasoline use per year by 2010. Now that sounds impressive until it is compared to the demand for petroleum used in the transportation sector. In the year 2000, we used approximately 130 billion gallons of gasoline and over 33 billion gallons of highway diesel. With that realization, the critical importance of the FreedomCAR partnership and the Hydrogen Fuel Initiative as a long-term strategy becomes clear.

With that, Mr. Chairman, I would be pleased to answer any questions you might have, either now or in the future. Thank you.

Senator THOMAS. Fine. Thank you very much.

[The prepared statement of Mr. Garman follows:]

PREPARED STATEMENT OF DAVID K. GARMAN, ASSISTANT SECRETARY, ENERGY EFFICIENCY AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY

Mr. Chairman, Members of the Committee, I appreciate the opportunity to testify before you today on energy use in the transportation sector.

I would like to begin by looking at the transportation sector in the context of the overall flow of energy in our economy. A diagram developed by Lawrence Livermore National Laboratory [Figure 1]* represents the current "energy flows" in the U.S. economy. It should not be regarded as a highly precise representation of these flows, but it is extremely useful in helping policymakers visualize complex energy data.

The primary energy inputs, including oil, coal, natural gas, nuclear and renewable energy are shown on the left. The relative sizes of the lines or "pipes" represent the

* Figures 1 and 2 have been retained in committee files.

relative contributions of the primary energy inputs, the impacts of energy conversion, and the end uses.

By using this diagram it is easier to visualize how the energy flows move toward electricity generation or through the different sectors of our economy. The diagram makes clear some inescapable features of energy use in the transportation sector:

- The transportation sector is almost entirely dependent on oil. In fact, it is about 97 percent dependent on oil;
- A majority of the oil we use is imported. We are currently importing about 55 percent of our oil from foreign sources a percentage that is expected to increase to 68 percent by 2025;
- A large amount of energy is rejected or wasted and transportation is the least efficient of the three sectors of our energy economy; and
- Looking more specifically at oil, as we do in the next graph [Figure 2], we see an imbalance between petroleum demand for transportation and domestic production and that automobiles and light trucks are the dominant reason behind that demand.

In the early 1990s, the petroleum required just by our highway vehicles surpassed the amount produced domestically. The "gap" between production and transportation demand is growing—and is projected to keep growing. The current gap between total U.S. consumption and net production of oil is roughly 11 million barrels per day. And this is a gap that we are unlikely to close with regulation, new domestic production, or both. Although promoting efficiency in the use of oil and finding new domestic sources of oil are important short-term undertakings, over the long-term a petroleum-free option is eventually required.

We also face environmental challenges resulting from our current transportation system. We have made tremendous progress in reducing pollutant emissions from our cars and trucks as well as our stationary power sources and we will continue to make incremental gains through regulatory approaches such as the Tier II fuel standards. But for true efficiency gains, we must develop a wholly new approach to powering our vehicles.

We ultimately want a transportation system that is free of dependence on foreign energy supplies and emissions-free. We also want to preserve the freedom of consumers to purchase the kind of vehicles they want to drive. That is the concept behind the FreedomCAR partnership and Hydrogen Fuel Initiative, which are designed to develop the technologies necessary for hydrogen fuel cell vehicles and the infrastructure to support them.

Secretary Abraham unveiled the FreedomCAR partnership in January 2002 at the North American Auto Show in Detroit with the major U.S. automakers by his side. And President Bush unveiled the Administration's Hydrogen Fuel Initiative during his State of the Union address in January. As the President put it:

> With a new national commitment our scientists and engineers will overcome obstacles to taking these cars from laboratory to showroom, so that the first car driven by a child born today could be powered by hydrogen and pollution free.

A few days later, at an event attended by at least two members of this Committee, the President reiterated his commitment to his new Hydrogen Fuel Initiative. After viewing fuel cell vehicles from DaimlerChrysler, Honda, Nissan, Ford, Toyota and General Motors, the President said:

> The technology we have just seen is going to be seen on the roads of America. And it's important for our country to understand that by being bold and innovative, we can change the way we do business here in America; we can change our dependence upon foreign sources of energy; we can help with the quality of the air; and we can make a fundamental difference for the future of our children.

A transportation system based on hydrogen provides several advantages:

- Hydrogen can be produced from diverse domestic sources, freeing us from a reliance on foreign imports for the energy we use at home;
- Hydrogen can fuel ultra-clean internal combustion engines, which would reduce auto emissions by more than 99 percent; and,
- When hydrogen is used to power fuel cell vehicles, the combination results in more than twice the efficiency of today's gasoline engines and with none of the harmful air emissions. In fact, fuel cells' only byproducts are pure water and waste heat.

But, to ultimately succeed in the mass-market penetration of hydrogen fuel cell vehicles DOE, in partnership with the Department of Transportation (DOT) and the private sector, must conduct the necessary research and development to advance industry's investment in a hydrogen-based infrastructure that performs as well as the petroleum-based infrastructure we now have.

Our current gasoline/hydrocarbon infrastructure has been forged in a competitive market. It is ubiquitous and remarkably efficient. It can deliver refined petroleum products that began as crude oil half a world away to your neighborhood for less than the cost of milk, drinking water, or many other liquid products you can buy at the supermarket. We are currently bound to that infrastructure. We have no alternative. Our vision sees drivers able to go anywhere in America and refuel their hydrogen-powered vehicle. That is necessary before they will be comfortable purchasing one.

That is why the President, in his State of the Union address, proposed that the federal government significantly increase our spending on hydrogen infrastructure research and development, including hydrogen production, storage, and delivery technologies, as well as fuel cells. Over the next five years, we will spend an estimated $1.7 billion on the FreedomCAR partnership and Hydrogen Fuel Initiative, $1.2 billion of which is for the Hydrogen Fuel Initiative, which includes funds for fuel cells and hydrogen. Of the $1.2 billion figure, $720 million is "new money."

We will not build the infrastructure. The private sector will do that as the business case becomes clear. But as we develop the technologies needed by the vehicles, we will also develop the technologies required by the infrastructure. In cooperation with DOT, we will convene the parties needed for technology partnerships, we will collaborate on the needed codes and standards, and we will promote international cooperation in this effort.

There is growing worldwide interest in hydrogen and fuel cell technology, as reflected in the dramatic increase in public and private spending since the mid-1990s in the U.S. and elsewhere. We estimate current investments across the U.S. government agencies to be well over $200 million, about $120 million of which is for hydrogen and polymer electrolyte membrane (PEM) fuel cell research and development (R&D). In 2003, the Japanese government nearly doubled its annual fuel cell research, development and demonstration (RD&D) budget (compared to 2002) to approximately $268 million, and is this month launching a joint government/industry demonstration of hydrogen fuel cell vehicles, including the deployment of more than seven new hydrogen refueling stations. Governments and companies in Canada, Europe, and Asia are also investing heavily in hydrogen RD&D. For example, ten new hydrogen refueling stations will be built in Europe over the next few years to fuel hydrogen-powered buses. By comparison, the U.S. currently has approximately ten hydrogen refueling stations, and plans several more as appropriate to fund limited "learning" demonstrations to help identify R&D needs to make hydrogen and fuel cell technologies cost competitive and technologically viable.

The economic stakes are high—a recent report by PricewaterhouseCoopers projects global demand for all fuel cell products (in portable, stationary, and transportation power applications) to reach $46 billion per year by 2011 and to grow to more than $2.5 trillion per year in 2021. The United States should strive to be a leader in hydrogen and fuel cell technology development and commercialization in order to secure a competitive position for future energy technology innovations, new products, and service offerings. Furthermore, the more than 19 million barrels per day of petroleum projected to be imported to the U.S. by 2025 will cost our economy an estimated $188 billion per year (based on EIA projections) in real 2001 dollars.

APPROACH

In November 2001 my office began a formal hydrogen vision and "roadmapping" effort. Working with industry, stakeholders and academia, we developed a national approach for moving toward a hydrogen economy—a solution that holds the potential to provide virtually limitless clean, safe, secure, affordable, and reliable energy from domestic resources.

To realize this vision, the Nation must develop advanced technologies for hydrogen production, delivery, storage, conversion, and applications. The National Hydrogen Energy Technology Roadmap, which we released in November 2002, identifies the technological research, development, and demonstration steps required to make a successful transition to a hydrogen economy.

This past fall, the Department also developed an internal Hydrogen Posture Plan (Plan) to support the President's Hydrogen Fuel Initiative. The Plan identifies specific technology goals and milestones that would accelerate hydrogen and fuel cell development to enable an industry commercialization decision by 2015. My Office of Energy Efficiency and Renewable Energy led the development of the plan in collaboration with DOE's Office of Fossil Energy, Office of Nuclear Energy, Office of Science, and Office of Management, Budget, and Evaluation.

The Plan integrates the Department's planning and budgeting for program activities that will help turn the concept of a hydrogen-based economy into reality. More specifically, the Plan outlines the Department's role in hydrogen energy research and development in accordance with the National Hydrogen Energy Roadmap. The Plan is currently in draft and under policy review. The development of the Plan could not directly involve industry and other non-government stakeholders because of the inclusion of fiscal year 2004 through 2008 budget planning. Their input to other efforts such as the Hydrogen Roadmap, the Hydrogen Vision, the FreedomCAR Partnership Plan, and the Fuel Cell Report to Congress (which included four workshops with industry) has been considered in the development of the Plan.

To ensure that the Department continues to conduct its hydrogen research in a coordinated, focused, and efficient manner, the DOE Hydrogen Working Group that developed the Plan will continue to function. This Working Group will be chartered to meet regularly and perform the following functions:

- Evaluate the progress of the Department's hydrogen and related activities with regard to milestones and performance goals;
- Strengthen information exchange on technical developments;
- Help ensure that the various activities (e.g., budgeting, execution, evaluation, and reporting) remain well coordinated;
- Provide suggestions for management improvements and stronger technical performance; and,
- Coordinate, through the Office of Science and Technology Policy, with other agencies (e.g., the Department of Defense, DOT, National Aeronautics and Space Administration, Department of Commerce) conducting similar research and development activities to ensure our efforts our complementary and not duplicative.

In anticipation of an energy bill this year, the Department is also preparing to form a Hydrogen Technology Advisory Committee (HTAC). This advisory group, composed of a diverse group of experts from industry, academia, and other stakeholders, would provide input to the Secretary.

My testimony today draws heavily from DOE's planning efforts including the Posture Plan, the FreedomCAR Partnership Plan, the Hydrogen Roadmap, and the Fuel Cell Report to Congress. These documents describe how DOE will integrate its ongoing and future hydrogen R&D activities into a focused Hydrogen Program. The program will integrate technology for hydrogen production (from fossil, nuclear, and renewable resources), infrastructure development (including delivery and storage), fuel cells, and other technologies supporting future hydrogen fueled vehicles. Successful implementation of the Administration's integrated plans and activities is critical to the FreedomCAR partnership and Hydrogen Fuel Initiative. Coordinating hydrogen activities within DOE and among the federal agencies will improve the effectiveness of our RD&D activities and strengthen its contribution to achieving the technical milestones on the road to a hydrogen economy.

TECHNOLOGY CHALLENGES

Let me now review the challenges to be faced and how these challenges are to be met. Achieving our vision will require a combination of technological breakthroughs, market acceptance, and large investments in a national hydrogen energy infrastructure. Success will not happen overnight, or even over years, but rather over decades; it will require an evolutionary process that phases hydrogen in as the technologies and their markets are ready. Success will also require that the technologies to utilize hydrogen fuel and the availability of hydrogen occur simultaneously.

Some of the significant hurdles to be cleared include:

- Lower by a factor of four the cost of producing and delivering hydrogen;
- Develop more compact, light weight, lower cost, safe, and efficient hydrogen storage systems that will enable a greater than 300 mile vehicle range;
- Lower by a factor of at least ten the cost of materials for advanced conversion technologies, especially fuel cells;
- More effective and lower cost (by a factor of ten) carbon-capture and sequestration processes (a separate program critical to fossil-based production of hydrogen);
- Designs and materials that maximize the safety of hydrogen use; and

- The development of needed codes and standards as well as the education of consumers relative to the use of hydrogen.

The Department has drafted a work breakdown structure consistent with each of the critical areas identified in the Roadmap (production, delivery, storage, conversion, and end-use) and has identified milestones and decision points that are part of the effort. Examples of key program milestones that support FreedomCAR and achievement of a hydrogen economy include the following:

- On-board hydrogen storage systems with a six percent capacity by weight by 2010 (more aggressive goals are being established for 2015);
- Hydrogen production at an untaxed price equivalent to $1.50 per gallon of gasoline at the pump by 2010;
- PEM automotive fuel cells that cost $45 per kilowatt by 2010 and $30 per kilowatt by 2015 and meet 100,000 miles of service life; and,
- Zero emission coal plants that produce hydrogen and power, with carbon capture and sequestration, at $0.79 per kilogram at the plant gate.

In the near future, we plan on partnering with energy companies to establish more specific goals related to technology and components needed to produce and distribute hydrogen using various fossil, nuclear and renewable pathways. In this exercise, we will be looking at the full range of hydrogen technology areas covered in the Roadmap. Advances in other technologies will also be necessary for the ability of a hydrogen fueled vehicle to realize its full potential. These include:

- Improved energy storage, (e.g., batteries that are more durable, cheaper, and better performing);
- More efficient and cost effective electric motors;
- Inexpensive and more effective power electronics; and
- Better materials for lighter, but strong, structural members.

These technologies will enable hydrogen-fueled vehicles to be more efficient, and to help lower the vehicle cost to the consumer.

In the near- to mid-term, most hydrogen will likely be produced by technologies that do not require a new hydrogen delivery infrastructure (i.e., from distributed natural gas). As RD&D progresses along renewable, nuclear, and clean coal and natural gas production pathways (including techniques for carbon sequestration) a suite of technologies will become available in the mid- and long-term to produce hydrogen from a diverse array of domestic resources. The economic viability of these different production pathways will be strongly affected by regional factors, such as feedstock availability and cost, delivery approaches, and regulatory environment.

For hydrogen to become a viable fuel, advanced hydrogen storage technologies will be required, especially for automotive applications, where a driving range of at least 300 miles is needed. Current storage systems are too heavy, too large, and too costly. Technologies to convert hydrogen into useful energy—fuel cells and combustion technologies—must also be further improved to lower cost and improve performance.

Detailed analysis of life-cycle costs and benefits for alternative hydrogen production pathways, carbon sequestration, and other elements will continue. "Well-to-Wheels" analyses have led to the conclusion that the energy and environmental benefits depend greatly on how hydrogen is manufactured, delivered and stored, and on the economic feasibility of sequestration for fossil feed stocks. The results of these studies will help in making down-select decisions and to ensure that the relative merits of specific hydrogen pathways are evaluated properly and in comparison with other energy alternatives. Out-year planning will identify needs for RD&D on production and storage technologies, delivery infrastructure, and education and safety/codes and standards. Public education of consumers and local code officials must also be pursued concurrently with the RD&D.

Finally, industry must develop and construct the infrastructure to deliver hydrogen where it is needed. We will work with the DOT to help industry develop a safe, efficient, nation-wide hydrogen infrastructure. The hydrogen distribution infrastructure can evolve along with the conversion and production technologies, since much of the infrastructure that is developed for fossil-based hydrogen will also be applicable to renewable- and nuclear-based hydrogen. We will partner with industry to develop infrastructure in pilot projects, and industry will expand locally, regionally, and ultimately nationally.

INTERIM STRATEGIES

As important as we believe hydrogen is for the long term, we are still working, in cooperation with other federal agencies, to maintain a robust, and in some areas growing, research and development program in non-hydrogen transportation technologies.

Under the FreedomCAR partnership we have proposed a funding increase in fiscal year 2004 for our hybrid (gasoline-electric and diesel-electric) technology, as well as increases in materials technology. We believe many of these technologies will deliver fuel savings both prior to and after the introduction of fuel cell vehicles, since lightweight materials and hybrid technologies are expected to be incorporated into fuel cell vehicle designs. Therefore, these investments are expected to pay off in the interim, as well as over the long term.

In addition, we had a number of interim strategies in mind as we established specific, measurable performance goals for our program. And our FY 2004 budget is aligned with these goals. For example:

- We are working to develop technologies for heavy vehicles by 2006 that will enable reduction of parasitic energy losses, including losses from aerodynamic drag, from 39 percent of total engine output in 1998 to 24 percent;
- The 2006 goal for Transportation Materials Technologies R&D activities is to reduce the production cost of carbon fiber from $12 per pound in 1998, to $3 per pound; and
- The 2010 goal for Hybrid and Electric Propulsion R&D activities is to reduce the production cost of a high power 25kW battery for use in light vehicles from $3,000 in 1998 to $500, with an intermediate goal of $750 in 2006, enabling cost competitive market entry of hybrid vehicles.

Automakers are introducing technologies that have resulted in part from DOE's work in this area. At the recent North American International Auto Show in Detroit, the major U.S. automakers announced that they will have a variety of new hybrid gasoline-electric models entering the market in the 2004 to 2008 timeframe.

Of course, hybrid vehicles are more expensive compared to conventional vehicles, which is why the President proposed a tax credit for hybrid vehicles in his National Energy Plan, and subsequent to that in his 2004 budget submission. We urge that Congress adopt this important incentive for more efficient vehicles.

And we will continue support for our Clean Cities program, a unique, voluntary approach supporting more than eighty local coalitions that deploy alternative fuel vehicles (AFVs) and promote supporting infrastructure. The Clean Cities goals, against which we are making steady progress, are as follows:

- One million AFVs operating exclusively on alternative fuels by 2010;
- One billion gasoline gallon equivalents of alternative fuels per year used in AFVs by 2010 (approximately equivalent to saving 24 million barrels of oil annually); and
- Seventy-five percent of Clean Cities coalitions self-sustaining by 2005.

We look to Clean Cities to maintain important momentum toward alternative fuels until hydrogen-powered cars become available.

The Administration strongly supports a renewable fuels standard (RFS) that will increase the use of clean, domestically produced renewable fuels, especially ethanol, which will improve the Nation's energy security, farm economy, and environment.

As important as the RFS and the Clean Cities program are, their goals illustrate the daunting challenges we face. Taken together, the RFS and Clean Cities are expected to offset about four billion gallons of petroleum use per year by 2010. That sounds impressive until it is compared to the demand for petroleum for transportation uses. In the year 2000, we used approximately 130 billion gallons of gasoline and over 33 billion gallons of diesel (highway use only). With that realization, the critical importance of the FreedomCAR partnership and Hydrogen Fuel Initiative as a long-term strategy becomes clear.

And, if we are to achieve real progress in the near term and our ultimate vision in the long term, we must continue to nurture productive partnerships with the private sector. It is the private sector that will make the major investments necessary for the transition to a radically different transportation future. Those investments will not be made in the absence of a clear-cut business case.

Mr. Chairman, I appreciate the opportunity to present this testimony today, and I would be pleased to answer any questions you may have now or in the future.

Senator THOMAS. Mr. Secretary, Secretary Frankel.

STATEMENT OF EMIL H. FRANKEL, ASSISTANT SECRETARY FOR TRANSPORTATION POLICY, DEPARTMENT OF TRANSPORTATION

Mr. FRANKEL. Mr. Chairman, members of the committee, it is a pleasure to be here to testify on the Department of Transportation's efforts to promote the development of hydrogen fuel cell transportation and other promising technologies.

At DOT, we see development of these new technologies as an integral part of our move toward sustainable mobility. DOT has long recognized the complex interdependence of energy, the environment, and transportation. A hydrogen-based transportation system has the potential to revolutionize that relationship. Developing this system will require a partnership among Federal agencies. Given the Department of Transportation's responsibilities and jurisdiction, we look forward to playing an important role in this partnership.

In the State of the Union address, as Secretary Garman has reminded us, President Bush recognized our need to reduce America's dependence on foreign oil. For nearly half a century, transportation has accounted for about one-fourth of total U.S. energy use and currently accounts for two-thirds of U.S. oil consumption. The development of a marketable hydrogen vehicle, as the President has proposed, will greatly reduce the Nation's dependence on foreign oil, and we are committed to achieving that goal. Today, more than ever, we must pursue a clean, safe, and secure energy future.

The Department of Transportation is poised to join with our colleagues in taking on this challenge. Just as the Department of Energy has a clear leadership role in implementing the President's new Hydrogen Fuel Initiative and the existing FreedomCAR partnership, DOT has a leading role as DOE's partner in ensuring safe and effective implementation of this new technology in the Nation's transportation system. Under the auspices of the national energy policy, the Department of Transportation plays an important role in meeting this challenge.

The Department of Transportation has existing authority and regulatory responsibility for vehicle safety and fuel economy through the National Highway Traffic Safety Administration, NHTSA, and for pipeline and hazardous material safety through the Research and Special Programs Administration, RSPA.

Furthermore, DOT has a unique role in providing capital to support and maintain the safety of the Nation's transportation infrastructure. Our research efforts have already put hydrogen fuel cell buses on the road in demonstration projects, and the Federal Transit Administration is working to integrate these vehicles into commercial fleets.

The Maritime Administration (MARAD) and the Federal Railroad Administration are exploring potential fuel cell applications in ships and trains. Through these roles, the Department is a major partner in the process of developing commercially available hydrogen fueled vehicles. In order to make our efforts successful, the Nation will require the concurrent development of a system to produce, store, and distribute hydrogen. Because DOT has primary responsibility for the safe transportation of hydrogen, we expect to play a major role in this development.

In the words of Energy Secretary Abraham, "Unless we work on parallel tracks, developing the vehicle and the infrastructure concurrently, instead of consecutively, this process could take three decades or longer." Secretary Mineta looks forward to working with Congress, with the Federal agencies, industry, and others to assure progress in hydrogen infrastructure, vehicle safety, and the application of hydrogen fuel cell technology.

The Department of Transportation has responsibility for ensuring the safe performance of all vehicles. NHTSA, the agency that sets safety standards for all new motor vehicles, is working with the Department of Energy and trade associations, such as the National Hydrogen Association, to ensure the safety of new hydrogen-based fuel systems.

As hydrogen fuel cell technology is developed for use in additional modes of transportation, other elements of the Department of Transportation will have a role to play. Before heavier-duty vehicle rail or marine applications can be deployed commercially, we will need to address maintenance and repair intervals and develop safety standards for such criteria as fuel system integrity under crash conditions.

The Department of Transportation has an important regulatory role to play concerning safe delivery of hydrogen. RSPA administers the Nation's pipeline and hazardous material safety programs that will be vital in a hydrogen economy. RSPA develops and enforces safety standards for the transportation of hazardous gases, liquids by pipeline or as vehicle cargo. And we currently oversee approximately 600 miles of hydrogen pipelines.

Finally, in the President's fiscal 2004 budget request for RSPA, the Department is pursuing the development of a hydrogen fuel infrastructure and standards for hydrogen vehicle fuel systems, so that fuel cell vehicles, direct hydrogen-fueled vehicles and other alternative-fueled vehicles can be developed as a safe alternative to conventional petroleum-fueled vehicles.

As the United States' lead agency in the development of international codes and standards both for vehicles and hazardous materials, the Department of Transportation is working on steps that may lead to the establishment of international safety codes. The Department is currently involved in a number of programs to develop fuel cell and other advanced vehicle technologies.

As I mentioned, FTA has been in the forefront of research, development and demonstration of fuel cell buses and, with the Department of Energy, has conducted a six-year program to prove the concept of the fuel cell bus for the transit industry. We currently have two 40-foot fuel cell buses in demonstration projects, one here in the District of Columbia and one in California.

FTA oversaw completion of a new bus in 2002 that integrates fuel cell and hybrid technologies for an even greater boost in efficiency. This bus is also already operating in commercial service. FTA is currently managing an effort with United Technologies Corporation (UTC) to develop and demonstrate a specific fuel cell powerplant for transit buses and every other heavy-duty vehicle. A national heavy-duty fuel cell vehicle working group has been established to coordinate and share information in this area.

Furthermore, local jurisdictions have used bus capital funds to purchase clean buses. Similarly, the Federal Highway Administration has provided funding for advanced buses and trucks, among other projects under CMAQ, the Congestion Mitigation and Air Quality Improvement program.

MARAD administers an interagency program on marine fuel cell applications with the U.S. Coast Guard, the Navy, the Department of Energy, and NOAA, that funds the development of marine fuel cell powerplants. These will benefit ship design, operations and maintenance while reducing conventional pollutants and carbon dioxide output.

Thank you for the opportunity to provide this testimony before this committee. The Department of Transportation plans to play and wants to play an important role in developing the safety standards and technologies required for the hydrogen infrastructure, refueling, and storage and distribution systems, as well as the fuel cell vehicles themselves.

This concludes my prepared testimony. I would be happy to answer any questions when we get to that point in the hearing.

Senator THOMAS. Thank you.

[The prepared statement of Mr. Frankel follows:]

PREPARED STATEMENT OF EMIL H. FRANKEL, ASSISTANT SECRETARY FOR TRANSPORTATION POLICY, DEPARTMENT OF TRANSPORTATION

Good morning Mr. Chairman and Members of the Committee.

It is a pleasure to be here today to testify on the U.S. Department of Transportation's (DOT) efforts to promote the development of hydrogen fuel cell transportation and other promising technologies. At DOT, we see development of these new technologies as an integral part of our move towards sustainable mobility. DOT has long recognized the complex interdependence of energy, the environment, and transportation. Hydrogen fuel cells have the potential to revolutionize that relationship. Development of a hydrogen-based transportation system will require a partnership among federal agencies. Given our complementary experience with pipelines and heavy-duty vehicle fuel cell applications, DOT looks forward to working with the Department of Energy on this issue.

In his State of the Union Address, President Bush recognized our need to reduce America's dependence on foreign oil. For nearly half a century, transportation has accounted for about one-fourth of total U.S. energy use and currently accounts for two thirds of U.S. oil consumption. The development of a marketable hydrogen vehicle, as the President has proposed, will greatly reduce the nation's dependence on foreign oil. We will accomplish this mission by developing technology and infrastructure for commercially viable hydrogen fuel cells to power cars, trucks, homes and businesses free of air pollution or greenhouse gases. Today, more than ever, we must pursue a clean, safe, and secure energy future.

The Department of Transportation is poised to take on this tremendous challenge. Just as the Department of Energy has a clear leadership role in implementing the President's new Hydrogen Fuel Initiative and the existing FreedomCAR Partnership, the Department of Transportation has a clear leadership role as DOE's partner in ensuring the safe and effective implementation of this new technology in the Nation's transportation system.

The Department of Transportation has regulatory responsibility for vehicle safety and fuel economy, through the National Highway Traffic Safety Administration (NHTSA), and for pipeline safety, through the Research and Special Programs Administration (RSPA). Furthermore, DOT has a unique role in providing capital to support, and maintain the safety of, the Nation's transportation infrastructure. Through DOT's ongoing programs, DOT also has extensive on-the-ground experience in the use of fuel cells in medium- and heavy-duty vehicles. Through these roles, the Department is committed to being a major partner in the process to develop infrastructure necessary to support commercially available hydrogen-fueled vehicles.

DOT is supporting work on the use of fuel cells in vehicles, particularly heavy-duty vehicles. The Federal Transit Administration (FTA) and the Federal Highway Administration (FHWA) have already put hydrogen fuel cell buses on the road in demonstration projects and FTA is working to integrate these vehicles into commercial fleets in several cities. The Maritime Administration (MARAD) and Federal Railroad Administration (FRA) are exploring potential fuel cell applications in ships and trains. We look forward to working with DOE as we bring these efforts to fruition.

In order to make our efforts successful, the Nation will require the development of an infrastructure system to produce, store and distribute hydrogen. Because DOT has primary responsibility for pipeline safety, we expect to be a major part of the process to plan the concurrent development of infrastructure to support the pace of commercially available vehicles. In the words of Energy Secretary Abraham, "unless we work on parallel tracks, developing the vehicle and the infrastructure concurrently instead of consecutively, this process could take three decades or longer." Secretary Mineta looks forward to working with the Congress, Federal agencies, industry, and others to assure progress in hydrogen infrastructure, vehicle safety, and the application of hydrogen fuel cell technology.

In the near term, we are continuing efforts to enhance the fuel efficiency of new vehicles.

ENSURING THE SAFETY OF THE NATION'S TRANSPORTATION SYSTEM: VEHICLE SAFETY ISSUES

Several agencies within DOT have responsibilities for ensuring the safe performance of passenger and cargo vehicles. NHTSA sets safety standards for all new motor vehicles. NHTSA is working with the Department of Energy to ensure that new hydrogen-based fuel systems for motor vehicles meet the need for safety, both during normal vehicle operation and during crashes.

NHTSA has begun collaboration with DOE and will participate in a new interagency working group on hydrogen fuel systems. NHTSA's researchers are also working with such trade associations as the Hydrogen Association, which has a meeting scheduled today here in Washington, DC to discuss fuel systems, and with academic and industry experts in the field. In addition, NHTSA has canvassed organizations in Europe that are working on hydrogen fuels and has collected much of the published research on the subject.

NHTSA's next step is to develop a research plan, using the existing research data as a basis for deciding what needs to be done to ensure the safety of hydrogen fuel systems. With the first fuel-cell vehicles already on the road, the agency will continue to research adequate safety measures to address fuel cell vehicle safety.

As hydrogen fuel-cell technology is developed for use in heavier transport vehicles, other elements of DOT will also have roles to play. Before these heavier-duty vehicles can be deployed commercially, FTA will need to address maintenance and repair intervals, and will work with NHTSA to develop safety standards for such criteria as fuel integrity under crash conditions. Similarly, as fuel cells are adapted to locomotive engines, heavy-duty trucks, and marine vessels, both as power plants and auxiliary power units, safety standards will need to be developed by such DOT modal administrations as FRA and Federal Motor Carrier Safety Administration, among others.

ONGOING DOT ADVANCED TECHNOLOGY VEHICLE PROGRAMS

Beyond these emerging activities that aid the development of a hydrogen-based transportation system, the Department of Transportation is currently involved in a number of programs to develop fuel-cell and other advanced vehicle technologies. Such programs include: fuel cell transit buses, 21st Century Trucks, and efficiency technologies in the intelligent transportation system.

FTA has been in the forefront in the research, development, and demonstration of fuel cell buses. FTA and DOE had previously conducted a program to prove the concept of a fuel cell bus for the transit industry (1988-1994). This effort resulted in three test bed 30-foot fuel cell buses. To further demonstrate the feasibility and potential commercialization of transit applications, FTA extended its efforts to 40-foot transit buses, the staple of transit service operations. Two 40-foot fuel cell buses have been developed. The Washington Metropolitan Area Transit Authority (Metro) recently agreed to a one-year demonstration of a fuel cell bus in revenue service operations. Metro plans to operate this fuel cell bus on a variety of Metrobus routes throughout the Washington, DC metropolitan area once pre-training activities are completed. A second fuel cell bus is currently being demonstration at SunLine Transit in Palm Springs, California.

FTA most recently managed an effort to develop a 30-foot fuel cell hybrid bus. This bus was completed in 2002 and is currently operating in revenue service operation at SunLine Transit under a demonstration and evaluation program. FTA is currently managing an effort with United Technologies Corporation Fuel Cells to develop and demonstrate a specific fuel cell power plant for transit buses and other heavy-duty vehicles. A national Heavy-Duty Fuel Cell Vehicle Working Group has been established to coordinate and share information in this area.

The TEA-21 Clean Fuels Formula Program was created to help areas meet and maintain the National Ambient Air Quality Standards under the Clean Air Act, and to support emerging clean fuels and advanced propulsion technologies for transit buses, and to create markets for those technologies. Although Congress never appropriated funds for the Clean Fuels Formula Program, it directed in appropriations acts that the funds authorized for this program be merged with the Section 5309 bus capital funds. These funds are available for replacement, rehabilitation, and purchase of buses and bus-related equipment, and the construction of bus-related facilities. Local jurisdictions have used these funds to operate clean buses in the nation's transit fleets.

Similarly, the Federal Highway Administration (FHWA) has provided funding for advanced buses and trucks under the Congestion Mitigation and Air Quality Improvement (CMAQ) program. These funds provide in excess of $1.5 billion annually for States and localities to reduce emissions in areas that do not, or did not, meet the national air quality standards. Under the CMAQ program, advanced vehicle demonstrations have been conducted in several places, including a fuel cell bus demonstration in Chicago.

The Maritime Administration (MARAD) administers an interagency program on marine fuel cell applications, with the U.S. Coast Guard, the Navy, DOE, and NOAA. Under this program, two 2500 kw marine fuel cell plant design contracts were awarded by the Navy and are underway. One 500 kw fuel cell plant may be fabricated in future years. Marine fuel cell power plants will benefit ship design, operations, manning and maintenance. In addition to reducing conventional pollutants, the projected high operating efficiency of fuel cells will also reduce CO2 output.

ENSURING THE SAFETY OF THE NATION'S TRANSPORTATION SYSTEM: THE HYDROGEN INFRASTRUCTURE

DOT has an important regulatory role to play concerning the current and future delivery infrastructure. Our Research and Special Programs Administration (RSPA) administers the nation's pipeline and hazardous materials programs that will play critical parts in a hydrogen economy. DOT is responsible for developing safety standards for the transportation of gaseous hydrogen and hazardous liquids by pipeline and enforces these standards through a comprehensive federal and state pipeline inspection program. As part of the nation's pipeline system, approximately 600 miles of low-pressure pipelines currently carry hydrogen. Wide-scale adoption of hydrogen technologies in transportation will likely lead to an infrastructure comprised, in part, of an expanded hydrogen pipeline system. The higher pressures and volumes potentially raise safety and security risks that may require additional regulatory actions (standards and codes) together with additional enforcement efforts.

Through its hazardous materials program, DOT already is responsible for identifying and managing the risks presented by the transportation of hydrogen in commerce. This includes not only the transportation of hydrogen as a compressed gas or cryogenic liquid, but also its transportation as cargo aboard vehicles or as vehicle components (like fuel cells) that contain hydrogen as a fuel.

We routinely work with industry to address new technologies and applications that are not currently provided for in our regulations—such as fuel cells—to provide for their use in the marketplace while ensuring that they are safe. Currently, large quantities of hydrogen are not transported but as demand increases, associated volumes will require DOT to address the security and safety risk associated with the larger number of hydrogen shipments moving through populated areas—using all surface modes—rail, highway and water.

As the U.S. lead agency in the development of international codes and standards for hazardous materials, DOT is already taking the steps necessary to ensure that energy materials, including hydrogen for fuel cells, may be safely and securely transported when installed in motor vehicles, or other applications, and when transported individually as new or replacement parts.

The Department also is addressing critical education and training needs in the emergency response community, working with the National Association of State Fire Marshals, the California Fuel Cell Partnership, and others.

Moreover, in the President's FY 04 budget request for RSPA, the Department is pursuing the development of a hydrogen fuel infrastructure and standards for hydrogen vehicle fuel systems, so that fuel cell vehicles, direct hydrogen-fueled vehicles and other alternative fuel vehicles can be developed as a safe alternative to conventional petroleum fueled vehicles.

THE CAFE PROGRAM

While these programs to develop hydrogen fuel cell and advanced technologies will lead to improved fuel economy and lower emissions in the longer term, DOT is involved in a number of activities that will yield such improvements in the nearer term. One is the Corporate Average Fuel Economy (CAFE) program. NHTSA has proposed light truck fuel economy standards for model years 2005 through 2007, with due consideration of recommendations in the recently released National Academy of Sciences study. The proposed increases are the highest in 20 years and can be implemented without compromising safety or employment, saving approximately 2.5 billion gallons of gasoline and improving the environment.

I thank you for the opportunity to provide this testimony before the Committee. I can assure you that DOT plans to play an important role in developing the safety standards and technologies required for the hydrogen infrastructure, refueling, and storage and distribution systems, as well as for the fuel cell vehicles themselves.

This concludes my prepared testimony. I would be happy to answer any questions you or members of the Committee may have.

Senator THOMAS. Thank you, Secretary Frankel.

Mr. Dana.

STATEMENT OF GREG DANA, VICE PRESIDENT, ENVIRONMENTAL AFFAIRS, ALLIANCE OF AUTOMOBILE MANUFACTURERS

Mr. DANA. Mr. Chairman, thank you for the opportunity to testify before the committee regarding energy and the transportation sector. My name is Greg Dana. And I represent the Alliance of Automobile Manufacturers, a trade association of ten car and light truck manufacturers.

The Alliance supports efforts to create an effective energy policy based on broad, market-oriented principles. Policies that promote research and development and deployment of advanced technologies and policies which provide customer-based incentives to accelerate demand of these advanced technologies set the foundation.

I would like to address some of the technologies automakers are focusing on today. The Alliance fully supports President Bush's Hydrogen Fuel Initiative to spend $1.2 billion developing fuel technologies, as well as infrastructure for fuel cell vehicles to be widely available. The fuel cell is the primary alternative to the battery for supply power to an electric vehicle's motor. Although a fuel cell looks like a battery, the former uses hydrogen fuel to continuously produce electric current, whereas the latter stores electricity in its electrodes.

Fuel cells work by chemically combining hydrogen and oxygen, a process that produces electricity in water. Because they produce less than one volt each, fuel cells must be stacked in a row to produce enough voltage for a motor. Hydrogen can be produced by reformulating a hydrogen-containing fuel or it can be stored in its pure form.

Automakers are racing to make fuel cell vehicles commercially viable, cost effective, and appealing to consumers. However, as the President recognizes, an infrastructure of hydrogen refueling stations will have to be in place across the Nation in order to encourage broad marketplace acceptance. Together with the already established FreedomCAR Initiative, the automobile companies look forward to working with government agencies to overcome technical and cost barriers, so we can deliver fuel cell vehicles and other advanced technology products to the American consumer.

Hybrid-electric vehicles can offer a significant improvement in fuel economy. These products capture power through regenerative braking. When decelerating an internal combustion vehicle, the brakes convert the vehicle's kinetic energy into heat, which is lost to the air.

By contrast, a decelerating hybrid vehicle can convert kinetic energy into stored energy that can be reused during the next acceleration. Hybrid vehicles do not require additional investment in fuel infrastructure, which helps reflect their potential for near-term acceptance.

Today hybrid vehicles face cost challenges. Advanced lean-burn technology diesel and gasoline vehicles employ highly sophisticated and costly combustion and emissions technologies that greatly enhance the existing advantages of lean-burn internal combustion engines. For example, advanced lean-burn technology diesel and gasoline vehicles are able to achieve exceptional combined city/highway mileage performance that can be higher than comparable conventional gasoline engine vehicles, offering both important energy conservation benefits and reduced lifetime fuel costs for consumers.

Moreover, the lean-burn technology's fuel economy benefits are immediate and will improve as these vehicles come to market with the introduction of near zero sulphur fuels. These vehicles must meet the new stringent EPA Tier II emission requirements through significant reductions of all regulated emissions.

Advanced lean-burn technology diesel and gasoline vehicles' conservation and environmental benefits are complemented by exceptional overall engine performance characteristics, including high torque power, application, various vehicle categories and classes, and low maintenance costs, all of which will help ensure consumer acceptance when the technology becomes available in the marketplace.

At present, current technology light-duty diesel vehicles comprise 40 percent of new vehicle sales in Europe, a figure that is projected to increase to 70 percent by the end of the decade. By contrast, current technology light-duty diesel vehicles represented less than 1 percent of the U.S. market in 2002 due to U.S. emission requirements.

An internal combustion engine vehicle powered by liquid hydrogen combines the goals of near-zero emissions with the utility and flexibility of an internal combustion engine, emitting only water vapor when burned. Combined with existing state-of-the-art technology, this same internal combustion engine can also run on gasoline. Such dual fuel capacity enables the vehicle to be switched to gasoline operation, should it become necessary, eliminating any restrictions that might be imposed by range or hydrogen availability.

In the fuels area, the auto industry is producing numerous vehicles that can operate on alternative fuels. In fact, the industry already offers more than 25 vehicles powered by alternative fuels. Approximately 2 million of these vehicles are on the road today and more are coming. Today, auto manufacturers offer alternative vehicles on the following fuels: natural gas, ethanol, biodiesel, and liquified petroleum gas.

The largest share of alternative fuel vehicles being produced by U.S. manufacturers are vehicles that can operate on a mixture of 85 ethanol and 15 percent gasoline. The Government has supported efforts to produce these vehicles by providing extra fuel economy credits to help meet CAFE requirements. While the volume of vehicles is now approaching a critical mass, we think continuation of these government incentives will spur further development of the needed ethanol infrastructure.

The race is on among all companies. And breakthroughs are being made every year. A continuous dialogue with policymakers, like those who serve on this committee, will ensure that the United States continues to be a leader for innovative and world-class technology, not only for the motor vehicle fleet but for all sectors of our economy.

Thank you for the opportunity to testify today.

Senator THOMAS. Thank you, sir. We appreciate it very much.

[The prepared statement of Mr. Dana follows:]

PREPARED STATEMENT OF GREG DANA, VICE PRESIDENT, ENVIRONMENTAL AFFAIRS, ALLIANCE OF AUTOMOBILE MANUFACTURERS

Mr. Chairman, thank you for the opportunity to testify before your Committee regarding automakers' efforts to develop advanced technology vehicles. I represent the Alliance of Automobile Manufacturers, a trade association of 10 car and light-truck manufacturers. Our member companies include BMW Group, DaimlerChrysler Corporation, Ford Motor Company, General Motors Corporation, Mazda, Mitsubishi, Nissan North America, Porsche, Toyota Motor North America and Volkswagen of America.

Alliance member companies have more than 620,000 employees in the United States, with more than 250 manufacturing facilities in 35 states. Overall, a University of Michigan study in 2001 found that the entire automobile industry creates more than 6.6 million direct and spin-off jobs in all 50 states and produces almost $243 billion in payroll compensation annually.

ALLIANCE R&D FOCUS

The University of Michigan study also found that the total R&D spending by the industry is approximately $18.4 billion per year, with much of it in the high-tech sector. In fact, the study stated the following: "The level of automotive R&D spending and the relatively high employment of research scientists and engineers in the U.S. auto industry has traditionally earned it a place in any U.S. government listing of high technology industries generally thought to be central to the long-term performance of the U.S. economy."

The auto industry is committed to developing and utilizing emerging technologies to produce cleaner, more fuel-efficient cars and light trucks. According to EPA data, fuel efficiency has increased steadily at approximately 1.5% per year on average from 1975 to 2001 for both cars and light trucks. The National Academy of Sciences (NAS), in its 2001 report to Congress, introduced their discussion of promising technologies by stating that "the 1992 NAS report outlined various automotive technologies that were either entering production at the time, or were considered "emerging" based upon their potential and production intent. Many of the technologies identified in the 1992 report as "proven" or "emerging" have already entered production. This has occurred primarily by market/competitive driven forces and occurred during a time that CAFE standards remained relatively unchanged. Automotive technology has continued to advance, especially in microelectronics, mechatronics, sensors, control systems, and manufacturing processes.

Auto manufacturers are working on future technologies such as hybrid, advanced lean-burn, hydrogen fueled internal combustion engines, and fuel cell vehicles that may lead to substantial improvements in efficiency and emissions performance without sacrificing safety, utility, and performance. These new and emerging technologies all share the need for cooperative efforts that bring all the key stakeholders together .including the automakers, energy providers, government policy makers and most importantly, the customers.

KEY ENERGY POLICY INITIATIVES

1. Promoting Market Based Principles

The Alliance supports efforts to create an effective energy policy based on broad, market-oriented principles. Policies that promote research and development and deployment of advanced technologies and provide customer based incentives to accelerate demand of these advanced technologies set the foundation. This focus on bringing advanced technologies to market leverages the intense competition of the automobile manufacturers worldwide. This competition drives automakers to develop and introduce breakthrough technologies to meet a variety of demands and customer needs in the marketplace.

The NAS report in 2001 summarized this diversity of demand and priorities in the marketplace when it stated that "automotive manufacturers must optimize the vehicle and its powertrain to meet the sometimes-conflicting demands of customer-desired performance, fuel economy goals, emissions standards, safety requirements and vehicle cost within the broad range of operating conditions under which the vehicle will be used. This necessitates a vehicle systems analysis. Vehicle designs trade off styling features, passenger value, trunk space and utility. These trade-offs will likewise influence vehicle weight, frontal area, drag coefficients and powertrain packaging, for example. These features together with the engine performance, torque curve, transmission characteristics, control system calibration, noise control measures, suspension characteristics and many other factors, will define the drivability, customer acceptance and marketability of the vehicle."

This is a long way of saying that in the end, the customer is in the driver's seat. Market based incentives and approaches ultimately will help consumers overcome the initial cost barriers of advanced technologies during early market introduction thereby increasing demand and bringing more energy efficient vehicles into the marketplace. This will also accelerate cost reduction as economies of scale are achieved in a timelier fashion.

2. Maintaining Technology Focus

The Alliance and its 10 member companies believe that the best approach for improved energy conservation and fuel efficiency gains is to aggressively promote the development of advanced technologies through cooperative, public/private research programs and competitive development and incentives to help pull the technologies into the marketplace as rapidly as possible.

The Alliance fully supports President Bush's Hydrogen Fuel Initiative to spend $1.2 billion developing fuel technologies as well as infrastructure needed for fuel cell vehicles to be widely available. The fuel cell is the primary alternative to the battery for supplying power to an electric vehicle's motor. Although a fuel cell looks like a battery, the former uses hydrogen fuel to continuously produce electric current whereas the latter stores electricity in its electrodes. Fuel cells work by chemically combining hydrogen and oxygen, a process that produces electricity and water. Because they produce less than one volt each, fuel cells must be stacked in a row to produce enough voltage for the motor. Hydrogen can be produced by reformulating a hydrogen-containing fuel or it can be stored in its pure form.

Automakers are racing to make fuel cell vehicles commercially viable, cost effective and appealing to consumers. However, as the President recognizes, an infrastructure of hydrogen fueling stations will have to be in place across the nation in order to encourage broad marketplace acceptance. Together with the already established FreedomCAR initiative, the automobile companies look forward to working with government agencies to overcome technical and cost barriers so we can deliver fuel cell vehicles and other advanced technologies products to the American consumer.

As a nation, we need to get these technologies on the road as soon as possible in an effort to reach the national energy goals as fast and as efficiently as we can.

NEW TECHNOLOGIES PROMISES AND CHALLENGES

Focus on Powertrain and Vehicle Technologies

Automobile companies around the globe have dedicated substantial resources to bringing cutting-edge technologies—electric, fuel cell, advanced lean burn, hybrid-electric vehicles as well as alternative fuels—including hydrogen fueled internal combustion engines—to the marketplace. Each of these technologies brings a set of unique advantages. At the same time, each technology has a unique set of challenges that inhibit widespread commercialization and acceptance. The internal combustion engine, fueled by relatively inexpensive gasoline, has been and continues to be, a formidable competitor against which all new technologies must compete.

For consumers sensitive to cost, fuel economy gains must be compared to the increased investment costs and risks in their new vehicle purchase decision. Assuming a fuel cost of $1.50 per gallon, a 20% increase in vehicle fuel efficiency offers an annual fuel savings of just over $150. This cost must be weighed against the convenience, utility and performance of the alternative.

The Alliance supports enactment of tax credits for consumers to help offset the initial higher costs of advanced technology and alternative fuel vehicles until more advancements and greater volumes make them less expensive to produce and purchase.

In reviewing Senate legislation that was recently introduced to spur the sale of advanced technology fuel-efficient vehicles, the Alliance believes that the overall concepts found in Senator Orrin Hatch's new bill offer a solid framework, but we also support the inclusion of tax credits for advanced lean-burn technology vehicles. Automakers look forward to working with this Committee and the Senate Finance Committee as a new energy and tax package is developed this year.

Automakers are keenly aware of the importance of consumer choices and the challenges to deliver new technologies that meet their affordability, performance and utility needs. While fuel cell vehicles are still many years away from being widely available, there are a number of other advanced technology vehicles in the marketplace today, or in the near future, for consumers.

Hybrid-Electric Vehicles

Hybrid-electric vehicles can offer a significant improvement in fuel economy. These products capture power through regenerative braking. When decelerating an internal combustion vehicle, the brakes convert the vehicle's kinetic energy into heat, which is lost to the air. By contrast, a decelerating hybrid vehicle can convert kinetic energy into stored energy that can be reused during the next acceleration. Hybrid vehicles do not require additional investment in fuel infrastructure which helps reflect their potential for near-term acceptance. Today, hybrid vehicles face cost challenges.

Battery Electric Vehicles

Vehicles that utilize stored energy from "plug-in" rechargeable batteries offer zero emissions. Battery electric vehicles continue to face weight, energy density and cost challenges that limit their customer range and affordability.

Advanced Lean Burn Technology Vehicles

Advanced lean-burn technology diesel and gasoline vehicles employ highly sophisticated and costly combustion and emissions technologies that greatly enhance the existing advantages of lean-burn internal combustion engines. For example, advanced lean-burn technology diesel and gasoline vehicles are able to achieve exceptional combined city/highway mileage performance that can be higher than comparable conventional gasoline engine vehicles, offering both important conservation benefits and reduced lifetime fuel costs for consumers. Moreover, the technology's fuel economy benefits are immediate and will improve as these vehicles come to market with the introduction of near zero sulfur fuels. These vehicles must meet the new stringent EPA Tier II emission requirements, through significant reductions of all regulated emissions.

Advanced lean-burn technology diesel and gasoline vehicles' conservation and environmental benefits are complemented by exceptional overall engine performance characteristics, including high torque power, application to various vehicle categories and classes, and low maintenance costs-all of which will help ensure consumer acceptance when the technology becomes available in the marketplace.

At present, current technology light-duty diesel vehicles comprise 40% of new vehicle sales in Europe, a figure that is projected to increase to 70% by the end of the decade. By contrast, current technology light-duty diesel vehicles represented less than 1% of the U.S. market in 2002 due to U.S. emission requirements.

Hydrogen Fueled Internal Combustion Engine

An internal combustion engine vehicle powered by liquid hydrogen combines the goals of near-zero emissions with the utility and flexibility of an internal combustion engine, emitting only water vapor when burned. Combined with existing state-of-the-art technology, this same internal combustion engine can also run on gasoline. Such dual fuel capacity enables the vehicle to be switched to gasoline operation should it become necessary, eliminating any restrictions that might be imposed by range or hydrogen availability.

Focus on Fuels and Infrastructure

Much of the discussion regarding energy policy and the transportation sector centers on the vehicles of the automobile manufacturers. But it is important not to forget about a vital component for any vehicle—the fuel upon which it operates. As automakers looking at the competing regulatory challenges for their products—fuel efficiency, safety and emissions—and attempting to move forward with advanced technologies, they must have the best possible and cleanest fuels. EPA has begun to address gasoline and diesel fuel quality, but fuel needs to get even cleaner. This is important to enable advanced lean burn vehicles to comply with increasingly stringent emissions standards and because gasoline will remain the prevalent fuel for years to come and may eventually be used for fuel cell technology.

Low Sulfur Gasoline

In 1999, new EPA rules were issued which direct oil refiners to reduce the amount of sulfur in gasoline to an average of 30 parts per million, a reduction of 90% over current levels. Low sulfur gasoline is vital to ensuring that vehicle pollution control devices, such as catalytic converters, work more efficiently. The Tier II emissions regulations were required under the 1990 Clean Air Act and will be phased in beginning in the 2004 model year.

Low Sulfur Diesel

Automakers are constantly evaluating fuel-efficient technologies used in other countries to see if they can be made to comply with regulatory requirements in the United States. One such technology is diesel engines, using lean-burn technology, which has gained wide acceptance in Europe and other countries representing about 40% of new passenger vehicle sales. Automakers have been developing a new generation of highly fuel-efficient clean diesel vehicles—using turbocharged direct injection engines—as a way to significantly increase fuel economy. However, their use in the U.S. must be enabled by significantly cleaner diesel fuel.

In 2001, EPA promulgated its low sulfur diesel rule that the Alliance aggressively supported as a strong step toward enabling use of clean diesel technology in light duty vehicles. In addition to lower sulfur, however, diesel fuel also must have higher cetane, lower aromatics and adequate lubricity, and the quality of the diesel fuel currently sold in the U.S. is inadequate with respect to these properties. Unless better fuel quality can be assured nationwide, companies will hesitate to introduce clean diesel technologies into the U.S. market.

Besides enabling advanced technologies, cleaner conventional fuels will provide emission benefits in the existing fleet of on-road vehicles. More information and details can be found in the World-Wide Fuel Charter which is endorsed by automakers around the world.

Alternative Fuels

Beyond conventional fuels, the auto industry also is producing vehicles that can operate on alternative fuels. In fact, the industry already offers more than 25 vehicles powered by alternative fuels. Approximately 2 million of these vehicles are on the road today and more are coming. Today, auto manufacturers offer alternative fuel vehicles on the following fuels:

- Natural gas
- Ethanol
- Biodiesel
- Liquefied petroleum gas (propane)

The largest share of alternative fuel vehicles being produced by U.S. manufacturers are vehicles that can operate on a mixture of 85% ethanol and 15% gasoline. The government has supported efforts to produce these vehicles with extra fuel economy credits to help meet the CAFE requirements. While the volume of vehicles is now approaching a critical mass, we think continuation of these government incentives will spur further development of the needed ethanol infrastructure.

As you can tell, the automobile companies—from the top executives to the lab engineers—are constantly competing for the next breakthrough innovation. If I can leave one message with the Committee today, it is to stress that all manufacturers have advanced technology programs to improve vehicle fuel efficiency, lower emissions and increase motor vehicle safety. These are not “pie in the sky” concepts on a drawing board. In fact, automakers have advanced technology vehicles in the marketplace now and have announced aggressive production plans for the near future.

The race is on among all companies and breakthroughs are being made every year. A continuous dialogue with policymakers, like those who serve on this Committee, will ensure that the United States continues to be a leader for innovative and world-class technology not only for the motor vehicle fleet but for all sectors of our economy.

This concludes my testimony. Thank you for the opportunity to testify before the Committee today.

Senator THOMAS. Mr. Friedman, we are glad you are concerned about this issue.

STATEMENT OF DAVID FRIEDMAN, SENIOR ANALYST, CLEAN VEHICLES PROGRAM, UNION OF CONCERNED SCIENTISTS

Mr. FRIEDMAN. Thank you, Mr. Chairman. We are concerned about a lot of things. That is in our name.

I am here representing the Union of Concerned Scientists. And we are a nonprofit organization of more than 60,000 scientists and citizens working for practical environmental solutions. I would like to start off actually partly where Senator Bingaman left off, which was focusing on the problem of our oil use today, the immediate effects and the immediate solutions that we can apply to those problems.

Today, we send more than $200,000 overseas every minute to buy oil. Even if we stopped importing oil, though, the U.S. economy would still be vulnerable. Global price hikes affect the cost of U.S. oil, whether we purchase it within our country or from somewhere else. This is because we buy oil on a global market, and prices are set by that global market. As long as the U.S. economy is tied to oil, we will be susceptible to OPEC's market power and Persian Gulf instability.

Finally, the oil use in our transportation sector also creates many significant environmental problems that impact our health and our economy. I think we do have to face the fact that there is no single silver bullet to address this problem. However, there is a broad set of technologies that can be used, many of which can be applied within the next decade. We should use these transportation technologies as an investment to cut our near-term and long-term oil use. And just like other investments in technology, investing in automotive technology will reduce our oil dependence while also being an engine for economic and job growth.

First, I would like to start with many conventional technologies that have not been addressed yet today. These are short-term, low-risk technology options that are proven, cost effective, and available to automakers today. We can put these technologies on the road over the next ten years. And the result can be a stabilization in the growth of oil use from our cars and trucks. That would be a very impressive result.

These technologies include things like efficient gasoline engines that incorporate variable valve technology, displacement on demand, and even gasoline-direct injection. We are also looking at improved transmissions, such as continually variable transmissions and efficient manual transmissions that the computer on board the vehicle can shift instead of the driver.

Also available are more mundane technologies, simple things like improving the aerodynamics of our cars and trucks, lower rolling resistance tires, and even things like electronic power steering.

Diesel, as you heard, is also another possible conventional technology option, though it is looking like it will not be as cost effective as many of these other gasoline and conventional technologies. Diesel has not made a significant entry into the U.S. market for several reasons. It is not because of air quality concerns, but rather because of the cost of the technology. Diesel has made significant inroads in Europe because there are gasoline taxes that favor diesel use.

Further, diesels are getting cleaner, but they do make it harder to address public health concerns regarding air quality, since they are unlikely to catch up with the cleanest gasoline cars.

Because these conventional technologies exist today and are cost effective, we do not need a major research program to get them on the road. Instead, we need to push to get automakers to put them in showrooms, providing consumers with the choices they currently do not have, choices like a 30- or 35-mile-per-gallon SUV or a 30- to 33-mile-per-gallon pickup truck.

The last push to get conventional technologies on the road proved very effective, cutting our passenger vehicle oil use by more than 25 percent in the year 2000, according to the National Academy of Sciences. The current approach, a 1.5-mile-per-gallon increase in the light truck fuel economy average, however, is a very modest goal. This would be the first increase in fuel economy standards in a decade but is extremely modest when you consider the wide availability of technologies. It will also have a negligible impact on our oil use, saving less than one day's worth of oil each year between 2005 and 2008.

These gasoline technologies are key for short-term and near-term improvements in fuel economy and productions in oil use. Hybrid technology and fuel cells definitely offer significant promise in the medium and longer term. Hybrid technology can double the fuel economy of our cars and trucks. Dedicated alternative fuels offer near-term air quality and oil savings benefits. And these same alternative fuels, such as natural gas and possibly methanol, will provide a major source of hydrogen in the transition to renewable hydrogen feed stocks.

Fuel cells offer long-term promise, but it certainly will be a challenge to get there. It will not be a small or inexpensive task. And so, therefore, the Government does need to provide vision and focus, along with clear goals and funding in order to achieve those benefits. Hybrid technologies and alternative fuels also need support, specifically in terms of market incentives, like tax credits that can buy down the initial cost of these vehicles and make them more affordable to consumers.

Finally, in closing I would like to say that as an engineer, I see the broad array of available technologies as an opportunity, an opportunity to roll up our sleeves and get to work, making vehicles that are safer, cleaner, and less dependent on oil. Because the available conventional technologies and advanced technologies will complement each other, this is not an either/or proposition. We must continue to focus on policies that will put conventional technology to work while we also invest in longer term technology options.

Thank you for the opportunity to testify today on this important issue.

Senator THOMAS. Thank you, sir.

[The prepared statement of Mr. Friedman follows:]

PREPARED STATEMENT OF DAVID FRIEDMAN, SENIOR ANALYST, CLEAN VEHICLES PROGRAM, UNION OF CONCERNED SCIENTISTS

Thank you Mr. Chairman and Members of the Committee for the opportunity to testify before you today. My name is David Friedman and I am an engineer and Senior Analyst in the Clean Vehicles Program at the Union of Concerned Scientists (UCS). UCS is a nonprofit organization of more than 60,000 scientists and citizens working for practical environmental solutions.

Today, I would like to begin by briefly describing the numerous challenges—ranging from growing dependence on foreign oil to public health concerns—posed by our transportation sector. I will then focus on both the technologies available today as well as the technologies of the future that will help us meet these challenges. UCS firmly believes that technology is available today that can increase our efficiency, help protect public health and provide consumers with safe transportation. We must continue to focus on policies that will put that technology to work for us now even while we invest in the technologies of the future.

ENERGY, OIL, AND THE TRANSPORTATION SECTOR

The United States currently uses about 20 million barrels of oil each day. Two thirds of that oil is used in the transportation sector. So, for the most part, our oil problem is a transportation problem and the economic, political, environmental and health risks associated with our oil dependence are inherently linked to the amount of fuel our transportation system requires every day.

Oil Markets

As the world's largest oil consumer, the United States is particularly exposed to the risks posed by an oil market beyond our control. Reliance on the economically powerful OPEC cartel[1] and the politically unstable Persian Gulf nations will only grow over time as oil supplies dwindle. OPEC owns four-fifths of the world's remaining proven oil reserves and nations in the Persian Gulf own two-thirds (Figure 1). Only a small proportion about 2 percent of the proven reserves lies within the United States.

Economic Impacts

Importing large amounts of oil carries significant economic costs: we send more than $200,000 overseas each minute to buy foreign oil.[2] But even if we imported no oil at all, the US economy would still be vulnerable. The world oil market determines the price we pay for oil, so global price hikes affect the cost of US oil because all oil retailers (domestic and foreign) charge more. As long as the US economy is tied to oil and oil is traded globally we will be susceptible to OPEC's market power and Persian Gulf instability. To date, the economic costs of oil dependence have been tremendous, totaling $7 trillion over the past 30 years by one estimate (Greene & Tishchishyna, 2000).

The political instability of the Persian Gulf has caused three major price shocks over the past 30 years. The Iraqi invasion of Kuwait in 1990 took an estimated 4.6 million barrels per day out of the global oil supply for three months. The Iranian revolution reduced global oil supplies by 3.5 million barrels per day for six months in 1979, and the Arab oil embargo eliminated 2.6 million barrels per day for six months in 1973 (EIA, 2001b). In each of these cases, the world oil supply dropped only about 5 percent (Davis, 2001), but world oil prices doubled or tripled (Greene et al., 1998). In the wake of these oil price hikes, US inflation increased markedly, accompanied by downturns in our gross domestic product (BLS, 2001;BEA, 2001;EIA, 2001a). In each case, recession followed.

Petroleum imports also exact a toll on our international balance of trade: the $119 billion we spent on foreign oil in 2000 accounted for a fourth of that year's US trade deficit (EIA, 2001c). The situation is likely to worsen as imports increase. Today, the United States imports over half the petroleum products we use; this portion can only rise as our oil appetite grows (Figure 2).

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[1] OPEC, the Organization of Petroleum Exporting Countries, consists of Algeria, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.

[2] UCS estimate based on the Energy Information Administration's import cost figure of $119 billion in 2000 (EIA, 2001c).

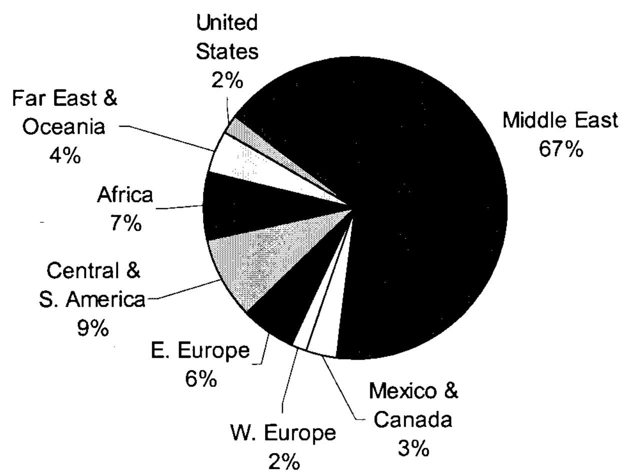

Figure 1. World Oil Reserves by Region, 2000

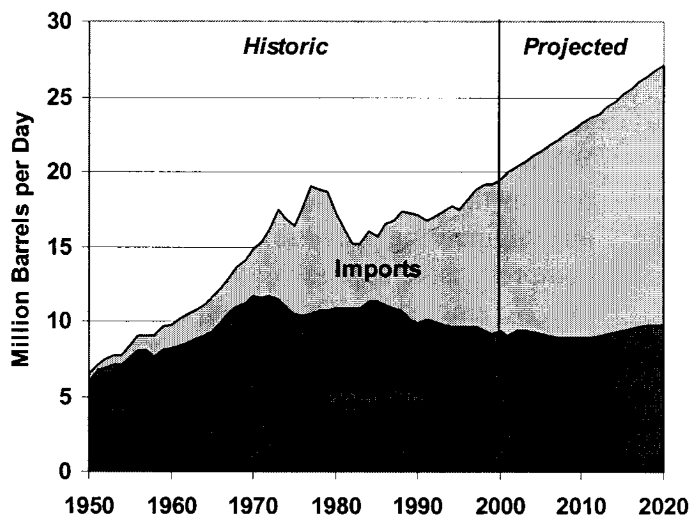

Figure 2. US Petroleum Supply, 1950–2020

Finally, consumers themselves feel a significant bite from our oil dependence. Forty percent of our daily oil consumption in 2000 (about 8 million barrels per day) went to fuel our cars and trucks, at a cost to consumers of $186 billion. By 2020, oil consumption is expected to grow by nearly 40% and consumers will be spending around $260 billion dollars per year to fuel up their cars and trucks.

Environmental Impacts

The cars and trucks we drive every day were responsible for over 20% of the global warming emissions produced by the United States during 2000: 1,450 million tons (358 million metric tons, carbon equivalent) of the heat-trapping gases linked to global warming.[3] Most of these gases will stay in the atmosphere for more than 100 years, contributing to an increase in the earth's average surface temperature. This is projected to rise 2.5 to 10.4°F (1.4 to 5.8°C) between 1990 and 2100, if no major efforts are undertaken to reduce emissions of global warming gases. As the earth continues to warm, we face a great risk that the climate will change in ways that threaten our health, our economy, our farms and forests, beaches and wetlands, and other natural habitats.

Cars and trucks are also major contributors to air pollution. Regulations have helped clean up passenger vehicles over the past three decades. However, rising demand for travel and increased vehicle ownership will outpace even the standards on the books through this decade. Cars and trucks will need to clean up their act even more if we are to eliminate the threat air pollution poses to public health especially to our children and the elderly.

Finally, producing and distributing the gasoline that went to fuel our cars and trucks in the year 2000 resulted in the emission of 848,000 tons of smog-forming pollutants and 392,000 tons of benzene-equivalent toxic chemicals, in addition to the pollutants emitted from the tailpipes of vehicles.[4] Altogether, cars and trucks are the largest single source of air pollution in most urban areas. As with US oil use and global warming emissions, upstream air pollution is expected to continue to rise significantly over the next two decades, posing the greatest health threat to children, the elderly, and other vulnerable members of our population. Gasoline and oil distribution also leads to water and ground pollution and catastrophic oil spills such as the Exxon Valdez that harm the entire ecosystem.

A COMPREHENSIVE, TECHNOLOGY BASED, PLAN TO KICK OUR OIL HABIT

While the problems of our oil dependence loom large, there is a suite of technology options that can be used to turn things around. We can take advantage of the technical and engineering prowess of U.S. industries to put these technologies to work in a comprehensive approach that can ultimately move the transportation sector away from oil. No single silver bullet can solve the problems posed by our use of cars and trucks—but if we, as a society, choose now to invest in a variety of solutions, ranging from near to long term, together they can eliminate the use of oil for transportation and at the same time address many of the other problems associated with our transportation system.

Because it will likely take most of the first half of this century to finally move ourselves off oil in the transportation sector, we must take advantage of every option that is afforded to us in that time. Conventional technologies can be put on the road over the next 10 years to stabilize oil use from cars and trucks. Hybrid technology can then begin to actually reduce that amount of oil below today's levels. Together, conventional and hybrid technology can fill the gap while the long-term hope offered by hydrogen fuel cells and alternative fuels begins to materialize.

At the same time these technologies are being put into play to address oil dependence and energy security, they offer the opportunity to address the air quality and safety problems associated with cars and trucks. The aggressive use of conventional and advanced technology can mark a return to "the age of the engineer,"[5] as Ford's

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[3] This UCS estimate is based on EIA 2000a. Each gallon of gasoline burned emits nearly 19 pounds of carbon dioxide, the primary pollutant responsible for global warming. The production and delivery of gasoline are responsible for another 5 pounds per gallon of global warming pollutants (Wang 1999).

[4] The production, refining, and delivery of each gallon of gasoline in the United States emit an estimated 6.4 grams (0.014 pounds) of smog-forming pollutants (Wang 1999). Upstream activities also release harmful toxic pollution in the air. This poses a major health hazard near refineries, along distribution routes, and at gasoline stations. For every gallon of gasoline delivered, 2.9 grams (0.0065) pounds) of benzene-equivalent toxic emissions are produced (Winebrake et al. 2000; Wang 1999).

[5] Robert B. Alexander, speech before the Management Briefing Seminars sponsored by the Michigan Chamber of Commerce and the University of Michigan (Traverse City, MI) August 4, 1977.

then Vice President of Car Product Development, Robert B. Alexander characterized the period in the late 1970's when automakers were challenged to provide consumers with more socially responsible vehicles by simultaneously improving safety, fuel economy, and emissions. The current and future levels of technology available in automobile development provide the exact same opportunity to both transform the internal combustion engine vehicles we have been driving for the past 100 years and to work on new technologies such as fuel cells and alternative fuels that offer the promise of addressing transportation problems in the longer run.

The technologies available today and those being developed for the future provide the opportunity to integrate air quality, safety, and reduced oil dependence into the regular redesign process that takes place for each car and truck model every 3-5 years. These three goals then become a complementary part of a refocused redesign process that can diminish and then ultimately kick our oil habit while also protecting public health through improved air quality, and making our highways safer. These technologies and this shift in focus are well within the abilities of our automobile and fuels industries, but will require a change in their priorities—a change that will need to be driven by clear signals from the government.

Like other investments in technology, using automotive technology to build a fleet of cleaner, safer, cars and trucks while reducing our oil dependence will be an engine for economic and job growth. For example, our analysis indicates that a reaching a fleet average of 40 mpg over the next ten years will provide consumers a net savings of more than $29 billion per year by 2015 because savings at the pump far outweigh the added vehicle costs. The money saved would be spent throughout the economy, yielding a net increase of 182,700 new jobs in areas such as the service industry, agriculture, construction, manufacturing and even 41,100 additional jobs for the US auto industry and their suppliers.

The federal government can play a key role in addressing oil dependence while simultaneously helping to make our highways safer and improving air quality. Providing a clear vision that guides technology development to meet these goals can fulfill part of this role. This vision must capture the urgency of the problems while providing realistic goals, timelines, and performance metrics. Finally, the vision needs to include rolling up our sleeves and getting this technology on the road and be backed up by the necessary policies and resources to truly address the problems that exist today.

Conventional Technology

The most effective near term approach to addressing the many problems associated with our cars and trucks is to put existing and emerging convention technology to work. These technologies can reverse the 15 year trend of declining fuel economy and dramatically improve fuel economy over the next ten years—filling a stop-gap role by keeping keep passenger vehicle oil use near today's 8 million barrels per day, rather than letting it continue to grow at unprecedented rates.

Many of the technologies that could have been used improve fuel economy while making safer and cleaner vehicles have been left on the automakers' shelves. These technologies include efficient engines that incorporate lower friction components, variable valve technology, displacement on demand, gasoline direct injection, and turbo or super-charging. Improved transmission technologies have also been developed: e.g. 6-speed automatic transmissions with aggressive lock-up control, continuously variable transmissions, and efficient "manual" transmissions that are shifted by a computer instead of by the driver. Integrated starter/generator technology that can turn off the engine instead of letting it idle have seen use in Japan and Europe and are available to US automakers. More mundane technologies can also be put to work: e.g. improved aerodynamics, lower rolling resistance tires, and electronic power steering.

Putting these technologies to work—according to our analysis and that of the National Academy of Sciences, researchers at MIT, and others—means that it is possible to make SUVs like the Ford Explorer that reach 34-35 miles to the gallon, family cars like the Ford Taurus that get up to 41-45 mpg, and full-size pickups like the Dodge Ram that can reach 30-33 mpg—all of which will have the same size, comfort, performance as consumers expect today along with the same or even improved safety (DeCicco 2001, Friedman 2001, NRC 2002, Weiss 2000). The added technologies will increase vehicle cost, but will more than pay for themselves in gasoline savings.

Another conventional engine technology that could be used to address oil dependence is diesel technology, sometimes referred to as "advanced lean burn" technology. Diesel engines offer improved efficiency and, like gasoline vehicles, rely on fuel derived from oil. In many ways, diesel is no different from the other conventional technologies that can be used to improve fuel economy and should be treated within the policy arena in the same way as the other conventional technologies listed above.

Several cautions are in order, however, on diesel:

1. Unlike the conventional technologies above, diesel makes it harder to address public health concerns regarding air quality. Current diesel technology in Europe is cleaner than past vehicles, but still produces toxic emissions and smog forming emissions that several times dirtier than the average gasoline cars and trucks under Federal Tier 2 emission requirements.
2. With added emission controls being developed by the auto industry, we expect that diesel vehicles will fall within the allowance of future US emission standards, but are unlikely to catch up with the cleanest gasoline cars. Conventional gasoline vehicles can already meet standards well below those required by current law, while diesel vehicles are expected to qualify within the dirtier emission categories under Tier 2.
3. Questions remain about whether future standards on the books are sufficient to protect public health, but even with a clean bill of health, diesel may not be as cost effective a fuel economy strategy as employing existing and emerging conventional gasoline technology.

With those cautions noted, and as long as diesel is held to the same standards as gasoline vehicles and provided with the same incentives as other conventional technology, it should still be part of the mix of conventional technologies being considered.

The main historical approach to getting conventional technologies on the road has been through fuel economy standards; which have proven quite effective—saving 43 billion gallons of gasoline in the year 2000, or a reduction of over 25%, according to recent work by the National Academy of Sciences (NRC 2002). The current effort on fuel economy is a proposal by the National Highway Traffic Safety Authority (NHTSA) to increase the fuel economy standard for light trucks by 1.5 mpg as of model year 2007, raising it from 20.7 mpg to 22.2 mpg.

While NHTSA's proposed rule would be the first increase in fuel economy standards in a decade, it is an extremely modest goal given the suite of technologies available in that timeframe and will not pose a challenge to automakers. It will also have a negligible impact on our oil use, saving less than one day's worth of oil each year between 2005 and 2008. Over that timeframe our cumulative oil use will be more than 30 billion barrels of oil compared to cumulative savings from the NHTSA proposal that amount to 0.02 to 0.06 billion barrels of oil from 2005 to 2008. Significantly more can be done with the use of conventional technology and we hope that NHTSA will take greater advantage of this in their final rule. We also hope that NHTSA or Congress will address many of the regulatory loopholes within existing fuel economy regulations that are adding to our increased oil dependence.

Additional approaches can be taken by the government to support of near term technology. Although choice is severely limited in today's car and truck market, the government can commit to purchasing the highest fuel economy car or truck that meets their needs and increasing the overall fuel economy of federal fleets. In this way the government can both provide the auto industry with a guaranteed market for vehicles that use conventional technology to improve fuel economy while also providing leadership by example. Government can also provide incentives for the purchase of cars and trucks with above average fuel economy.

Advanced Technology

More recent developments have led to a new suite of technologies that can follow on the heels of the conventional technology improvements discussed above. These include the development of hybrid electric vehicles, hydrogen fuel cell vehicles, and dedicated alternative fuel vehicles.

Hybrid Electric Vehicle Technology provides fuel economy improvements primarily during city driving, with the ability to more than double city fuel economy while providing incremental benefits on the highway. Creating a hybrid entails the use of an electric motor and battery along with a conventional internal combustion. The electric motor provides regenerative braking that recovers energy in stop and go traffic, idle off capability that turns the engine off when you would otherwise be wasting fuel at a stop light, and electric motor assist that provides the necessary boost for driving around town and accelerating onto the highway. Analysis in our recent report on hybrids indicates that a fleet of hybrid cars and trucks could reach 50 to 60 miles per gallon (Friedman, 2003). Hybrids will also provide added features that will appeal to consumers: such as improved low-end torque, smoother acceleration when using the electric motor, reduced engine and brake maintenance and added electrical capacity.

Honda and Toyota have both offered first-generation hybrid cars in the marketplace for the past few years. Ford and GM are planning to join the hybrid market with SUVs in 2004 and 2005, while Toyota is expected to offer a luxury hybrid SUV that will outperform the conventional model. Fully developed gasoline hybrid electric technology, technology that builds on the benefits of improved conventional vehicles, offers the potential to begin reducing passenger vehicle oil use below today's 8 million barrel per day level during the next decade while meeting the strictest existing Federal tailpipe emission levels, Bin 2.

Hybrids will cost more than conventional vehicles, especially in the early years when production volumes are low and automakers are unable to take advantage of economies of scale. Once sufficient production volumes are reached, automakers will be able to sell hybrids for a profit while consumers save more on gasoline than they spent for the added technology—a win/win situation. The challenge with hybrids is how to reach those economies of scale as soon as possible. Hybrids can benefit from tax credits and other financial incentives to encourage consumers to purchase the early hybrid offerings. These tax credits must incorporate emissions and fuel economy performance metrics to ensure that taxpayer dollars are spent on the most promising technology—hybrids that can provide consumers with the greatest gasoline savings and cleanest air. Without the assurance that hybrid tax credits are going to vehicles that perform better than the average vehicle on the road, such a program would run the risk of following in the footsteps of the Arizona budget crisis that was created by offering tax breaks to alternative fuel vehicles without requiring environmental performance metrics.

The goal of hybrid the tax credits would be to get the technology on the road and help familiarize consumers with a new vehicle option. Getting hybrids on the road in significant numbers also has the benefit of supporting fuel cell vehicles as they both share many of the same electric technologies. Hybrid tax credits will not guarantee oil savings or improvements in energy security, but they will help to pave the road for those benefits to be realized in the future.

As with some of the conventional technology mentioned, a note of caution is also required regarding some vehicles that may end up being labeled by some as hybrids:

1. Of specific concern are vehicles that use the 42 volt integrated starter/generator, or idle-off, technology mentioned in the conventional technology section. This is a wonderful conventional technology that can provide fuel economy improvements of more than 10%, but as noted above, hybrids provide more than just idle-off capability and the two technologies should not be confused when establishing policies and providing incentives for hybrid technology. If treated like hybrids instead of conventional technology, these idle-off systems have the potential to repeat the problems of the Arizona budget crisis on a national scale.
2. Of additional concern are vehicles that use hybrid technology to increase the weight and power of a vehicle without providing fuel economy benefits. These "muscle hybrids" represent a squandering of hybrid technology and are reminiscent of past technology trends where conventional fuel "efficiency" technology was used to make vehicles heavier instead of helping them to get better fuel economy. Policies must also recognize that the label "hybrid" does not inherently imply improved fuel economy performance.

Hydrogen Fuel Cell Vehicle Technology offers the ultimate potential of complete energy independence, dramatic reductions in greenhouse gas emissions and zero tailpipe emissions. Fuel cells combine hydrogen with oxygen in the air to produce electricity, water, and some heat. If the hydrogen is stored on-board the vehicle, no smog forming emissions, carbon dioxide or toxic pollutions are emitted from the tailpipe. Hydrogen fuel cell vehicles can also provide a smooth, quite and comfortable ride possible with electric drive technology. Fuel cells can also be used for many other things, from powering laptop computers to providing the electricity for a hospital, home or office building.

To be successful, fuel cell vehicles will rely on many of the conventional and hybrid technologies reaching the consumer market before fuel cells—therefore efforts made by automakers on conventional and hybrid vehicles will also pay off in the scope of their longer term fuel cell vehicle development. Many of the same conventional technologies that would help today's cars and trucks reach 40 miles per gallon, e.g. improve aerodynamics and reduce rolling resistance, along with the high strength materials that can make vehicles both lighter and safer, will help to fuel cell vehicles efficient and cost effective. The technology for the electric motors, batteries and electric auxiliary systems in hybrid vehicles will be used in the same roles to make fuel cell vehicles work.

Fuel cell vehicles, however, will not be ready in the same timeframe as existing conventional technologies or even hybrid vehicles. Without sufficient government support, it will probably take more than 20 years for millions of fuel cell vehicles and the necessary hydrogen fuel to be offered to consumers. It will take even longer, with business as usual, for the majority of the hydrogen to be supplied by renewable energy sources. If hydrogen fuel cell vehicles are going to be widely available in the marketplace within the next 10 to 15 years, a government program on the scale of the Apollo project will be necessary. And even with such an aggressive program, fuel cells must still be considered a long-term investment, needing to be supported by the shorter-term investments of getting conventional, hybrid and alternative fuel technology on the road.

As with the Apollo project, a similar program to support hydrogen fuel cell vehicles must have a clear development target. The engineers knew what they were shooting for: putting a man on the moon and getting them back safely by the end of the decade. That meant they needed to develop the technology to build a rocket that could put a human on the moon and then make it happen within a certain amount of time. For today's automotive engineers to know what is being asked of them on hydrogen fuel cell vehicles the parallel set of goals would be as follows: develop the technology to build a fleet of a safe, clean, efficient and cost effective hydrogen fuel cell vehicles; develop the technology to provide a clean, cost effective source of hydrogen; and then make it happen within the next 15 years. Developing the technology is not enough; a fuel cell vehicle "Apollo-like" project must also include clear vehicle production and fuel supply goals, performance targets and timelines along with the resources to make the program successful.[6]

A final note of caution regarding fuel cell and hydrogen technology: just because a fuel cell vehicle runs on hydrogen, it should not be assumed that it is clean. Hydrogen can be made from many feedstocks and is actually considered an energy carrier and not an energy source, or fuel, in and of itself. In that way, it is much like electricity; it's overall energy and environmental benefits are linked to the fuel or energy source used to make the hydrogen in the first place. For that reason it is important to that funding for hydrogen and funding for renewable energy go hand in hand. Renewable resources such as wind, solar and biomass energy will be vital in making the clean hydrogen future a reality. Cuts in renewable funding jeopardize investments in hydrogen and fuel cells.

Alternative Fuels offer the promise of 100% oil displacement, often along with significant air quality benefits. In the long term, alternative fuels based on renewable, home grown agricultural waste and dedicated crops can be one of the backbones of clean, domestic energy production—even supplying some of the hydrogen that can be used in fuel cell vehicles. In the nearer term, alternative fuels such as natural gas can serve both as an alternative to diesel in heavy duty vehicles and as a bridge to hydrogen fuel cells (both by helping to develop technology to support the use of gaseous fuels and by providing a key early feedstock for hydrogen). Alternative fuel support can also help domestic industries that provide fuel options that can move us off of oil.

Much like hybrids, one of the hurdles alternative fuels face is their high cost in low volume production along with the initial costs of building the necessary infrastructure. And again, much like hybrids, tax credits for alternative fuel vehicles, fuel, and infrastructure can help to build the necessary economies of scale. Many other incentive programs are also possible, though clear enforcement mechanisms are vital to their success.

It is important, also, to recognize some of the technical limitations associated with some alternative fuel approaches. Vehicles that could run on an alternative fuel are not providing energy security or environmental benefits if they are actually being run on gasoline or diesel, both of which are clearly derived from oil and are not alternative fuels. Thus targeting any incentives to directly encourage and reward alternative fuel use can both help to ensure growing markets for the alternative fuels and provide the associated benefits.

CONCLUSION

The United States has a history putting technology to work in solving many of the problems around us. We developed mass-production, computers, the Internet, and we put several people on the moon. We now have the technology to put people into cars and trucks that don't guzzle so much gas and can further develop the technology to put them in cars and trucks that don't use gasoline at all.

As an engineer, I see the broad array of available technology as an opportunity to roll up our sleeves and get to work making vehicles safer, cleaner and less de-

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[6] For reference, President Kennedy asked for $531 million in fiscal year 1962 alone to support the Apollo program, today that would be equivalent to more than 3 billion dollars in the FY 2004 budget.

pendent on oil while saving consumers money and creating new jobs. We can rely on existing conventional technology over the next ten years to take advantage of this opportunity. At the same time, we can make investments in hybrid vehicles, alternative fuels, and hydrogen fuel and fuel cell vehicles to take advantage of the longer-term opportunities. Because these conventional and advanced technologies compliment each other, it is not an either/or proposition. And because our need for safe vehicles, clean air and increased energy security is so important and immediate we cannot afford to these technologies and the opportunities they represent slip through our fingers. The Federal Government has a key role to play in developing sound policies to ensure that we take advantage of these opportunities.

Thank you for the opportunity to testify before the Committee today. I would be happy to answer any questions you may have.

Senator THOMAS. We have a vote that has just begun. But I believe we will go ahead, Mr. Cromwell. If you will do your testimony, then we will take a brief recess while we run over and do our duty.

So, Mr. Cromwell, please.

STATEMENT OF RICHARD CROMWELL III, GENERAL MANAGER AND CEO, SUNLINE TRANSIT AGENCY

Mr. CROMWELL. Thank you, Mr. Chairman and members of the committee. I appreciate this opportunity to discuss the use of clean energy in the transportation sector. It is something we live and breathe on a daily basis.

Sunline Transit Agency is the only transit operator in the country to generate hydrogen onsite and use it in three fuel cell buses. Ours is a small system located in a rural area known as the Coachella Valley or Palm Springs Desert Resorts. You may know it as the "Playground of the Presidents" or the "Golf Capital of The World." Those slogans have a great deal to do with why we became clean air champions.

We wholeheartedly support the President's commitment to hydrogen technologies. However, we are encountering significant challenges as we move forward. And we respectfully request your help. We know from experience it will take years of refinement before heavy-duty fuel cell engines can withstand 19-hour-a-day/7-day-a-week transit use. We need committed long-term funding for the continued development of fuel cell buses. Without it, the United States will lose this important industry to an international market that appears more ready to support it. We are currently being outspent by hundreds of millions of dollars by programs in Japan, Europe, China, and others.

Because fuel cell technology is not ready for commercialization, we urge you to endorse the Clear Act incentives for development of natural gas vehicles and the development of natural gas infrastructure. Methane is the key bridge fuel to a hydrogen economy.

We also support incentives for fuel efficiency and the use of other alternative fuels. We believe there are many paths to reduce oil consumption. And America needs to ambitiously pursue them all. This is not the time to limit options. It is the time to open doors to innovation. And it is absolutely critical from our standpoint as we urge you to support early adopters of new advanced vehicle technologies.

Regardless of whether you use natural gas, hybrids, or hydrogen, those of us who take the risk and make the investment to purchase cleaner new technologies and improve our energy and secure air quality are often left with the most expensive version of the least reliable technology. We need ongoing support to upgrade when improvements become available.

People often ask us how Sunline started down the clean air/fuel path. The answer is simple. Eleven years ago, our board of directors, all elected officials, passed a resolution mandating the use of alternative fuels. Their decision was motivated by commitment to clean air, public health, a vibrant tourism economy, and a desire to reduce oil imports.

For nearly 10 years, we operated our public transit, para-transit, and regional street sweeping fleets 100 percent on clean-burning alternative fuels. We currently operate vehicles on natural gas, hydrogen, and blended fuels. We created what we call the Nation's first clean fuels mall. Our fuels are available to the public 24 hours a day. We have over 25 million miles of experience on alternative fuels, mostly natural gas. And we know what works and why.

We have created what we consider a highly reputable model, where public transit service has a regional clean air catalyst. We were able to build seven public access natural gas stations by launching a public-private partnership with Energy, the largest builder/operator of public natural gas stations.

We have also built and are operating an outside public access hydrogen station. By taking the lead in the Coachella Valley's Clean Cities Program and helping other fleet operators take advantage of incentives, we have been able to deploy over 1,000 AFVs in our public and private fleets. Our approach has always been to remove barriers to the use of alternative fuels. And we stress training, public education, and top-down commitment.

Because of our expertise, we have hosted visitors from 30 countries and dozens of transit properties from all over the United States. We believe problems encountered by fleet operators who are switching to alternative fuels can almost always be resolved by better training.

May I leave you with these thoughts to best support the President's plan? We need to build a program under the Federal Transit Administration with committed funding for fuel cell development that runs concurrent with the Department of Energy's FreedomCAR and Hydrogen Fuel Incentives; address and remove the barriers to utilize hydrogen, such as clarifying codes and standards; improve opportunities for public education, technician training, and technology transfer; and provide tax and other incentives that will help transition the market to alternative fuels in advanced vehicle and station technologies.

The private sector has invested billions of dollars in hydrogen vehicle and related technologies. At the present time, none of these efforts have generated a profit. And my background tells me nothing happens until something sells. We feel incentives are needed to motivate consumers to buy the clean vehicles that are already on the market today and encourage infrastructure developers to keep on building.

While we have faith that our technology partners will be successful in bringing down costs and improving reliability, we believe government must ensure sustained support to encourage the private sector to continue investing.

I invite all of you to visit us in Thousand Palms and see for yourselves what today's model for tomorrow's world looks like in a working environment.

Thank you again for the opportunity.

Senator THOMAS. Thank you.

[The prepared statement of Mr. Cromwell follows:]

PREPARED STATEMENT OF RICHARD CROMWELL III, GENERAL MANAGER & CEO, SUNLINE TRANSIT AGENCY

Why Do We Need To Change Direction?

We must transform the way we power our transportation sector:

1. Globally, transportation generates approximately 1/3 of all greenhouse gases. In California (because of a relatively clean power mix), the transportation sector generates more than 1/2 of the state's greenhouse gases.
2. Mobile sources generate more than 2/3rds of the air quality and resulting public health problems in our nation's urban areas.
3. America's dependence on foreign oil puts our security and economy at risk.

How Do We Get To Where We Are Going?

SunLine Transit Agency recognized the above issues 10 years ago. We also recognized the potential of natural gas to address the issues, and our experience has been highly successful. There are two sides to the energy sustainability issue. One is technology and the other is infrastructure/public awareness. Because hydrogen technology is still in development, the most prudent public policy path is through fuel cell buses—where the public can see the technology up close, ride the bus and be among the influence-makers.

SunLine Transit Agency is now working on the next energy source—hydrogen. In fact, we would offer that SunLine Transit Agency has more experience with fuel cells and hydrogen than any transit property in the country. However, it is important to note that fuel cell technology is still in the prototype phase and not yet ready for the street. The President announced two important programs: The Freedom Car and the Freedom Fuel Initiatives. These programs seek to develop the fuel cell industry by focusing on the passenger car market. What the initiatives lack is a fuel cell bus component.

What's The Direct Route?

The Europeans have a major fuel cell bus program underway that addresses real world factors such as:

- The lack of current hydrogen refueling network is not a problem for buses. They operate on fixed routes and return to centralized refueling stations.
- Transit districts have highly trained technicians and mechanics who are more adept at handling advanced technologies.
- Transit buses don't have the same packaging and weight constraints as passenger cars.
- Buses can be used as mobile classrooms and are a great way to educate people about new fuel technologies.

Who's Coming Along For The Ride?

SunLine Transit Agency, along with WestStart-CALSTART, the Northeast Advanced Vehicle Consortium and many other partners, is seeking $25 million per year in the reauthorization of TEA-21 for the development and demonstration of fuel cell bus technology. We do not advocate creating a whole new program. In fact, we are asking that the Department of Transportation's existing Advanced Vehicle Program be modified to focus exclusively on the development of fuel cell buses. Such funding would be used to make fuel cell buses commercially viable over the six-year life of the next TEA bill.

Changing the way we power our country is no simple task. We need multiple approaches involving multiple federal agencies.

What Are The Key Destinations in our Journey?

Public/Private Partnerships:

Government takes the lead by building programs that build demand. The private sector takes the lead by satisfying market demand.

Education:

Training is key to SunLine's success in alternate fuels usage. Technical skills enhance the role of the mechanic. Targeted engineering skills will be needed for future business models. When expertise leads to implementation, technologies flourish.

Outreach:

If we are to achieve the President's goal of having children born today driving fuel cell cars on their 16th birthdays, we need to get the message out now that there are clean air alternatives. Children are consumers. We should be nurturing their lack of fear of adopting new technologies.

Public Will & Responsibility of Elected Officials:

All government is local. Enlightened public policy happens in transit boardrooms across the country. Freedom to move from one place to another and clean air to breathe are compelling local issues that can drive policy discussions at every level.

The Challenge of Market Limiters

Multi-Year Funding

Technology does not move from the lab to the street in one generation. Industry and policy leaders must commit to a "Path of Continuous Improvement." That requires sustained field testing of multiple generations of equipment. As a rule, grantors don't favor multi-year projects and appropriators like to spread funds around.

Supporting the Early Adopter

Given the lack of support for multi-year funding, those of us who adopt new programs and technologies early are taking a disproportionate risk for the potential rewards available. We support the establishment of a set of criteria to designate proven early adopters for multi-year projects while mandating them to share the expertise they develop with affiliated agencies.

Enforcing Fleet Rule Standards

EPAct: Federal agencies are not being closely monitored by the DOE to determine if they are spending the dollars they were directed to spend on alternate fuel vehicle fleets. As a result, the conversion rate, which was intended to be at 10%, has reached only 3.6%, according to the GAO. At the very least, we would advocate for more publicity for the agencies that do comply.

Fleets that comply by way of the flex fuels program have absolutely no impact on clean air goals as long as E85 remains largely unavailable and vehicles are allowed to run on petroleum. If you go back another step to the CAFE standards, you add insult to injury when both the manufacturer AND the end user get credits for vehicles that do not meet clean air standards. The fleet average requirement has remained the same over the past ten years while technology has improved dramatically. The current standard is weak.

Clean Cities

During the same ten-year period mentioned above, great strides in fleet conversion have been made through the DOE's Clean Cities Program via realistic incentives and effective public outreach. And yet, the program is facing widespread budget cuts at a time when significant progress is being made. The program's assigned 2010 goals of having one million AFVs operating exclusively on alternative fuels and one billion gasoline equivalents per year used by AFVs is now in jeopardy. The perceived message this budget reduction conveys to supporters seems in conflict with the recent administrative directives broadcast from The White House.

> Tonight I am proposing $1.2 billion in research funding so that America can lead the world in developing clean, hydrogen-powered automobiles. Join me in this important innovation to make our air significantly cleaner, and our country much less dependent on foreign sources of energy.
>
> —President George W. Bush, State of the Union Address, January 28, 2003

The President's call to reverse America's growing dependence on foreign oil harkens to the decision SunLine Transit Agency's board of directors made in 1994. That was the year SunLine became the first transit agency in the world to park all of its diesel buses and switch overnight to a fleet powered 100% by clean-burning compressed natural gas (CNG).

Since 1999, SunLine Transit Agency has worked with the U.S. Department of Energy (DOE), U.S. Department of Defense (DOD), and the U.S. Department of Transportation (DOT) to develop and test hydrogen infrastructure, fuel cell buses, a heavy-duty fuel cell truck, a fuel cell neighborhood electric vehicle, fuel cell golf carts and internal combustion engine buses operating on a mixture of hydrogen and compressed natural gas (CNG).

Visitors to SunLine's Clean Fuels Mall from around the world have included government delegations and agencies, international journalists and media, industry leaders and experts and environmental and educational groups.

Three years ago the DOE established a hydrogen infrastructure in Southern California at SunLine Transit Agency in Thousand Palms, California.

The investment made by the DOE has yielded significant benefits. Not only was the project constructed as scheduled, but it has surpassed the original goals under SunLine's Best Test Center for Alternate Energy Technologies to become part of SunLine's daily operations and maintenance activities. In other words—our "rolling laboratory" has taken the technology out of the science lab and into the real world.

One of the project's significant objectives was to educate the public on the safety and reliability of fuel cell vehicles. By demonstrating fuel cell bus service using compressed hydrogen in a normal transit operation, officials and riders alike got to experience for themselves the pollution-free transportation technology of the future. Another objective was to show the potential to other transit operators for using a liquid fuel reformed to hydrogen in fuel cell buses.

SunLine worked with College of the Desert and other partners to develop the first training manual for hydrogen fuel cells and related technologies. The curriculum, funded in part by the Federal Transit Administration and the Department of Defense, is set to be delivered to students at College of the Desert and other community colleges throughout the state through the California Community Colleges' EdNet initiative.

Other than cost, SunLine's track record of experience has identified several challenges to hydrogen commercialization:

- The need to improve fuel cell reliability
- The need to engage the insurance industry in over-coming liability issues
- The establishment of reasonable codes and standards
- The implementation of comprehensive hydrogen education and outreach programs to elevate public awareness to mainstream levels

Hydrogen technology will one day help solve pollution and resource consumption problems. It offers a clean, safe, reliable and domestically produced source of fuel. Hydrogen fuel cell vehicles can replace those powered by hydrocarbon-based internal combustion engines (which emit greenhouse and smog-producing gases). Further environmental benefits can be realized when the hydrogen is generated using renewable resources, such as solar and wind. The result is a clean fuel that can be used to supply public and private transportation vehicles that emit only water.

SunLine has effectively demonstrated the need for a path of continuous improvement. Investments in fuel cell technology should be made on a measured basis of how they contribute to the global body of knowledge. While it is important to test and demonstrate the technology, it is also important to invest wisely. Finite resources should be devoted to those organizations and programs that have demonstrated a passion to make things work, the policies and political will to further hydrogen and fuel cell development and the capability to perform technology transfer to future organizations.

Selective investment is a must.

Sunline Fleet Vehicles Operate on Clean-Burning Alternate Fuels

Since November 2000, SunLine has utilized hydrogen generated on-site to fuel vehicles including:

- Two Hythane® buses (which use 80% CNG/20% hydrogen)
- The Ballard/XCELLSIS ZEbus (zero-emission fuel cell bus)
- The ThunderPower hybrid electric fuel cell bus
- The nation's first street-legal hydrogen fuel cell mini-car (SunBug)
- Three hydrogen fuel cell powered golf carts
- Pickup powered by a hydrogen powered internal combustion engine
- Over five passenger vehicles brought by automobile manufacturers for testing in the Coachella Valley
- Hydrogen Internal Combustion Engine Shelby Cobra.

SunLine built and operates the world's first Clean Fuels Mall where compressed natural gas, liquefied natural gas, hydrogen and Hythane® are available to the public 24 hours a day. Additionally, global shoppers for electrolyzers, reformers and other equipment that generates, stores and dispenses alternative fuels can visit SunLine to see prototype and product-development units in operation. SunLine has worked with the equipment manufacturers to develop educational displays throughout its facilities.

SunLine has produced an educational video series entitled "Energy Matters." Thirteen, two-minute videos distributed to PBS stations in major California markets cover such topics as alternative fuels, electricity and the grid, fuel cells, micro-turbines and new car technologies. The videos are also available to teachers and administrators for use in classrooms. SunLine has worked with the South Coast Air Quality Management District to develop a workbook for middle school children that corresponds to the video series.

A significant objective of the XCELLSiS Phase 4 Program was to educate the public on the safety and reliability of fuel cell vehicles. The ZEbus provided officials and riders alike with an opportunity to experience the pollution-free transportation technology of the future. The objective of the ThunderPower Program is to demonstrate fuel cell bus operations in normal transit operations. The significance of the Georgetown Bus Program is to demonstrate the capability of a liquid fuel cell bus to other potential transit agencies.

Senator THOMAS. Thank you all very much. We will recess. We will be back shortly. I hope you will all stay for the excitement of the question period.

[Recess.]

STATEMENT OF HON. LAMAR ALEXANDER, U.S. SENATOR FROM TENNESSEE

Senator ALEXANDER [presiding]. Could we come back to order?

I am an apprentice chairman today. Senator Bingaman is going to watch to make sure I do this correctly. He has done it for many years, and I am new.

I want to thank all of you for coming. Other Senators should be coming back as the vote concludes. We will go ahead, if we may. I will make a short statement. And then I have a couple questions. And then I will ask Senator Bingaman if he has questions, and then we will go from there.

I am very pleased with the President's bold initiative on the hydrogen car, because it takes an issue of energy and our dependence on foreign oil and gives us a way to talk about it. It does a lot of things, but that is one thing it does. The American people have lots of things to think about. And energy as a subject always seems abstract. It is not very abstract today, though. And talking about the future and about the hydrogen car gives us a way, it seems to me, to address most of the components that help make up a comprehensive energy policy.

We have to talk about generation. We have to talk about use. We have to talk about regulation. We have to talk about transmission. We have to talk about research and development and who has the allocation of resources to do all those various things. So I welcome that discussion.

And it also puts it in a very practical sense to me, just as I think of our own State, as we think about the hydrogen car and the future and the kinds of questions that we need to consider in terms of that and any other form of alternative transportation and other forms of alternative fuel. It affects the kind of investments that Nissan and Saturn and 900 auto parts suppliers make just in our State.

It affects TVA's decision to go ahead with a new nuclear powerplant, whether that is a wise thing to do or not. It could bear on the priorities of the largest energy laboratory at Oak Ridge and on investments and priorities at our large research universities, like the University of Tennessee and Vanderbilt. It affects a company like Eastman, which has had coal gasification for 25 years to provide its own fuel and is deciding what to do in the future, in terms of whether to invest dollars in that.

It affects whether the Great Smokey Mountains are better named the Great Smoggy Mountains, because a lot of that problem comes from emissions. And we find Knoxville and Nashville both with air pollution problems.

So the hydrogen car or other alternatives and all the questions that surround it help us to have a way to have a national conversation about a comprehensive energy policy. And that is one of the great byproducts of the President's bold discussion.

I am chairman of the Energy Subcommittee. And in thinking of ways to have that committee make its most useful contributions, I have talked with the chairman and look forward to talking with Senator Bingaman and others about how that subcommittee might focus on the hydrogen car proposal and other sorts of proposals as a way of advancing that bold idea and maybe do that in a continuous way over the next year or two years. So I look forward to that opportunity.

Now let me ask a couple of questions. I hope I do not plow too much ground that you already plowed in the first hour before the vote. But let me ask this question. And, Mr. Garman, I will start with asking you to answer it. But if others would like to then comment, I would appreciate your comments.

Taking the President's hydrogen car idea puts up front immediately questions about "What is the best source of hydrogen long term? And what are the biggest obstacles?" So let me ask you: Taking three long-term sources of hydrogen, what are the biggest obstacles to their use? One is natural gas, one is coal, and one is nuclear. And I suppose I should say as a fourth, biomass and other such fuels. I do not want to leave out solar and wind. I know they are important in the shorter term. But I am looking longer term, especially on the familiar.

So let us start with natural gas, coal, and nuclear. What are the biggest obstacles to those as a source of hydrogen? What are the problems we have to solve if we want to consider those?

Mr. GARMAN. Well, as you have pointed out, one of the great benefits of hydrogen is that it can be produced from a variety of feed stocks. In going through each of those, natural gas is actually the producer of most of the hydrogen that is produced today. Approximately 9 million metric tons, I believe, are produced almost exclusively from natural gas.

It is a well-known process. It is a steam reformation process. It is an excellent near-term approach because, as we think about the very first filling stations, and those that we actually have in place today, some of those use natural gas and reform the natural gas and make hydrogen at the site—at the filling station. And that eliminates the need for hydrogen pipelines in the near term.

One of the biggest impediments, of course, is assurance of long-term natural gas supply. With natural gas prices that we have today, we need to be a little concerned about putting all of our hydrogen eggs, if you will, in the natural gas basket. We want to make sure——

Senator ALEXANDER. So supply and price.

Mr. GARMAN. Supply and price is a concern there. Right now, it has a price advantage. If you do have $4 natural gas, we believe that by 2010 we will be able to produce hydrogen at a gas station for $1.50 per gallon of gas equivalent untaxed, which makes it very competitive with gasoline. And when you add the efficiency, inherent efficiency, of fuel cells, you actually get—it is a great deal for the consumer.

The challenge for coal is going to be whether or not we can develop effective carbon capture and sequestration technology. It does not do us much good on the carbon side of the equation if all we are doing is making hydrogen from coal, which we can do. We know how to gasify coal and make a hydrogen-rich gas, split that off and use that hydrogen. But if we cannot capture the carbon dioxide and permanently sequester it so it is not released to the atmosphere, then, again, the environmental advantages of the President's plan do not really come to fruition. So we are not interested in that.

Nuclear could be a superb way to make hydrogen. Of course, the impediments are political and public acceptance more than anything else. There are a couple of different ways you can make hydrogen with nuclear. You can make it through direct electrolysis, or through a thermochemical water splitting process using the heat of the nuclear reaction.

Biomass represents an excellent long-term method of making hydrogen. You would similarly gasify the biomass into a hydrogen-rich gas. That is carbon neutral. So that is a very positive prospect. I guess the biggest impediment on biomass is economically collecting agricultural residues, bringing them together, and producing the hydrogen.

Senator ALEXANDER. And let us finish up with wind or solar——

Mr. GARMAN. Wind or solar——

Senator ALEXANDER [continuing]. The impediments to those.

Mr. GARMAN. Solar is cost. Solar electricity costs around 25 cents a kilowatt hour today from photovoltaics. If you were to take that electrolyzed water, that would be a very expensive process. But it can be done. Sunline does it at their facility.

Wind, we have a lot of wind capacity in areas of the country. Again, it is coming in at 4 to 6 cents a kilowatt hour. You could use that electricity to electrolyze water and produce hydrogen in that method. But then you would have to get it to the sources of demand, the population and load centers.

Senator ALEXANDER. For transmission.

Mr. GARMAN. For transmission. So that brings up images of a lot of pipelines and infrastructure.

Senator ALEXANDER. Thank you, Mr. Garman. That is such a complete answer, that took up our entire——

[Laughter.]

Senator ALEXANDER. No, no. That is good. That is a good answer. But I think it is time to ask Senator Bingaman if he has questions.

Senator BINGAMAN. Well, thank you very much. You raise a very interesting set of questions. Let me put up a chart and ask maybe a few follow-on questions.

There is a report that was done by General Motors, Argonne National Lab, BP, ExxonMobil, and Shell. It came out in June 2001. I am sure you have seen that, called Well to Wheel Energy Use. I think it is a good report because what it does is it gets us away from just talking in terms of how great it would be to have a vehicle where you stick hydrogen in one end and it runs down the road and out the other end. If anything comes out, it is just water vapor or something. And it talks about the real energy requirements.

This is a chart from that study that I have put up on the board here. And it shows energy required to deliver one million Btus to a vehicle or to vehicles. Several of the points you were making, I think, Mr. Garman, seem to be much less efficient, I mean, as far as energy use. The suggestion that, for example, we use electrolysis at a station in order to produce hydrogen—that is the very tall red line there, the third from the right in this chart, I think. It shows that you have to use over two-and-a-half million Btus of energy in order to get one million Btus to a vehicle, if you do it that way.

I do not know if that is a reason not to do it that way, but it seems to me to be at least something we ought to think seriously about before we start down that road. So if the theory is we are going to use nuclear power or we are going to use wind power or we are going to use any—you referred in your opening statement to our desire to become a petroleum—to find a petroleum-free option. If we are really going to do that, then we are not looking at using natural gas. We are not looking at using diesel. We are looking at one of these other options, which seem to me to have some major drawbacks.

Do you agree with that analysis? Do you disagree with it?

Mr. GARMAN. Well, what this chart is not conveying is the inherent efficiency of the fuel cell vehicles. This is just conveying what is required to deliver the energy equivalent to the vehicles. We have done very similar well-to-wheels analysis. And when you consider the fact that the fuel cell vehicle, the hydrogen fuel cell vehicle, is two-and-a-half times more efficient, it will actually get two-and-a-half times more work out of that energy than the gasoline vehicle will, and——

Senator BINGAMAN. Let me show you another chart that directly relates to that.

Mr. GARMAN. I looked ahead to your next chart. So I knew this was coming.

Senator BINGAMAN. Okay. The next chart is also from the same study. And it tries to take into account and give credit for the efficiency of the fuel cell itself. And it still—do we have a copy of these we could give to the folks here? Senator Alexander, as well?

It tries to make the same analysis and basically concludes that, as I read the chart, that a diesel hybrid is more efficient in the Btus per mile than the fuel cell, when you go from the well to the wheel, as they are trying to in this analysis. Do you agree with that?

Mr. GARMAN. No, sir, I do not. Our well-to-wheel analysis showed that the final total well-to-wheel efficiency of a diesel hybrid electric is 18 percent. A compressed hydrogen, natural gas, steam reformed fuel cell vehicle is 22 percent. And to break that down, our diesel fuel chain efficiency is 84 percent. You multiply that by the vehicle efficiency, which is 22 percent. And that gives you the 18 percent final efficiency for the diesel-hybrid electric fuel vehicle.

And for the natural gas vehicle, we have a lower fuel chain efficiency of only 60 percent compared to the 84 percent of the diesel, but a higher vehicle efficiency, 37 percent compared to 22, which gives you a final wheel-to-wells efficiency of 22 percent, which is higher than the diesel.

Senator BINGAMAN. But now you are saying that we are going to spend the next 20 years researching this in order to get a four-percent improvement in efficiency?

Mr. GARMAN. That is a quite remarkable amount of efficiency. And just to illustrate it, if I have a fuel cell vehicle, and even if I use natural gas, and even if I do not sequester any carbon from the natural gas, and even if I account for all of the energy inputs needed to compress the natural gas and reform it at the station into hydrogen, my vehicles will be twice as efficient as gasoline vehicles, and I will have 60 percent fewer carbon emissions compared to the gasoline vehicles. So it is an excellent proposition over the next 20 years.

Senator BINGAMAN. Now on the emissions issue, I have another chart from the same study.

Mr. GARMAN. I have run out of charts, Mr. Chairman, so I know who is going to win this.

[Laughter.]

Senator BINGAMAN. These are all from the same study. And I just know these are credible organizations that did this study. And one of them is your own Department of Energy.

And this shows emissions, total system greenhouse gas emissions, grams of carbon equivalent per mile. It looks to me like if we wanted to—the way I read this, ethanol is by far the best on emissions. Hydrogen from natural gas is second. But that is not one of the—that is not what you are working on. That is not a petroleum-free option, as you are trying to get to.

Mr. GARMAN. Hydrogen from natural gas is a short-term option. Over the long term, a fossil option that has carbon sequestration would also be a zero carbon emission proposition.

Senator BINGAMAN. Well, let me ask about the carbon sequestration from coal that you are talking about. In this study, they analyzed—and I think Exxon owns some coal. That has been my impression. And they analyzed 75 different pathways, fuel pathways, to get to this hydrogen, new world of hydrogen. And they did not analyze using coal. They obviously think that there are some problems in using coal and getting the emissions problems of coal dealt with. Now, you acknowledge that there are serious problems.

Mr. GARMAN. Yes, sir.

Senator BINGAMAN. But do you really think that it is worth running down that rabbit patch, or—what is the phrase that Senator Gramm used to use around here?

Mr. GARMAN. I think that sequestration is a very important technology that we cannot deny, particularly when we are talking about carbon, which, of course, global emissions of carbon is really what we care about. We do not only care about what we are emitting here in the United States; we also care about what China and other nations are emitting.

And this kind of technology, were we to perfect it, would be very important in ensuring that China and India and other nations could participate in the effort to reduce carbon emissions. I think China is mining about one billion metric tons of coal a year. They plan to continue. And I think it is in all of our interests to develop the technologies that can be successful.

Now, it is difficult. I will grant you. It is extremely difficult to capture carbon from a waste stream, separate it from the flue gas, sequester it in a way where you have confidence that it is going to stay where you put it. And that is really what the President's FutureGen Initiative announced just last week is all about.

Senator BINGAMAN. Mr. Chairman, I will wait for another round in order to ask a few of the other witnesses these same types of questions. Thank you.

Senator ALEXANDER. Senator Bunning.

Senator BUNNING. Yes. Thank you, Mr. Chairman. I have an opening statement. I am not going to read it. I would like to submit it for the record.

Senator ALEXANDER. It will be done.

Senator BUNNING. Thank you.

[The prepared statement of Senator Bunning follows:]

PREPARED STATEMENT OF HON. JIM BUNNING, U.S. SENATOR FROM KENTUCKY

Thank you, Mr. Chairman.

Examining our energy use in transportation is important as we look to developing a new energy policy in this country.

Low cost transportation is a major way that we have kept our economy from becoming worse than it already has been. Low cost transportation enables people to spend money on other goods and enables companies to keep product costs down.

Today, our main source of energy use are petroleum products.

In 2001, we used 8.6 million barrels of motor gasoline per day, which is 44 percent of all of our petroleum consumption. In fifteen years, we are expected to use over 20 percent of the world's energy on transportation.

Obviously these statistics cause some concern as we are facing a tight reserve of oil and a high possibility of a war with Iraq.

I am looking forward to hearing about the feasibility of using advanced technologies and alternative fuels in transportation. We must keep in mind, however, that these alternative technologies and fuels must be both economical and practical for consumers to use.

I appreciate the time the witnesses have taken to come here today and testify on this issue.

Thank you.

Senator BUNNING. I do not know if you were here last week. I do not think you were. But we heard last week at a hearing that we have an emerging natural gas crisis. I would say it was worse than emerging, actually. In fact, I think it is here, if we are paying $10 per million Btus. Actually, it is about $7 right now.

The spot market, it got to $30 within the last 2 weeks. So I think that as record high reserves are being withdrawn from underground storage during this winter's heating season, there is a severe mismatch between supply and demand for natural gas. We enticed an awful lot of electric producers to use natural gas turbines to produce electricity.

On the other hand, the United States has over 250 years of a coal reserve. And technology is currently being developed to produce hydrogen from coal. There are specific programs and technologies that I can show you. And I know you, at the Department, have been shown them. Is DOE seriously considering coal as a fuel source for developing hydrogen, or not?

Mr. GARMAN. Yes, sir, it is. And last week's announcement by Secretary Abraham of the FutureGen Project Initiative, which is a project to develop both electricity and hydrogen from coal with no emissions——

Senator BUNNING. Do you think sufficient funds are being allocated to hydrogen from coal projects to allow for those projects to compete with other potential sources, such as natural gas, other renewables like Senator——

Mr. GARMAN. I know that $1 billion is projected from Federal funds and anticipated industry cost share over the next 10 or so years.

Senator BUNNING. Do you think that is sufficient to deal with the possible problems we will have extracting the hydrogen out of the coal?

Mr. GARMAN. It is difficult for me to make that judgment. I work mainly in energy efficiency and renewable energy, but I am working more closely with our fossil colleagues in the Department, as we have tried to align our posture on hydrogen. And I would like to take that question back to some fossil folks.

Senator BUNNING. I would appreciate that very much. And to get a written reply, I would appreciate that, also.

Mr. GARMAN. Yes, sir.

[The following information was received for the record:]

COAL FROM HYDROGEN PROJECTS

As part of the President's Hydrogen Initiative, the Office of Fossil Energy has been provided five million dollars of Fiscal Year 2004 funding to start a new research activity for developing advanced coal-to-hydrogen technology. This level of funding is believed to be sufficient to support the initial phases of a new program and is consistent with milestones established for the early phases of the R&D activity. During the planning of this research and development activity it has been determined that the effort should encompass a technology envelope that begins with the separation of hydrogen from mixed coal-derived gas (i.e., synthesis gas) streams and conclude at the interface between the hydrogen supply system and the utilization device or storage unit. Within this technology envelope there are two possible processing options that are considered in the production and delivery of hydrogen from these mixed gases. In the first option, advanced technologies will be developed to more effectively and economically separate and store the hydrogen in gaseous form. In the second option, advanced synthesis gas conversion processes would be used to produce zero-sulfur, high-hydrogen content, coal-derived liquids. These liquids would be transported to the consumer in existing systems and reformed to produce the hydrogen at the distribution center. The current program includes plans for the development of the innovative technology needed to support either option. A schedule for the Hydrogen-From-Coal Program has been prepared that will achieve technology development milestones consistent with the current projected need for the advanced concepts. A re-evaluation of the goals and funding of the Hydrogen-From-Coal program may be required once the schedule and demands for innovative technology needed to support other associated initiatives (e.g., FreedomCar, FutureGen) are established.

Senator BUNNING. You just mentioned the President's FutureGen Initiative providing almost $1 billion for research and development of coal technologies, including uses for hydrogen, and that the President's Hydrogen Fuel Initiative and FreedomCAR Initiative will provide nearly $1.7 billion for development hydrogen fuel cells. In the Hydrogen Fuel Initiative and FreedomCAR Initiative, will the DOE focus on coal as a use for the hydrogen?

Mr. GARMAN. We will focus on coal as a way to produce hydrogen. Again, one of the——

Senator BUNNING. But, I mean, you mentioned four others, natural gas being one. If we have a short supply of natural gas, and that is the easiest of all the things to produce hydrogen from, and we can convert that right almost at the pump, would it not be kind of foolish to develop it, if we do not know we are going to continue to have the source of natural gas in the future and the supply being used for other things?

Mr. GARMAN. One of the things that we do to hedge against that is to have a diversified technology portfolio, where we are exploring making hydrogen from coal, hydrogen from renewables, hydrogen from natural gas, and hydrogen from biomass. We want to make sure we are looking at all the possibilities because, again, that is one of the great benefits of hydrogen, is that you have a great deal of flexibility.

Senator BUNNING. You mentioned China, I did note, about the amount of coal they are using. And do you not think they also are looking at alternative fuels, too?

Mr. GARMAN. Yes, sir.

Senator BUNNING. So would not they be—if they are mining that much coal, would they not be also trying to extract hydrogen from that same coal?

Mr. GARMAN. Yes, sir. And the Chinese have approached us, and we are under discussions with them on some collaborative work, so that we can work together on some of these problems.

Senator BUNNING. Well, since we do have a large supply, not only in Kentucky but other places, of fossil fuel and coal, I suggest that we look to make it clean and be able to do something with the extraction of the hydrogen, along with the carbon, and make sure that we can dispose of the carbon, so we do not have any carbon residues being used in any kind of fuel.

And I urge the Department to make use of the $2.7 billion that has been put into the President's program. And I appreciate your answers. Thank you very much.

Mr. GARMAN. Thank you, Senator.

Senator ALEXANDER. Senator Dorgan.

Senator DORGAN. Mr. Chairman, thank you.

Because we did not give opening statements, let me make a couple of comments and then ask a couple of questions. First of all, I appreciate the statements that all of you have given today. I think it is helpful.

I seldom disagree with my colleague from New Mexico, Senator Bingaman, and I guess I do not necessarily disagree when he says let us talk about the near term, and the short term, or immediate. We cannot just focus on the intermediate and longer term. We do have short-term issues. So I agree with that. But I also think, and he probably agrees, if that is all that we do, we lose.

Every 10, 15, or 20 years, we have an energy debate in the Congress. This one will last actually 4 or 5 years, this single debate, because we did not get a bill done in the last Congress. It is a repeat every time we have this debate. It is like the movie "Groundhog Day." You just wake up, and you do it again. And 20 years later, you do it again.

I think it is important for us, instead of debating the same construct of our energy circumstances, to try to pole-vault to new ground. Perhaps everyone has heard me say that my first car was an antique Model T Ford that I restored. You put gas in the 1924 Model T the same way you put gas in a 2003 car. Nothing has changed.

So when the President called for his Hydrogen Fuel Cell Initiative, I thought it was very welcome. I think it is very timid, but I think it is welcome. Those who allege and suggest that somehow he is doing this in order to avoid other issues, I do not buy that. I think putting the administration on record in support of new technology and moving to new ground with respect to energy is very, very helpful.

But the fact is, it is very timid. I am mindful that when elephants fly, you ought not criticize them for being awkward. So I am a little ginger in suggesting there is anything wrong with what the President is suggesting except this point. The President is suggesting an initiative that does not have very much money or boost behind it. Some of the money that is in the initiative comes from other areas of the budget that I think are very important, and the result was a reduction in biomass, wind, geothermal, and distributed energy funding, just to mention a few.

I happen to think this is a big idea. It needs to be an Apollo-type project with an aggressive, bold approach. I have introduced legislation with a number of my colleagues to that extent last week. My bill is a $6.5 billion, 10-year program, that is a big idea that says, "Let us move forward, and get on track and set goals."

In the Energy bill last year, we had a provision that I wrote that required the DOE to set goals to get two-and-a-half-million vehicles using fuel cells on American roads by 2020. Now I admit the goal in last year's energy bill that we sent to conference was not an enforceable goal, but it was at least establishing a policy goal for this country, which is what I think we need to do.

So rather than move in the right direction in low gear, I suggest that we go in high gear. We almost always, when we focus on energy, talk about digging and drilling. I come from a State that produces natural gas, oil, and coal. So the fact is, we will dig and we will drill. But we do that understanding there are consequences. We have clean coal technology initiatives and other initiatives, which I support. But if digging and drilling are our only strategy, then again our country loses.

If the only major debate we have is the satisfaction of beating each other up over ANWR or CAFE when we finish an energy bill, that is not much satisfaction for my children or my grandchildren. And I think we should debate ANWR and CAFE. I think we should produce more energy from coal, oil, natural gas. I think we should conserve more, and we should have more efficiency. I think we should boost limitless and renewable sources of energy. All of that ought to be in an energy bill.

But we need to establish a bold, Apollo-type program to move towards hydrogen fuel cell technology for this country's future. I will not go into the charts that were just used, but the fact is, the fuel cell is so much more efficient and puts water vapor out the tailpipe. There are great advantages in moving in this direction for our country. And it cannot possibly be done without an aggressive public policy.

You have production. You have storage. You have transportation. You have infrastructure. You have all of these issues that come to the same intersection, when you talk about making this kind of a policy change. It will not happen next year. It will not happen 4 years from now. But it will happen over a 5-, 10-, 25-, and 50-year period, if it is our determination and our public policy in this country to move in this direction. I feel very strongly that we need to do it. We need to be bold.

As I say that, let me again come back to my colleague's statement. Yes, we have short-term issues that we cannot possibly ignore. Let us resolve them. Let us address them. But I am more interested in deciding how we can escape from the annual 20-year debate that we call "yesterday forever." That debate is not very satisfying to me.

So when I attended the President's speech on this issue, I said, "Good for him." But again, it is way too timid. So let us boost it, and get to the business of making this happen.

Mr. Garman, let me ask you the obvious question. $1.7 billion, or slightly less than half, I think, is new money. But some of the money comes out of very important investments. As you know, I am a very big supporter of wind energy, which can also be used to produce hydrogen, and I hope that will be the case. But biomass, wind, geothermal, and distributed energy are all cut. I assume you would say to me, "Yes, but we have increased funding for hydrogen fuel cells," but this is at the expense of others.

We should be bold and develop a program without cutting funding in these very important areas.

Mr. GARMAN. To comment on that, Senator, there has been a small cut in wind from $44 million to $41.6 million, an increase requested for hydro, a small decrease in geothermal from $29.8 million to $25.5 million, roughly flat on solar photovoltaic.

Senator DORGAN. Well, where do you get the hydro? I do not want you to——

Mr. GARMAN. $5.3 million to $7.4 million is hydropower.

Senator DORGAN. Hydropower.

Mr. GARMAN. Hydropower.

Senator DORGAN. I have $7.4 million from $7.4 million, but maybe——

Mr. GARMAN. No, we actually ended up with $5.3 million last year. But there was a significant cut in biomass mainly in two areas. A demonstration program on black liquor gasification for pulp mills, because that is a technology that is close to commercialization. And the other in our energy supply account, there were $26.7 million worth of earmarks.

When you take that away, we are actually asking for a little bit more for biomass than Congress gave us last year. Now I realize, I am not suggesting and cannot suggest, that earmarks are going to disappear. But I did want to provide that bit of context for the committee.

Senator DORGAN. So you are cutting it, but there is actually going to be more.

Mr. GARMAN. There is actually——

Senator DORGAN. Very good, Mr. Garman.

Mr. GARMAN. I think there is actually going to be more core money for some of our R&D goals in biomass.

Senator DORGAN. But you have to support the budget that was sent to us. I assume that you, because I know a little about you, would prefer that we increase investment in wind, geothermal, biomass, distributed energy, would you not?

Mr. GARMAN. I support the President's budget, Senator.

[Laughter.]

Senator DORGAN. I take that is a given. I was just asking what do you think.

Mr. GARMAN. Well, somewhere above my pay grade, the——

Senator DORGAN. Mitch Daniels.

Mr. GARMAN. I think all of our programs and our efforts are incredibly important. But somewhere above my pay grade, the dollars that one would put in energy efficiency competes against the dollars that one would use for education, curing cancer. And, frankly, those decisions need to be made above my pay grade and in Congress.

Senator DORGAN. It is Mitch Daniels. Tax cuts, yes, especially cutting taxes.

Let me make one final point, Mr. Chairman. $6.5 billion over 10 years is 1 percent of the President's proposal for new tax cuts, in the next 10 years; 1 percent. If we commit 1 percent to a bold new program of hydrogen fuel cells, it will be of incalculable benefit to our country. But it does not have quite the same sway in some circles high above your pay grade, I think.

Nonetheless, I really hope that we will take a look at these priorities in a significant way, especially here on this committee. Senator Domenici, who is not here today, is someone who also attended the President's speech. We talked there. I think he is very interested in advancing some of these issues, as is my colleague Senator Bingaman, and others. We need to work together to construct an energy policy that works for the long term in this country.

Thank you very much.

Senator ALEXANDER. Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman. I am really enjoying this conversation.

Recognizing that within the transportation sector essentially petroleum is the number one fuel used here—and I appreciate the direction that you all are suggesting that we need to move to, this petroleum-free world and recognize that the initiatives that have been proposed and the alternatives that are out there are laudable and a direction we need to look to, but we cannot forget that we are still going to need the petroleum for the asphalt that we drive on, for the trains, for the marine fuel, for the lubricants, for the vehicles. We are never going to be able to be completely free of it; so let's just recognize that at the outset.

And we are recognizing that, in fact, it is important to reduce our dependence on foreign oil. I do not have any objection to that. It is something that we have been crying for in Alaska for a long time: Let us reduce the dependence on foreign oil. Let us help you, coming from the North, deliver additional domestic petroleum products down here to the lower 48.

And so these new technologies that are out there, the advancements, are great. They are wonderful. We support them. And it was interesting reading the comments from those that have spoken this morning. I am sorry I was not here to hear the actual presentations. But in reading through the comments, it seems that everybody is jumping to that next step, talking about what we need to do with the research and the technology, talking about the merits of hydrogen-based initiatives, how we are going to make these, how we are going to power these. But we need to get to that first step. How do we get the hydrogen?

And I am not going to profess to be any great expert in terms of how we get it. But I understand. And the charts this morning have been relatively helpful. The conversation, Mr. Garman, that you have directed has been helpful in saying: These are some of the alternatives. We can look to natural gas. We can look to coal methane. We can look to the process where we disassociate the water through electrolysis, which requires a high amount of energy, a high amount of water.

And so yes, we need to develop the technology so that we can get there. But it still comes back to those base natural resources that we have got to be able to provide in order to get us to that hydrogen point.

So you had made a comment earlier, Mr. Garman, about some of the obstacles that we face, whether it relates to getting our hydrogen from natural gas or through the use of coal, and the concerns about the carbon, and that is something that we will work towards. I appreciated your statement to Mr. Bunning that, in fact, we are moving with that.

But you indicated that, as it relates to natural gas, that this was, I think your word was, it was just a short-term option, or "a near-term approach" is exactly the words that you used. And I am not certain from what you said how you envision natural gas playing out in the lifetime of this hydrogen initiative. Can you give me some more clarification there?

Mr. GARMAN. We think that over the near term natural gas will be the almost exclusive producer of hydrogen until some of these other technologies come into play.

Senator MURKOWSKI. And can you define "near term"?

Mr. GARMAN. When we are talking about hydrogen and changing the infrastructure—I see natural gas being the dominant hydrogen producer through at least 2025.

Senator MURKOWSKI. Okay.

Mr. GARMAN. So that near term is pretty long term.

Senator MURKOWSKI. Well, and it is important to put these in time frames that are realistic. And as Senator Bunning had indicated, we have a crisis, if you will, as it relates to our ability to meet the demand when it comes to natural gas. And we are, again, in Alaska trying to do something to help down here by getting the natural gas pipeline from Alaska to deliver gas here, into the rest of the United States. We still have a long way to go on that.

But if we are not able to meet that natural gas supply demand in the short term, where are we?

Mr. GARMAN. Alaskan natural gas is very important to the Nation over the short and long term. And I know that there is, what, at least 85 trillion cubic feet of natural gas just in Alaska's North Slope, a lot of that on the Prudhoe Bay gas cap, that will play a very important role in our energy future. And I think the price of natural gas, until recently, has probably been a little on the shy side of what it needs to be to amortize that pipeline and bring that gas down.

But recent prices show that perhaps that is not the case. And we are excited about the possibility that that pipeline could be built and that Alaska gas could be brought down to the lower 48 to solve our near-term and mid-term and long-term problems.

Senator MURKOWSKI. Well, it is real. And again, going back to how you get the hydrogen, okay, we talked about natural gas. I appreciate your comments there. And again, we need to do everything that we can to meet that gas demand. And we will be working very, very concertedly on that.

And we have also had a little bit of discussion about coal and the availability of it. That is another area where we are certainly in a position to help you. We have 120 million short tons of known coal reserves in Northwest Alaska and another 20 million short tons of coal identified throughout the State.

Again, with my State, it is a situation of, "How do we get it to you in order that it be effective?" So we have some access issues before we can be able to meet that demand.

But before we get too excited about a hydrogen initiative and the ability to make it happen, we need to make sure that we have these supplies that are available. So we will certainly be looking forward to working with the administration to make sure that we can meet the immediate-term, mid-term, and long-term needs for this initiative.

So thank you.

Mr. GARMAN. Thank you, Senator.

Senator ALEXANDER. I would like to ask a question about transmission. And I would like to give the other witnesses a chance to react. So let me move from production to transmission of hydrogen. And starting with Mr. Frankel and going down the line, then, Mr. Garman, you can be last.

Could you take a minute and talk about the problems and opportunities and solutions associated with the transmission of hydrogen, or any other remark you might want to make from the comments you have heard here, Mr. Frankel?

Mr. FRANKEL. Mr. Chairman, thank you. I think a lot of this, of course, turns on the technologies that Secretary Garman has described. As I indicated in my statement, the role of the Department of Transportation, specifically RSPA, is in assuring and doing research in what would be the hydrogen infrastructure and assuring its safety. That is a specific mandate to that agency.

I think, as Mr. Garman has said, it depends on the particular technology developed whether or not we are going to need an extensive hydrogen pipeline system. There is some system already. It depends on where the reformation, if you will, occurs.

Although we have not yet introduced the bill to reauthorize TEA-21, we have been considering research in the area or seeking resources so that we can undertake further research in the development of safe hydrogen infrastructure, including pipelines, which I see as a key role for the Department of Transportation in this regard.

Senator ALEXANDER. Mr. Dana.

Mr. DANA. Senator, it is one of the many issues I think we all face in bringing fuel cell vehicles to market. Today we have an infrastructure that has been developed for over 100 years. We have gas stations literally around the corner from wherever we live or work. And as we look forward to putting fuel cell vehicles on the road, we have to think about how we can make hydrogen available to the consumer in a similar way that we make gasoline available to the consumer today.

So it is one of the big impediments, I think, that we are facing as we look to the future, one of the many impediments that we see, one of the main—"challenges" is probably a better word—as we look towards the future of the fuel cell vehicle. So it is critically important to us.

Senator ALEXANDER. Mr. Friedman.

Mr FRIEDMAN. Thank you. In terms of the transmission of hydrogen or how you get hydrogen to the vehicle, the way we see the pathway to fuel cell vehicles is we agree that it will start with natural gas. And I think we need to put that amount of natural gas in perspective.

Even if we are at 15 percent of new vehicles by 2020 that are fuel cell vehicles, we are still only talking about using for transport only a small fraction of the natural gas that we use in electricity and power generation.

The current problems with natural gas really are actually transmission problems. They are infrastructure problems. We have a fair amount of natural gas that we can tap into in order to build the early years of the hydrogen infrastructure. What that means is supplying natural gas to fuel stations, and reforming natural gas right at the fuel station using today's natural gas infrastructure. It is actually a quite elegant solution. And the technology is already being developed.

In the long run when we talk about infrastructure issues for hydrogen, we think that actually the best option for producing hydrogen is renewable electricity. And so renewable electricity supported by things like renewable portfolio standards and credits for production of renewable energy mean that we can produce electricity with basically no greenhouse gas emissions, put that electricity again over existing transmission lines, and again at the fuel station create hydrogen via electrolysis.

If you take the graph that was shown before of greenhouse gas emissions, if we look at hydrogen from electrolysis, if this is based off of renewable fuels, this bar disappears. It goes to zero. Minimal transportation issues arise because you are using existing infrastructure for both cases, dramatic reductions in greenhouse emissions, and significant improvements in efficiency.

So we actually do not think that the transmission problems are going to be that difficult to overcome with existing technology.

Senator ALEXANDER. Mr. Cromwell.

Mr. CROMWELL. Thank you, Senator. It is interesting as an end user, taking a look from a totally different perspective as one that is doing this every day, our philosophy has always been to address the barriers that seem to get in the way and solve those one by one, utilizing what is in place. Public/private partnerships are in place that will help us build fueling stations, especially in natural gas, which could then be easily, hopefully, converted to dispensing of hydrogen in the future, making it a sustainable support to make sure that we continue in the process of evolving to the goal, which the President has already indicated could be 15 years plus.

And I think an amusing thing I heard the other day is that for the last 40 years we said fuel cells would be ready in the next 10 years. Well, let us hope that is right. It is certainly at a point where it looks very real.

And then education: I would like to leave this with the committee, if I may. This is a book we have produced through the help of the FTA and many others. It is a hydrogen educational tool that is in connection with our project we did with Ballard and the XCELLSIS fuel cell bus. So if I could leave that with the committee. It has been put on the InRail website. In the first two months it received 132,000 hits. So obviously there is interest in moving this program.

Natural gas, we obviously think, is the direction in which to go. There are a million miles of pipeline in the system already. We are using natural gas at seven stations. We have a hydrogen station in operation that is using gas reforming and solar power to generate electricity, to use an electrolyzer.

We are about ready to put together a project where we use wind power to generate hydrogen and develop transportation techniques that could see if that might be a good way to do it. How do we move it from point A to point B? We have done that in a very small package with the city of Palm Desert for the Department of Energy, set up a program with golf carts that were used in park maintenance. We made the hydrogen at Sunline and then transported it over to the city of Palm Desert where we fueled the vehicles. And that project was a DOE project that went on for 2 years.

So we know that those kinds of strategies are in place. We just need to continue the work forward.

Senator ALEXANDER. Thank you.

Mr. Garman.

Mr. GARMAN. Yes. You have heard a lot. And I will not add much other than we cannot use existing natural gas pipelines to transmit hydrogen because of issues of embrittlement, compressors, seals, a different materials challenge.

We have built hydrogen pipelines, and we know how that works. We have approximately 500 miles of hydrogen pipelines in the country. There is some thinking that maybe it is possible to blend natural gas and hydrogen together, maybe up to a 20 percent blend of hydrogen with a natural gas, and be able to use the same pipelines. That has not been validated yet. We are not quite sure, but we are looking at all of the options.

And I think what you hear among the panel are the benefits of hydrogen is that it is something that gives you options. Natural gas is an option, but prices are volatile. Coal is an option, but we are dependent, you know, on the ability to develop sequestration technology.

So I think at this point, a long-term perspective, having a diverse technology portfolio, where we are looking at lots of options, to generate lots of options for you, the policymakers, to determine how we best need to proceed on this, is the right way to go.

Senator ALEXANDER. Thank you very much for your answers.

Senator Bingaman.

Senator BINGAMAN. Thank you very much. First, let me just ask Mr. Garman if we can get a copy of that study, the Well-to-Wheel study that you said that you folks have obtained. I guess it may be—is this the one that Arthur D. Little did?

Mr. GARMAN. I believe this is the Arthur D. Little study. But we will get that for the committee.

[The information follows:]

As requested by Senator Jeff Bingaman, attached is the Arthur D. Little final report, "Guidance for Transportation Technologies: Fuel Choice for Fuel Cell Vehicles" that Mr. Garman referenced during the March 6 hearing when responding to a question by the Senator relating to well-to-wheel efficiency of a diesel hybrid electric fuel vehicle (see attached pages 48, and 74 of the hearing transcript).

The energy efficiency numbers presented by Mr. Garman at the March 6 hearing were calculated from the Arthur D. Little report. Attached is an extract from the report that reflects information used to calculate the energy efficiency numbers presented by Mr. Garman.

[Note: The attachments have been retained in committee files.]

Senator BINGAMAN. That would be very useful, if we could have that.

Let me ask Mr. Friedman—could I put up the first of the charts that we had there, that one with the red bars on it?

Your view is that we should produce the hydrogen from renewable sources and, therefore, eliminate any emissions and eliminate any or, I guess, a lot of the other disadvantages. Now on this first chart the production of hydrogen from electrolysis, which is what you are talking about, it looks like you have to produce—in order to produce 1 billion Btus for use in vehicles, you have to use up 2.5 million Btus. Now I guess your answer on that is that it is unlimited, the renewable sources. I mean, if we use wind or solar, there is no limit to the availability of that. And so it still makes good sense. Is that——

Mr. FRIEDMAN. Well, there are some limits, obviously, in terms of the total capacity. But I think the real way to look at it is: Energy use is not necessarily inherently bad. Energy use is one of the engines of our economic growth. The problem are the results of energy use. And renewable fuels allow us to decouple the negative results from energy use from that actual energy use.

So really, I think the potential here is that renewable energy can allow our economy to grow and thrive without all these traditional problems that we have had to deal with, without, you know, the air quality problems, without the waste problems.

Senator BINGAMAN. Let me just ask you—I am trying to get in my mind how it would work. We have, for example, a wind farm going on in my State. It is quite a ways from the population centers. But that is where the wind happens to be.

Mr. FRIEDMAN. Right.

Senator BINGAMAN. But is it your thought that those wind turbines would produce electricity which would then be brought to the metropolitan areas, and then at that point the electrolysis would occur? Or the electrolysis would occur at the station, or the electrolysis—where do you see the hydrogen being produced?

Mr. FRIEDMAN. Right. There are several models for that. And that does not just include—they definitely include wind farms, solar farms. They also include producing renewable energy right in the city, on top of roofs of buildings and things like that. So renewable energy is a very distributed energy source.

You would very likely produce the hydrogen either within the metropolitan area or directly at the fueling station. If it is within the metropolitan area, you would still be either trucking or piping the hydrogen. But that is a much smaller infrastructure that you are dealing with.

If you just simply electrolyze the hydrogen at the fueling station or even in your home, you are still just using the current electrical infrastructure. And you are not having to even add a hydrogen infrastructure.

Senator BINGAMAN. So conceivably, you would have a substantial increase in the demand for electricity, but you would be meeting that demand through renewable sources and thereby avoiding all the negative problems that we saw.

Mr. FRIEDMAN. Yes. And I think we do have to understand, obviously this is a long-term solution. There would be an increase in the demand for electricity, which also would mean upgrades to that infrastructure, which would be very important.

Senator BINGAMAN. Let me ask Mr. Frankel on a totally different issue: We had in law here for several years a prohibition on NHTSA changing or increasing the corporate average fuel economy standards on all vehicles.

Mr. FRANKEL. Specifically, Senator, on light trucks and SUVs.

Senator BINGAMAN. Well, I thought we also had it on cars.

Mr. FRANKEL. I do not believe so. I think the restriction that was in place was for——

[Note: The following letter was received from the Department of Transportation:]

U.S. DEPARTMENT OF TRANSPORTATION,
OFFICE OF THE SECRETARY OF TRANSPORTATION,
Washington, DC, April 11, 2003.

Hon. JEFF BINGAMAN,
Ranking Member, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR SENATOR BINGAMAN: During my March 6th testimony before the Energy and Natural Resources Committee on the U.S. Department of Transportation's (DOT's) role in reducing energy use in the transportation sector, you asked about the restriction that had been placed on our efforts to increase CAFE standards. I am correcting my response for the record.

The restriction did indeed apply to all vehicles, as you stated. For Fiscal Years 1996 through 2001, the Department of Transportation Appropriations Act contained a provision that prohibited the use of funds to prepare, prescribe, or promulgate CAFE standards for automobiles that differed from those previously enacted. The term "automobiles" included both cars and light trucks. At the request of the Administration, Congress lifted this prohibition in late 2001. My response focused on light trucks because, immediately after the prohibition was lifted, the Department determined that the light truck sector had the greatest potential for reducing fuel use. In fact, the Department has just issued new CAFE standards for model year 2005 through 2007 light trucks.

We also discussed the additional authority DOT may need to reform the CAFE program. While we are pursuing reform within our current authorization, full-scale reform will require additional authority. The Department has already requested such authority from Congress. I am enclosing a copy of a letter from Secretary Mineta that outlines the Department's views on reform of the CAFE legislation.

The Department looks forward to meeting the challenge outlined in the President's Hydrogen Initiative while also addressing increased fuel efficiency in the short term. Please let me know if I can be of further assistance.

Sincerely,

EMIL H. FRANKEL,
Assistant Secretary for Transportation Policy.

[Enclosure]

THE SECRETARY OF TRANSPORTATION,
Washington, DC, February 1, 2002.

Hon. THOMAS A. DASCHLE,
S-221, The Capitol, Washington, DC.

Hon. TRENT LOTT,
S-230, The Capitol, Washington, DC.

Hon. J. DENNIS HASTERT,
H-232, The Capitol, Washington, DC.

Hon. RICHARD A. GEPHARDT,
H-204, The Capitol, Washington, DC.

DEAR GENTLEMEN: The Administration supports increasing fuel economy by encouraging new technologies that reduce our dependence on imported oil while protecting passenger safety and American jobs. This has been our consistent position, as reflected in the President's National Energy Plan and our statement of administration policy on the House Energy Bill.

Congress requested that the National Academy of Sciences (NAS) review the Corporate Average Fuel Economy (CAFE) program and report back to Congress. The President's National Energy Plan also recognized the importance of the NAS' work to any changes to the program. The NAS recently finalized their report, which made two important findings: (1) we can significantly increase fuel economy safely through the use of new and existing technology, and (2) the current CAFE system has created an incentive for manufacturers to produce smaller and lighter cars, which the majority of the NAS committee believes has led to many additional traffic injuries and fatalities. The Department, like many members of Congress, is deeply concerned by the NAS study's findings about the adverse impact the current CAFE program has had on safety.

On behalf of the Bush Administration, I am writing today to urge Congress to provide the Department of Transportation with the necessary authority to reform the CAFE program, guided by the NAS report's suggestions. As we wrote in our statement of administration policy on H.R. 4, "the Administration looks forward to working with Congress to achieve significant improvements to fleet fuel economy by encouraging development and introduction of new technologies and reforming the CAFE program."

Specifically, I look forward to working with Congress on legislation that would authorize the Department of Transportation to reform the CAFE program, fully considering the NAS report. Possible reforms include: (1) adopting fuel economy targets that are dependent on vehicle attributes, such as vehicle weight, that inherently influence fuel use and have minimal adverse safety consequences; (2) utilizing market-based incentives, such as trading of fuel economy credits, to obtain fuel savings at the lowest possible cost to the consumer while providing continuous incentives for additional fuel economy enhancements; (3) encouraging development and implementation of new technologies; and (4) establishing realistic, long-term targets and deadlines to increase fuel economy safely while providing greater long-term product planning for the vehicle manufacturers.

The Administration appreciates that in December 2001 Congress lifted the provision that, since Fiscal Year (FY) 1996, has prohibited the Department from addressing fuel economy standards. Now that the ban has been lifted, we are prepared to develop and evaluate potential reforms to the CAFE program. Accordingly, the President's budget will request that Congress significantly increase the Department's budget for fuel economy standards by providing $1 million for FY 2003. In addition, the Department has notified Congress of its intent to reprogram funds in FY 2002 so that the Department's fuel economy standards program exceeds $800,000—up from just $60,000 in FY 2001.

To ensure we meet our current obligations, we also will seek public comment on new light truck standards for the model years 2005 through 2010 and on the NAS study's findings and recommendations.

These efforts build on what the President already has done to increase fuel economy, To encourage Americans to buy more fuel efficient vehicles today, the President's energy plan proposes tax incentives for the purchase of hybrid and fuel cell vehicles totaling more than $3 billion (from '02 to '12). To advance and accelerate the development of even more fuel efficient vehicles in the future, the Administration is funding and working with partners (both research universities and the private sector) to leverage resources for research and development of new vehicles and fuel technologies, including the new fuel cell FreedomCAR program, hybrid vehicles, renewable fuels, and ultra-low sulfur fuels.

I look forward to working with you and others in Congress to authorize the Department of Transportation to undertake the reforms needed to improve fuel economy by encouraging new technologies, without negatively impacting safety or jobs. Thank you for your consideration and support.

Sincerely yours,

NORMAN Y. MINETA.

Senator BINGAMAN. So there has not been any restriction on your ability to increase CAFE standards for cars.

Mr. FRANKEL. I think the CAFE standard has been legislatively driven. But the restriction on SUVs, which was placed within the Department of Transportation and within NHTSA, there was a restriction on NHTSA doing any work at all for a period of 5 or 6 years up until, I think it was, 2002.

Senator BINGAMAN. Yes. So since last year that restriction——

Mr. FRANKEL. 2001, the end of 2001.

Senator BINGAMAN. Yes. That restriction has gone away. Do you have any plans in NHTSA to look at the possibility of increasing CAFE standards on the rest of the fleet?

Mr. FRANKEL. Senator, that is something we will be examining with the Congress. I think there was discussion around the energy bill in the last Congress, about allowing a more fundamental look at reform of the CAFE program. There was no bill, and it obviously was not enacted.

I do not think it is simply a question of increasing the standards in and of themselves, whether we are talking about SUVs or, in this case, about private automobiles, and that is consistent with the National Academy of Sciences study. It is timely to take a fundamental look at the CAFE program, and to undertake that fundamental look really requires legislative authority, statutory authority, which Congress needs to be engaged in.

Senator BINGAMAN. So you do not think you have the authority to do that.

Mr. FRANKEL. Not the fundamental look that I think is required. There are some elements that can be examined, but we need to really undertake a more fundamental examination, including some of the elements that were raised in the National Academy of Sciences study and have been raised by other people about transforming the kind of basis on which classifications are made. It is our view that that kind of fundamental review is best undertaken with statutory authority.

Senator BINGAMAN. Well, Mr. Chairman, I would just suggest that NHTSA or any Federal agency has full authority to look at any of these issues that they have regulatory responsibility for and make recommendations to the Congress.

Maybe there would have to be some change in law, depending on what you recommended. But clearly, if you felt that there was some change appropriate in this area, I think you should move ahead and give us recommendations.

Mr. FRANKEL. Well, certainly that continues to be under review at the Department and within the administration, Senator.

[Note: See letter to Senator Bingaman from the Department of Transportation, dated April 11, 2003.]

Senator BINGAMAN. Thank you very much, Mr. Chairman.

Senator ALEXANDER. Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman.

Mr. Friedman, you have been talking a little about the electrolysis process. And I understand that in order to get to the hydrogen state, you have to disassociate the hydrogen from water.

Mr. FRIEDMAN. Yes.

Senator MURKOWSKI. Now in my State we do not have any problem with water. We have more water than most people would know what to do with. I am chairing the Subcommittee on Water and Power for the Energy Committee and getting into the water issues that we have in this country, particularly in the West, where, in times of drought and even, quite honestly, when we are doing okay, the water market is very, very, very tight.

How does this process then work so that it is feasible? We are talking about another resource that has a finite supply, if you will.

Mr. FRIEDMAN. Well, one of the really exciting things about fuel cell vehicles is, yes, you start off by cracking that water into hydrogen and oxygen. Once you recombine the hydrogen and oxygen onboard the fuel cell vehicle, you produce water. So you get all that water right back, when you actually use the hydrogen.

So there are no questions of, or concerns over, depleting our water resources, because it is just a perfect cycle. It is a perfect circle. You crack the water. You make hydrogen. You use hydrogen to make electricity. And you get the water right back.

Senator MURKOWSKI. So it is diverted for just a very short period of time. I have no idea, really, how long this process takes.

Mr. FRIEDMAN. Right. It is diverted. I mean, the minute you start, once you fuel up with your fuel cell vehicle, the minute you start driving, you are putting water right back into the system. So if it took, you know, a few minutes to produce that hydrogen, it will maybe take a few days for that hydrogen to—excuse me, for the water to return to the system.

Senator MURKOWSKI. So in your opinion, this will not have any effect on the limited water market that we have.

Mr. FRIEDMAN. I believe that is correct, and especially considering we actually are not talking about very large portions of water.

Senator MURKOWSKI. If I may, Mr. Garman, if we are able to achieve what the panel is proposing here, that we really do move from a transportation industry that is less reliant on petroleum and we do increase our efficiency standards so that we are using less gasoline, we are moving from that, we are not going to be seeing the gasoline tax go into the Highway Trust Fund. It is that Highway Trust Fund that is able to keep our roads drivable, essentially.

So how do we plan, or what is the proposal if we are successful in what you are attempting to do, that we will be using less gasoline, how do we refill or replenish our Highway Trust Fund?

Mr. GARMAN. Well, I think your earlier point is very important as context, that this transition to the hydrogen future takes many decades to happen. So this is a concern or an issue that folks in your chair will have to grapple with many decades from now, rather than something that is a short term issue. But I would imagine that one would tax the hydrogen fuel of a vehicle just as one would tax the gasoline fuel of the vehicle today, if a sustaining mechanism was needed for the Highway and Infrastructure Trust Fund.

But again, it is difficult for me to project 20 or 30 years into the future for that question.

Senator MURKOWSKI. Thank you.

Thank you, Mr. Chairman.

Senator ALEXANDER. Mr. Frankel.

Mr. FRANKEL. I might say, Senator and Mr. Chairman, that I think there are broader issues in terms of the future of the Highway Trust Fund and the financing of the Highway Trust Fund. I think that there will be consideration in Congress about examining, over this next reauthorization period, the future of the Highway Trust Fund and how it is going to be financed.

We do have a national policy to develop alternatives to a petroleum-based transportation system. We may have disputes about exactly how we are going to achieve it and how long it is going to take us to achieve it. Moving away from a petroleum-based transportation system is becoming national policy. At some point that is going to have an impact on the Highway Trust Fund that we have to recognize.

I think that the administration will have to undertake a very careful and serious study of this issue. Some of that work is already going on within DOT, and at the Department of Energy, and the Department of the Treasury.

Senator ALEXANDER. I want to thank the witnesses on behalf of the committee for your time and your intelligence and your help. If different opinions occur to you after you leave or if there were things that you wanted to say that you could not today because you did not have time, we would be glad to receive those comments here in the committee and make them a part of the record.

And I am sure there will be many more hearings and discussions on the same subject. Thank you very much.

[Whereupon, at 12:10 p.m., the hearing was adjourned.]

APPENDIXES

Appendix I

Responses to Additional Questions

SUNLINE TRANSIT AGENCY,
Thousand Palms, CA, April 28, 2003.

JOHN PESCHKE,
Professional Staff Member, Senate Energy and Natural Resources Committee, Hart Building, Washington, DC.

DEAR MR. PESCHKE: Enclosed please find answers to questions posed by members of the Senate Energy and Natural Resources Committee. If you or members of the committee have additional questions or need further clarification, please don't hesitate to ask.

Please also pass on our appreciation to Chairman Domenici for the opportunity to offer this input. We are encouraged by the interest shown in clean fuels and renewable energy, and by the very thoughtful (and difficult!) questions asked by Committee members. Best of luck on the final draft of this vital policy.

Sincerely,

RICHARD CROMWELL III,
General Manager/CEO.

P.S. Should you or any member of the Committee be in the Palm Springs area, we would be honored to offer a private tour of our Clean Fuels Mall and Beta Test Center for Advanced Energy Technologies.

[Enclosure]

RESPONSES TO QUESTIONS FROM THE SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

HYDROGEN FUEL PRODUCTION

Question. What are the advantages of using natural gas or another hydrogen carrier fuel as the feedstock for hydrogen in the short term? How will this increased demand for natural gas impact natural gas supply and prices?

Answer. No technology that exists today can compete on a cost basis with reforming hydrogen from natural gas. Proven reforming technology exists, is cost-effective, and when combined with carbon sequestration, begins to be competitive with electrolysis from a greenhouse gas perspective. If we define "short term" as present day—2020 to 2030, there would be no negative impact on natural gas supplies. Rather, as demand increased, it would become economic to increase production. Beyond 2020-2030, it might be necessary to supplement U.S. natural gas supplies with imported liquefied natural gas (LNG).

All that aside, every possible program should be put in place to make renewables cost competitive for hydrogen production. SunLine has demonstrated solar electrolysis since 2000. It works. We're about to demonstrate wind-hydrogen production as well. But until demand is sufficiently high to lower the cost of production, it will never be competitive. Another "chicken and egg" scenario. The solar and wind industries need incentives and large orders to increase production.

Question. Is it more likely that we will have hydrogen fueling stations, or we will see hydrogen generated in our garages from distribute energy resources?

Answer. Based on what we're hearing today, it is unlikely home electrolysis units would be cost competitive. However, a home reformer may be feasible. If manufacturers solve the technology issues that currently exist and home reformers become available, there could be a mix of home fueling and stations, but the primary method of delivery will likely be fueling stations.

ALTERNATIVE FUEL VEHICLE MANDATES

Question. Should the EPAct alternative fuel vehicle mandate program be continued? If so, how should it be fixed? Should we offer credits toward compliance for investments in fueling stations or use of fuel?

Answer. Yes, the EPAct mandate program should be continued. It could be improved as follows: Include a study provision intended to promote trading of emissions credits between mobile and stationary sources; provide double EPAct credits for fleets acquiring dedicated heavy-duty alternative fueled vehicles; provide credits for companies that make a significant contribution to the development of alternative fuel infrastructure; and require the GSA to allocate the incremental cost of an alternative fuel vehicle over the entire federal fleet. Currently, GSA charges an agency the entire incremental cost of an NGV.

Substitute language, endorsed by our partners in the Natural Gas Vehicle Coalition, follows:

> "Sec. 13265. The Secretary shall establish an optional program under which fleets subject to the requirements of sections 13251 or 13257(o) of this subchapter may opt out of the requirements of those sections by making a demonstration to the satisfaction of the Secretary that the fleet or covered person is in good standing with the regulations issued pursuant to sections 13251 or 13257(o) and that the fleet will achieve reductions in the use of petroleum fuels if it is permitted to opt-out of the requirements of these sections. The program established by the Secretary shall by rule:
>
> (a) Establish a measurable annual petroleum reduction requirement for a covered fleet equal to the amount of alternative fuel the fleet would use if at least 60 percent of the annual amount of fuel used in all light duty motor vehicles owned or otherwise controlled by the fleet was alternative fuel.
>
> (b) Allow a fleet that opts into the program to achieve petroleum reduction in any manner it chooses, except that reductions in the size of the fleet shall not be considered in determining the total amount of petroleum reduction by the fleet."

Question. If we are moving to a fuel-cell based transport fleet, should we still be interested in ethanol, biodiesel, natural gas, etc., or should we just use them to make hydrogen?

Answer. We should absolutely still be interested in and provide incentives for purchase of alternative fueled vehicles (AFVs) powered by ethanol, biodiesel, natural gas, and hydrogen-natural gas blends, as well as for hybrid vehicles that dramatically increase fuel efficiency. As if not more important, we should provide incentives for purchase of alternative fuels at the pump. AFVs can't reduce foreign oil and lower emissions unless they alternate fuels are consumed.

Unlike SunLine, which parked a fleet of diesel buses and went into service overnight with a new fleet powered by natural gas, as a country, we will never see a wholesale conversion at any point in time to a new fuel (hydrogen or otherwise). What we've seen repeatedly this past 10 years is that different clean fuels fit different circumstances and what works in one location/situation may not in another. Options should never be limited. Our goals (displacing imported petroleum and improving air quality) should be fuel neutral. What should be mandated or regulated is the outcome—not the fuel type.

CORPORATE AVERAGE FUEL ECONOMY (CAFE)

Question. Should impacts on passenger safety, vehicle technology, consumer preferences, and market-economics be considered when considering new fuel economy standards?

Answer. Passenger safety should of course be considered. Consumer preferences, however, are directly tied to the price of oil. If the price of our national security, air quality, and public health were factored into the price of a gallon of gas, every consumer in the country would develop an overnight fondness for high fuel efficiency vehicles, regardless of design.

Question. Rather than argue here in Congress about arbitrary mile-per-gallon levels, should we just get out of the way and let the experts at NHTSA do their job?

Answer. That would be a dangerous precedent in our view. It should not be up to government staffers to set policy. That is the role of electeds who represent the voters of this country. Turning it over to NHTSA without a specific target for reductions opens the door to a staff decision that fuel efficiency is less important than the other factors cited.

Question. Should we consider CAFE credits for hydrogen vehicles as a way to encourage their manufacture and sale?

Answer. Yes. In addition to hydrogen's national security and air quality benefits, fuel cell vehicles are far more energy efficient than traditional internal combustion engines.

Question. Should we remove the cap on CAFE credits for AFVs to provide a greater incentive for their sale?

Answer. Yes.

Question. Is "miles per gallon" an appropriate efficiency metric if we are no longer using gallons of gasoline in the future? Will CAFE be needed in a hydrogen-car based system?

Answer. Gasoline powered vehicles will be on the road 30 years from now, so for at least the next generation, "miles per gallon" or "miles per gas gallon equivalent" are appropriate metrics. Regarding the need for CAFE in a hydrogen-car based system (assuming the absence of traditional gas-powered vehicles)—the answer is no. In an all-hydrogen system, the reasons CAFE standards were passed will no longer apply (reduce foreign oil, reduce air pollution).

ADDITIONAL QUESTIONS

Question. Aside from new R&D funding, what can/should Congress do to hasten development of hydrogen-fueled vehicles?

Answer. Revise DOE's timetable from 2020 back to 2010-2015; increase the purchase and use of hydrogen vehicles by federal fleets; pass sustained, guaranteed funding for research, development and demonstration of heavy duty fuel cell transit buses; offer incentives for infrastructure development.

Question. Which policy actions are more important for deployment of advanced technology vehicles—R&D, tax incentives, demonstration projects or regulations?

Answer. No one action can be singled out. A coherent program is needed that addresses all of the above. Transitioning to a hydrogen economy has been likened to putting a man on the moon.

Many in the industry think it will be more difficult! We have to do everything possible as a concerted, coordinated effort to move the technology forward.

Question. Give the focus on hydrogen as the transportation fuel of the future, how much effort should we expend on using other alternative fuels? For example, should we use natural gas directly for transport or convert it to hydrogen first?

Answer. As stated above, we will never see a wholesale conversion at any point in time to a new fuel (hydrogen or otherwise). Use of all alternative fuels should be encouraged/rewarded. Every gallon we use (or gas gallon equivalent) reduces our dependency on imported oil, reduces airborne pollutants and reduces greenhouse gases.

Question. Where is the U.S. compared to Europe and Japan in terms of competitiveness for the emerging hydrogen market? Will this new initiative push the U.S. ahead of its competition?

Answer. While this question was likely directed toward the passenger car market, my answer addresses the heavy-duty transit bus market. There are currently seven fuel cell transit buses on order in the U.S. compared to 30 buses that will be delivered to 9 European cities and Australia through the EU's multi-national CUTE program. Japan, Singapore, and a group of undeveloped nations working with the World Bank and UNDP likewise have programs underway. Despite the fact that transit buses are the most visible vehicles on the road, and that public transit is the ideal launch pad for a fuel cell program (because of centralized fueling, bus size/shape, and having trained mechanics and operators), the U.S. has no committed, sustained funding for the ongoing development/refinement of heavy-duty fuel cell buses. Through our experience, we've learned it will take several generations of engines before a fuel cell can withstand the rigors of the public transit environment. Without a multiyear commitment to technology development and demonstration, the U.S. will absolutely not be competitive with Europe or Japan in this market.

Question. What is your experience with the fleet mandate program for alternative fuels under EPAct? What changes in that program would you suggest?

Answer. Because we converted 100% of our fleet to natural gas in 1994, we've not had any personal experience with EPAct. However, the changes we support are detailed in the section on page 1, Alternative Fuel Vehicle Mandates.

Question. What lessons have we learned from the demonstration projects that DOT has funded with SunLine Transit Agency and other fleets?

Answer. We're so glad you asked! We have over 25 million miles of experience operating vehicles on compressed natural gas, liquefied natural gas, hydrogen and blends of hydrogen and natural gas. From our point of view, there are many layers to address.

First, we have learned that training is the key to the successful implementation of any alternative fueled fleet. By properly training our mechanics, operators and station technicians, we successfully avoided nearly every problem we might have encountered.

Second, we learned that our community college network is the ideal education/training partner. By working together, we've developed courses for alternative fuel technicians that help provide a skilled workforce from which we can draw. Thanks to funding from FTA and other partners, we were recently able to complete the first community college level training course on heavy duty fuel cells and related technologies. The manual is posted on DOE's National Renewable Energy Laboratory's Alternate Fuels Data Center website and has logged more "hits" than any other publication in the site's history.

Third, vehicles that run on high-pressure gases pose no problem—whether the gas is natural gas, hydrogen, or a blend. However, technology transfer is another key to their successful implementation. By working with partners like Ballard, developers of the ZEbus we demonstrated for 13 months, and ISE Research, our system integrator on the ThunderPower hybrid fuel cell bus demonstration project, our mechanics were trained to work on many of the bus' systems. In the case of the ThunderPower bus, it was possible for us to integrate a prototype bus into our daily route service—operate it, carry passengers on it, clean it, fuel it—in short, through the help of technology partners, we successfully integrated the bus into a normal transit operation.

Fourth, it is of vital importance to "bring the community along." Public outreach should never be overlooked. Public opinion should never be underestimated. By educating our residents and visitors, they have become clean air proponents.

Next, FTA's allowing us to form a public-private partnership for infrastructure development was a catalyst for over 1,000 alternative fueled vehicles to be in daily use in the Coachella Valley. By partnering with ENRG, a private sector infrastructure developer, we leveraged funding to build seven natural gas stations in our service territory. That enabled other fleet operators to be within minutes of fuel anywhere in the valley. As an aside, but in support of continued incentives for AFVs, together with ENRG, we helped other fleet operators access grant funds that were the deciding factor in the purchase of many of those 1,000 vehicles.

Last, and most important relative to hydrogen—because the transit bus market in the U.S. is so small in relation to all other heavy-duty segments, it will never be profitable for a private sector firm to fund the RD&D necessary to develop viable fuel cell buses. We MUST have a government-funded program if we are ever to transition from diesel transit buses to hydrogen fuel cell buses. That is the only way the needed research, development and demonstration will be possible.

Question. What challenges have you faced in operating several different kinds of alternative fuel vehicles in the same fleet?

Answer. At the risk of over-simplifying the answer—the only challenge we feel we face is economic. We are dependent on government and private sector funding for all activities that relate to our Beta-Test Center for Advanced Energy Technologies, where we demonstrate both stationary and transportation technologies. We are likewise economically challenged when it comes to space. We need to expand our facilities to increase the hydrogen production technologies we are demonstrating and we need more land to park and maintain these prototype vehicles. Our challenge is finding funding. We take care of the rest by training, working with partners, having realistic expectations, and being so excited by what we do that we don't realize other people might view our fun as a "challenge."

Question. You mentioned education and outreach as being important—who should carry out that function?

Answer. As I mentioned earlier, the community college network is an ideal partner for training technicians. We also strongly advocate an engineering degree program with a specialization in fuel cells. Regarding outreach, we believe all public agencies should incorporate an education/outreach component in every alternative fuel and/or clean air program they undertake. We find we are most successful when we work with a team of professional writers, graphic artists and education partners to carefully craft the messages we disseminate. It is vital to make people aware of both problems and solutions and to make them feel their participation in the solution is essential.

RESPONSES TO QUESTIONS FROM SENATOR BUNNING

Question. What fuel option is the DOE currently focusing on for use in fuel cells? Is DOE examining all possible options including natural gas and methanol from coal and ethanol?

Answer. According to a DOE presentation we just saw, the answer is yes—the agency is examining myriad options for generating hydrogen though natural gas is generally regarded as the best near-term solution.

Question. Do you think biodiesel from soybeans and animal fats is a viable alternative fuel? Is DOE looking into R&D using biodiesel as an alternative source of fuel to help reduce reliance on foreign oil?

Answer. While we are not familiar with DOE's programs in this area, we think biodiesel from soybeans, animal fats and recycled vegetable oil are all good options for displacing petroleum. Process economics vary widely with feedstocks and incentives are needed for biodiesel to be cost-competitive. But if the technological aspects and performance issues can be worked out (through research, development and demonstration projects in both stationary and automotive engines), it can help displace petroleum, support agricultural producers, and potentially reduce problematic waste from landfills.

FLEET DEMONSTRATION PROGRAMS

Question. Do you agree that the transit bus and fleet vehicle applications should or will precede the automobile market?

Answer. Yes. Definitely. Buses have fewer packaging restraints than passenger cars, skilled mechanics on staff that perform daily maintenance, centralized fueling, and a subsidized purchasing system. Buses are mobile classroom and billboards, and are generally in service 19 hours a day, over 360 days a year. Transit buses have also demonstrated a far more successful transition to alternate fuels than passenger cars. There are over 6,000 natural gas transit buses on the road today, 500 hybrids in use or on order, in addition to biodiesel, propane, and electric buses. If the rest of the nation followed transit's lead, imports of OPEC oil could be halved.

In addition, while heavy-duty vehicles account for less than 6% of those on the road, they produce 60% of the NO_x and over 80% of the particulate matter generated by vehicles. Cleaning up the heavy-duty sector has greater gains at far less cost than attempting the widespread implementation of passenger vehicles.

Question. What kind of coordination is occurring between the Department of Transportation and Department of Energy regarding the demonstration fleet vehicles including transit buses?

Answer. From our standpoint, in the past, there has been little coordination between the two departments. We recently attended an industry meeting where a DOT rep stated his department's role began at the point where new technologies were ready for deployment. DOE, however, does not fund heavy-duty transit bus R&D—which leaves transit operators in a crack in the system. We need a coordinated program for research, development and demonstration of multiple generations of fuel cell buses and corresponding funding for continuing hydrogen infrastructure upgrades in order to have a success. We have the same problems with early generations of hydrogen generating, storage and dispensing technologies as we do with early generations of fuel cell bus engines. The early generations can't withstand the daily rigors of the transit environment over a multi-year period. We need continued funding for early adapters to upgrade to each next generation to improve reliability, efficiency, and cost.

RESPONSES TO QUESTIONS FROM SENATOR BINGAMAN

Question. What does the so-called "Alternative Fuels Failure" tell us about trying to influence changes in the transportation fuels market?

Answer. The short answer is this: That heavy-duty markets and fleets should receive tax breaks, grants, and other incentives to become early adapters and developers of infrastructure; that the government needs to work closer with and fund industry to ensure cleaner engines are manufactured in advance of a profit opportunity; and that government fleets should be among the first and most loyal consumers. The same is true of stationary generation technologies. Government purchases would enable manufacturers to achieve quantities sufficient to reduce prices and make cost-effective products available to the market.

The longer answer, and the reason why government has not been a major purchaser of AFVs, is GSA policies. They are in contrast sharply with the requirements of EPAct and have adversely affected its ability to succeed. Please consider the following:

- Amortization of the incremental cost of the vehicle is due in the first year rather spread out over the 3-year lease life. Other vehicles leased by GSA are amortized over three years. This has the effect of adding $700 a month to the cost of the vehicle.
- All Federal agencies wanting to purchase or lease dedicated alternative fuel vehicles must provide GSA with a letter of justification. To our knowledge, no other vehicle purchased or leased by GSA is required to provide such justification.
- Federal agencies that have previously purchased or leased dedicated alternative fuel vehicles are required to re-justify their interest in purchasing the vehicle annually; even in cases where the infrastructure, training and other dedicated alternative fuel vehicles already exist.
- In many cases, Federal agency fleet managers have had their initial request to purchase or lease a dedicated alternative fuel vehicle rejected by GSA. Only after intervention by senior Federal agency staff has the request been approved.
- GSA does not inform its customers that they may request a natural gas vehicle to replace a gasoline vehicle. The customer will not get a natural gas vehicle unless it specifically knows it can do so and specifically requests it. Few of GSA's customers understand they have this option.
- Other Federal agencies have gotten around the GSA process by purchasing the vehicles directly.

A dedicated natural gas vehicle provides two EPACT alternative fuel vehicle acquisition credits.

GSA has attempted to meet its EPACT obligations by purchasing a large number of flex-fuel and bi-fuel vehicles that can operate on either gasoline or E-85. Unfortunately, those vehicles operate almost exclusively on gasoline.

The Civic GX is currently certified to the 2004 Tier II, Bin-2 emissions level. This is equivalent to a Super Ultra Low Emissions Vehicle (SULEV). The only vehicle cleaner is an electric vehicle. All Civic sedans have received the highest NHTSA safety rating, 5-stars for driver and passenger.

We would, therefore, like to propose some questions of our own for GSA:

1. Do GSA policies and procedures discourage the purchase or lease of dedicated natural gas vehicles by Federal agencies?
2. I understand that a letter of justification is required by all fleet managers to acquire dedicated natural gas sedans but not other vehicles purchased for the Federal fleet. Why is that?
3. Please explain the rationale of the GSA lease program that requires the Federal agency to pay all of the incremental costs of the AFV within the first 12 months of the lease rather than 3 years of equal payments, which is the norm?
4. What percentage of GSA alternative fuel vehicles are flex-fuel or bi-fuel vehicles?
5. What percentage of the flex-fuel or bi-fuel vehicles currently in the Federal fleet runs on the alternative fuel?
6. Please identify what Federal agencies have requested and procured a dedicated natural gas sedan for purchase or lease?

Question. What makes us think the Hydrogen Fuel Initiative will be any more successful than programs in the past to deploy alternate fuels and displace petroleum?

Answer. The U.S. government has the opportunity to correct all prior mistakes in regard to transitioning to a new, cleaner fuel. For the first time, efforts could truly be coordinated between the Departments of Defense, Energy, and Transportation so each has a preplanned role in reaching the same end point. In addition, the government can look to successful models between government, industry, energy providers, OEMs, and transit agencies such as the California Fuel Cell Partnership to learn how to leverage the efforts of multiple stakeholders. One final thought is that the RFP process and the earmark process don't particularly support the advancement and deployment of emerging technologies. The Consortia-based Advanced Vehicle Program was far more successful in bringing new technologies to the marketplace than other government programs.

Earmarks tend to fragment funds and no coordination between projects is required. RFPs are very specific and exclude many very viable and necessary projects (and in some cases, manufacturers) because of technicalities that often contribute little to the outcome. A better system is to establish a pool for projects of a certain type and rank them on what they add to the country's objectives, which is how the Consortia-based program brought hybrid technologies to the marketplace. While very consideration should of course be given to U.S. technologies, it is self-defeating to exclude or penalize foreign automakers, bus makers, and/or manufacturers whose products perform better than similar American products. The goals are to reduce foreign oil imports and improve air quality—not subsidize American industry.

Question. Given that carmakers have already embraced a number of more efficient vehicle technologies in products now coming into the marketplace (continuously variable transmissions, hybrid electric engines), what would be the argument against a national policy to use these technologies to reduce gasoline demand and increase our national security, instead of sitting by while they are used simply to increase vehicle weight even more and keep us in our current state of import dependence?

Answer. There is no valid argument against using hybrid electric engines and other technologies already available. We cannot fathom a policy that ignores the present while focusing on 15-20 years in the future. Every gain that can be made in the interim makes us stronger politically and economically and focuses attention on the need to change our behaviors and our attitudes now. It is madness to wait when viable technology exists.

ALLIANCE OF AUTOMOBILE MANUFACTURERS,
April 28, 2003, Washington, DC.

Hon. PETE DOMENICI,
Chairman, Committee on Energy and Natural Resources, Washington, DC.

DEAR CHAIRMAN DOMENICI: Enclosed are responses by the Alliance of Automobile Manufacturers to a list of questions submitted for the record following the March 6, 2003 hearing on energy use in the transportation sector.

Thank you for your leadership on the Committee. If you should have any additional inquiries, please let me know.

Sincerely,

GREG DANA,
Vice President, Environmental Affairs.

[Enclosure]

RESPONSES TO QUESTIONS FROM THE SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

Question 1. Should impacts on passenger safety, vehicle technology, consumer preferences, and market economics be considered when considering new fuel economy standards? Are these factors considered now?

Answer. Yes. It should be remembered that CAFE is a sales weighted average and that the levels reported each year by manufacturers are, to a large degree, driven by consumer preference. Consumer preference is of course driven by market economics; for example, when fuel prices are low, consumers typically opt for vehicles that provide greater utility or performance, while placing little value on fuel economy. When NHTSA sets CAFE standards at a "maximum feasible level," the agency is required to take into account technological feasibility, economic practicability, the effect of other Federal motor vehicle standards on fuel economy, and the need of the nation to conserve energy. NHTSA does consider these factors now. It is not clear that legislative proposals before the Congress have always considered these factors.

Question 2. Does the National Highway Traffic Safety Administration (NHTSA) have sufficient authority and expertise to consider these impacts? What statutory changes might be needed?

Answer. NHTSA has sufficient authority and expertise to consider these impacts.

Question 3. Is there any reason to assume that the National Academy report on CAFE is less accurate now than it was when released a year ago?

Answer. As you know, when the original report was issued, the Alliance raised some serious questions regarding the methodology and the assumptions used in the report. For example, we stated that the panel underestimated the penetration rates of certain key technologies thus the baseline fuel economies already reflect key technologies that NAS later applied. Having said that, we also note that the costs and the fuel economy benefits of the technology included in the NAS analysis do not reflect industry input. The panel generally underestimated the costs of the technologies and overestimated the benefits.

Question 4. Rather than argue here in the Congress about arbitrary mile-per-gallon levels, shouldn't we just get out of the way and let the experts at NHTSA do their job?

Answer. The Alliance agrees.

Question 5. Should we consider CAFE credits for hydrogen vehicles as a way to encourage their manufacture and sale?

Answer. TITLE 49, SUBTITLE VI, PART C, CHAPTER 329, Section 32905 of the U.S. Code provides for CAFE credits for alternative fuels including hydrogen. In addition to these existing credits, some credits should also be given for hydrogen infrastructure development.

Question 6. Should we remove the cap on CAFE credits for alternative fuel vehicles to provide a greater incentive for their sale?

Answer. Technically, there should be no cap on the credits as an incentive for the sale of vehicles that can operate on non-petroleum fuels. At a minimum, the Alliance believes that Congress should extend the current 1.2 mpg cap on CAFE credits for the sale of dual fuel vehicles for at least 4 additional years. This will provide further incentive to manufacturers and will further increase the number of alternative fuel capable vehicles in public use.

Question 7. Is "miles per gallon" an appropriate efficiency metric if we are no longer using gallons of gasoline in the future? Will CAFE be needed in a hydrogen-car based system?

Answer. It might be helpful to consumers to have a means of comparing fuel prices using a convenient, readily understood metric such as "miles per equivalent gallon" We don't believe that CAFE would have any applicability in the new world of hydrogen cars.

ADDITIONAL QUESTIONS

Question 1. Aside from new R&D funding, what can/should Congress do to hasten development of hydrogen-fueled vehicles?

Answer. Incentives for development of the infrastructure to support these vehicles are needed.

Question 2. Which policy actions are more important for deployment of advanced technology vehicles—R&D, tax incentives, demonstration projects, or regulations.

Answer. The first three items listed are all important in development of advanced technology vehicles.

Question 3. Given the focus on hydrogen as the transportation fuel of the future, how much effort should we expend on using other alternative fuels? For example, should (we) use natural gas directly for transport or convert it to hydrogen first?

Answer. There may be many paths to hydrogen as a fuel. Work needs to be done to evaluate different production methods for hydrogen.

Question 14. You say in your testimony that fuel efficiency has improved at 1.5% per year for the last 20 years. Why, then, has actual fuel economy remained relatively flat?

Answer. The statement in my testimony refers to the continual application of new technology to vehicles, such that the fuel efficiency of vehicles has increased continually. Efficiency should not be confused with fuel economy, especially fleet average fuel economy. The average fuel economy of the fleet has declined in recent years due to a shift in the sales mix of the fleet. As fuel prices have remained low, consumers have opted for larger, more versatile vehicles.

Question 15. To what extent do consumer choices play a role in determining whether actual fuel economy increases from one year to the next?

Answer. Consumer choice is the paramount driver for whether average fuel economy increases or decreases from one year to another. Manufacturers continue to offer more fuel efficient models and powertrain combinations each year, yet the fleet average economy is relatively stable.

Question 16. What can the Federal government do to encourage the auto manufacturers to produce hydrogen fuel-cell vehicles?

Answer. The Administration has already set in place the Freedom Car and Freedom Fuel programs. These efforts directed at basic R&D in the development of fuel-cell cars and in the hydrogen infrastructure are critical. Beyond this, the most important action the government can take is to pass legislation similar to the CLEAR Act of last year that provides tax incentives to consumers to purchase advanced technology vehicles.

Question 17. Do we have to wait for the end of the FreedomCAR program to see results, or will there be interim technologies that can be incorporated sooner?

Answer. As the PNGV program, the predecessor to the FreedomCAR program showed, as discreet developments occur in basic R&D these can be periodically moved into mainstream vehicles when opportunities exist to provide value to customers.

Question 18. What is the potential fuel economy benefit of technologies of hybrid and diesel technologies?

Answer. Depending on the type of hybrid system employed in a vehicle, the fuel economy benefit can range from very small to upwards of 50% improvement (depending on driving conditions) compared to a conventional gasoline-fueled vehicle. Advanced technology diesels can achieve up to 30-40% improvement compared to a conventional gasoline-fueled vehicle.

Question 19. What must be done to improve diesel fuel quality and enable widespread diesel use in transportation?

Answer. Diesel fuel in the United States needs to improve up to the levels of fuel sold in Europe and California. Four critical areas of fuel quality improvement to enable the next generation of light duty diesel vehicles in this country include: cetane, aromatics, lubricity and sulfur.

- Cetane, is an indication of how quickly the fuel ignites in the engine. Low cetane levels increase NO_x emissions, according to European auto/oil studies. Low cetane causes poor vehicle performance in terms of smoking on start-up and increased noise, vibration and harshness. This issue creates a significant barrier to customer acceptance in the marketplace.

  Importantly, the high cetane levels found in Europe and California have enabled the newer, high performance common-rail diesel engines beginning to emerge in that market. According to Infineum's Worldwide Winter Diesel Fuel Quality Survey 2002, the mean cetane number in Europe was about 53 with a minimum of 47 (Romania). In the U.S., the corresponding values were 44 and 38 (excluding California which requires higher cetane). That survey shows U.S. cetane levels to be the worst in the world, including developing countries, yet cetane is easily raised. The World-Wide Fuel Charter, endorsed by automakers from around the world including the Alliance, recommends a minimum cetane number of 55 or cetane index of 52 for countries requiring the most advanced technologies and having the most stringent emission standards.
- Aromatics are precursors to soot and particulate emissions and affect both current and future vehicle technologies, especially diesel particulate filter operation. High levels of aromatics will cause premature filter plugging and require more frequent filter regeneration, which, in turn, reduces fuel economy. It also affects NO_x emissions, which is one of the most challenging of the new Tier 2 emission standards for diesel-powered vehicles. The World-Wide Fuel Charter recommends a maximum total aromatics content of 15% by weight. The most recent fuel survey conducted by the Alliance [1] shows U.S. diesel aromatics levels averaging over 36% by volume and ranging to 49% by volume. Europe limits the most troublesome aromatics (multi-ring or poly-aromatics) to 1% by volume.
- Lubricity affects the amount of wear on moving metal parts. Inadequate lubricity cause excessive pump wear and, in some cases, catastrophic failure. Modern light duty diesels, in particular, require good fuel lubricity due to their very high fuel injection pressures. Fuel additives can assure adequate lubricity very inexpensively (for less than 0.5 cpg). The World-Wide Fuel Charter recommends a maximum of 400 microns wear scar diameter at 60°C using the HFRR (high frequency reciprocating rig) test method. This test method is also incorporated into the European fuel specification, albeit at a slightly higher level of wear (460 microns).
- Sulfur is the most critical fuel component for enabling the new emission control devices needed to achieve Tier 2 emission standards for light duty diesel vehicles. The lower the sulfur, the better the vehicle performance in terns of emissions, durability and fuel economy. The U.S. EPA recently issued a regulation, supported by the Alliance, that will cap sulfur in highway diesel fuel at 15 parts per million (ppm) in late 2006. Europe has adopted a 10 ppm limit on fuel sulfur.

Question 20. Do you agree with the UCS analysis that automakers will have no problem meeting the proposed 1.5 mpg increase in light truck/SUV CAFE standards?

Answer. No, as noted above, CAFE is a sales weighted average reflecting customer purchase habits. Consumer demand drives the marketplace and consumers place little value on fuel economy. Consumers demand better performance and continued improvement in vehicle safety. These two factors can have detrimental impacts on fuel economy.

[1] Alliance of Automobiles Manufacturers' North American Fuel Survey, Summer 2002.

RESPONSE TO QUESTION FROM SENATOR AKAKA

CARBON DIOXIDE EMISSIONS AND GLOBAL CHANGE

Question. Within the transportation sector, what percentage of carbon dioxide emissions come from vehicles with lower CAFE standards, such as SUVs and light trucks, or diesel engines, compared to passenger cars with higher CAFE standards?

Answer. According to the EPA's most recent annual inventory, U.S. Greenhouse Gas Emissions and Sinks: 1990-2001 (draft), in 2001, transportation sector $C0_2$ accounted for 26% of total U.S. greenhouse gas emissions. Automobile and light truck $C0_2$ accounted for 9% and 7%, respectively, of the total U.S.GHG emissions (or 35% and 26%, respectively, of transport sector $C0_2$ emissions). These statistics illustrate that the transport sector is one component of total greenhouse gas emissions and also, while light truck sales have increased significantly in recent years, many more older automobiles are still on the road today.

APPENDIX II

Additional Material Submitted for the Record

STATEMENT OF HON. DAVE CAMP, U.S. REPRESENTATIVE FROM MICHIGAN

Mr. Chairman, I appreciate the opportunity to submit testimony on a subject that has the potential to revolutionize the way Americans view the automobile. Hydrogen fuel cell and other alternative fuel, advanced technology vehicles have the potential to positively impact the American economy, our environment, and bolster national security. The ability for cars to run on zero emissions will produce powerful results.

In January President Bush outlined a comprehensive strategy for our nation that included a commitment to developing a hydrogen fuel cell auto market. As you may recall, President Bush announced a $1.2 billion hydrogen fuel project that seeks to make hydrogen-powered fuel cell vehicles commercially competitive. The initiative seeks to also reverse America's growing dependence on foreign oil by developing the technology for commercially viable hydrogen-powered fuel cells to power cars and trucks.

On Tuesday, March 4, 2003 I introduced the CLEAR Act which stands for the "Clean Efficient Automobiles Resulting from Advanced Car Technologies Act". This legislation would provide consumers tax incentives for purchasing advanced technology and alternative fuel vehicles. These incentives are one of the most positive steps that can be taken today to promote increases in the fuel economy of new vehicles. With growing concerns about our energy supplies and prices in the U.S., we should move quickly to accelerate the introduction of these alternative fuels and advanced technologies into the marketplace.

All of the major automakers that sell in the U.S. market have either introduced or have announced plans to introduce vehicles that promise to provide advantages of one type or another compared to conventional, internal combustion engine technologies. Compared to conventional vehicles, these new products may have better emissions characteristics, use alternative fuels or may provide significant increases in the mileage achieved on a gallon of gasoline. Regardless, they utilize new and emerging technologies that—at the present time—are much more expensive than conventional vehicles with which they must compete. As these vehicle technologies gain consumer acceptance and production volumes increase, the cost differential between these vehicles and conventional vehicles will be reduced or eliminated.

So what do we need to do to put consumers in the drivers seat and provide them the ability to choose—and accelerate the demand for—these new technologies? The CLEAR Act would provide tax incentives to help offset the higher costs of these vehicles, so that the cost to consumers can be held at a competitive level. This legislation provides incentives for a broad spectrum of vehicle and fuel technologies. This broad coverage is very important because the choice of the right vehicle and its attributes is best left to the consumer and the marketplace, not government decisions or limitations.

Specifically, the legislation will develop market acceptance of a wide range of advanced technology and alternative fuel vehicles including: Fuel Cells, Hybrids, Dedicated Alternative Fuels and Battery Electric.

The CLEAR Act provides a tax credit of 50 cents per gasoline-gallon equivalent for the purchase of alternative fuel at retail. To give customers better access to alternative fuel, we extend an existing deduction for the capital costs of installing alternative fueling stations. We also provide a 50 percent credit for the installation costs of retail and residential refueling stations.

Finally, we provide tax credits to consumers to purchase alternative fuel and advanced technology vehicles. To make certain that the tax benefit we provide translates into a corresponding benefit to the environment, we split the vehicle tax credit in two. One part provides a base tax credit for the purchase of vehicles dedicated to the use of alternative fuel or vehicles using advanced technologies. The other part offers a bonus credit based on the vehicle's efficiency and reduction in emissions.

Tax incentives will sunset within 6 years for all applications with the exception of fuel cell vehicles which are extended to 10 years. With minimum development cycles of 2-4 years for new vehicles, incentives are needed now to move existing designs to the market so they can accelerate the process for customer acceptance.

The CLEAR Act was introduced in the Senate by Senator Orrin Hatch and enjoys broad support from automobile manufacturers, the environmental community and alternative fuel groups. I urge my colleagues to look seriously at this proposal and initiate this important step toward greater vehicle and fleet fuel economy. America will be the winner for having provided this opportunity to pull these exciting new technologies into the marketplace more quickly than they might arrive on their own merit. These consumer based tax incentives will put American vehicle owners in the drivers seat by giving them the opportunity to purchase these new advanced technology products.

Thank you Mr. Chairman for allowing me the opportunity to offer my views on this important issue.

Statement of the American Petroleum Institute

The U.S. oil and natural gas industry is committed to meeting the nation's future transportation fuel needs. Since its beginning, the industry has been in a constant state of change, working to better serve its customers and a growing nation. Relying heavily on advanced technology, the industry has provided improved products to Americans with a steadily reduced impact on the environment, and we will maintain this commitment in the future.

We believe that competition and the resulting push to innovate will mean that our children and grandchildren will be driving vehicles using fuels that, together, are safer, cleaner, and more efficient than ever. These improved cars and trucks may well be propelled by something other than today's internal combustion engine, whether it is an advanced version of that engine or electric hybrids or fuel cell vehicles. We believe the 21st century will be an exciting new era for personal transportation.

While we expect conventional hydrocarbon fuels will remain the dominant energy source, at least through the mid-century, the oil and natural gas industry is committed to providing the fuels for the nation's transportation needs regardless of the fuel type. Future automobiles may be based on a variety of advanced technology engine-fuel systems, including hydrogen-powered fuel cells. At least initially, all of these systems will likely rely heavily on hydrocarbon fuels either directly or indirectly. These advanced fuel/vehicle systems should be allowed to compete with each other in the marketplace and on a level playing field.

The Role of Hydrogen in Meeting Transportation Needs

The American Petroleum Institute appreciates this opportunity to present the views of its member companies on the role of hydrogen in meeting the transportation needs of American consumers.

In his State of the Union Address, President Bush announced a Hydrogen Initiative to hasten the development of hydrogen-powered fuel cells in motor vehicles. API believes that fuel cell vehicles are an exciting new technology that could figure prominently in America's transportation and energy future.

As we understand the program, the Hydrogen Initiative will focus on pre-competitive research aimed at advancing the technology to produce, store, distribute, and deliver hydrogen for use in fuel cell vehicles and electricity generation. The Administration has indicated that the Hydrogen Initiative will complement the FreedomCAR initiative, which supports pre-competitive research in advanced automotive technologies for the mass production of a full range of affordable vehicles, including fuel cell vehicles.

At the outset, we must all recognize that development of hydrogen as a viable transportation fuel source will take time. The U.S. Department of Energy's National Hydrogen Energy Vision and Roadmap reports envision a path for hydrogen development that would span between three and four decades. It is important to keep this timeframe in mind and recognize that hydrogen research will require a long-term commitment. We should also recognize that major technological breakthroughs are required before hydrogen can become a viable fuel source.

The increased national interest in hydrogen as a transportation fuel is understandable. Hydrogen exists in nearly unlimited abundance and, when used in a fuel cell vehicle, generates zero emissions. However, it should be noted that hydrogen only exists in combination with other chemical elements, and significant energy and costs are required to produce and distribute hydrogen for use in fuel-cell vehicles.

API believes that, in weighing the pros and cons of any fuel/vehicle system, it is vital to undertake a "well-to-wheels" analysis of the entire system. The "well-to-wheels" approach considers energy use and emissions for both "well-to-tank" (i.e., production and distribution of the fuel) and "tank-to-wheels" (i.e., use of the fuel in the vehicle). When using this approach, different fuel/vehicle systems can be analyzed on a comparable basis. The internal combustion engine is the benchmark against which the progress of emerging advanced fuel/vehicle systems should be measured.

In considering future transportation fuel needs, there are near- and mid-term options for increasing fuel use efficiency and reducing emissions. Alternatives include hybrid engine systems—a combination of an electric motor and gasoline or diesel engine—and advanced gasoline and diesel engine technologies. The rate of market penetration for hybrids will likely depend upon price and performance; however, it should be recognized that gasoline hybrids are currently in the marketplace and numerous auto manufacturers have announced plans to introduce a variety of additional hybrid models over the next few years. Ongoing R&D continues to focus on reducing the component cost of hybrids. All of this suggests that there is substantial promise for hybrid technology playing an important role in improving efficiency and lowering emissions.

When comparing greenhouse gas emissions on a well-to-wheels basis, a number of advanced vehicle and fuel options compare favorably with today's gasoline internal combustion engine. Diesel engines, gasoline and diesel hybrids, on-board gasoline reformer based fuel cells (i.e., systems where hydrogen is produced on-board the vehicle via extraction from gasoline-like fuels), and fuel cell vehicles powered by hydrogen produced from natural gas all have lower greenhouse gas emissions. In contrast, hydrogen produced via electrolysis of water using electricity from typical U.S. sources has very high greenhouse gas emissions. Thus, there are a variety of advanced systems that have the potential to lower greenhouse gas emissions, but none of these systems result in 'zero' greenhouse gas emissions.

To address the areas mentioned above, API member companies have undertaken substantial research activity in advanced technologies such as hydrogen production and storage, combustion fundamentals, exhaust aftertreatment, and improved hydrocarbon-based fuels that enable lower emissions and higher efficiency. Much of this work is done in close collaboration with automobile and engine manufacturers, the government and other partners.

TECHNOLOGICAL BREAKTHROUGHS NEEDED FOR HYDROGEN AND FUEL CELL VEHICLES TO BE VIABLE

Technological breakthroughs are required to reduce fuel cell vehicle costs and to reduce production, delivery and storage costs of hydrogen for the system to be competitive against the ever-improving performance of advanced internal combustion engine and hybrid vehicle systems. Moreover, increased use of hydrogen as a transportation fuel involves other challenges, including safety, the potential need for a new distribution infrastructure, and a need for approaches that address potentially increased emissions due to hydrogen production.

COST REDUCTION AND CO_2 EMISSIONS NEED TO BE ADDRESSED

Breakthroughs are needed to lower the cost of fuel cells and fuel cell vehicles. For example, the cost of the fuel cell stack needs to be reduced substantially to compete with a conventional powertrain. The cost of fuel cells has dropped by about a factor of 100 over the last 10 years, but automakers say that costs must still be reduced by more than a factor of 10 for the technology to become competitive.

Like electricity, hydrogen is an energy carrier, not an energy source. To succeed in the market, hydrogen will need to be produced in large volumes at reasonable cost. But, without a major breakthrough in production technologies, most hydrogen would likely continue to be produced from natural gas, the most affordable source of hydrogen with current technologies. However, the United States is short of indigenous natural gas and, in order to provide large amounts of hydrogen, access to the potentially large natural gas reserves on government lands and/or imported LNG will be needed. Hydrogen production is, therefore, an important research area.

If hydrogen were made from natural gas or other fossil fuel sources, then CO_2 would also be generated as a by-product. If low greenhouse gas emissions are to be achieved in that scenario, it would be necessary to separate, capture and store the CO_2 generated (i.e., CO_2 sequestration). Thus, breakthrough research focusing on CO_2 separation, capture and storage methods is also important. If, on the other hand, sufficient electricity could be generated by renewable or nuclear technologies to make hydrogen from water, then CO_2 sequestration technologies would be less important. However, cost reduction breakthroughs in renewable and nuclear technologies would be needed.

DISTRIBUTION INFRASTRUCTURE ISSUES NEED TO BE ADDRESSED

Hydrogen distribution could take one of two forms: pipelines or specially designed, very-low temperature tankers. Currently, high-pressure tankers are limited in their energy-transporting volume. Because hydrogen has a much lower energy density than gasoline, it would require 19 hydrogen tankers to carry the energy value of one gasoline tanker assuming the hydrogen and gasoline tankers were of similar size. On the other hand, pipelines could move much greater volumes, but existing natural gas pipelines are not suited for hydrogen and new ones would be required.

Developing a distribution infrastructure for hydrogen for direct fuel use would be costly. However, there are alternatives such as using the existing hydrocarbon fuels infrastructure and extracting the hydrogen with an on-board reforming system or producing the hydrogen at the retail station. These alternatives would help resolve safety and infrastructure issues needed for the initial introduction of fuel cell vehicles, provide time to advance breakthrough research, and provide a 'bridge' to hydrogen should breakthrough research be successful. The on-board gasoline reformer faces a number of challenges that must be overcome as well. Reducing reformer start-up time and energy losses are key areas of improvement where R&D is and needs to be focused.

SAFETY AND STORAGE ISSUES NEED TO BE ADDRESSED

Issues related to hydrogen production and distribution, retail delivery, storage and vehicle safety must all be addressed and the unique safety challenges should be addressed through the development of data-based codes and standards. Breakthroughs in hydrogen storage are needed and are being progressed. Areas of focus include advanced materials for low-pressure storage, technologies to extend driving ranges and reducing storage costs.

LOOKING AHEAD

As we move into this new century, the U.S. oil and natural gas industry will continue working with the automotive industry and government to keep improving our fuels and vehicles. Working together, we have made tremendous progress since the 1970s in reducing emissions and improving fuel economy while maintaining consumer satisfaction. Reduced auto emissions have contributed heavily to the dramatic reductions in overall emissions of major pollutants. Despite a 41 percent increase in energy consumption in that time period, ambient levels of carbon monoxide have been reduced by 28 percent, sulfur dioxide by 39 percent, volatile organic compounds by 42 percent, and particulate matter by 75 percent. We will accomplish a great deal more this decade under existing standards of the Clean Air Act as well as new national vehicle emission and fuel standards that come into effect in 2004 and 2006.

The auto and oil industries have made tremendous progress together over the years, introducing a range of improved vehicles and enabling fuels to reduce emissions, and increase fuel economy, and performance. We fully expect this trend to continue and strongly support R&D focused on achieving the full potential of advanced internal combustion engines, hybrids, and advanced fuels. We also recognize the long-term commitment required for R&D focused on the breakthroughs necessary to enable fuel cell vehicles and hydrogen fuel opportunities.

Moreover, whatever role government plays in fuel cell development, it should be a broad one. Government should encourage a multi-faceted approach. We believe that government's research role should be focused on pre-competitive, breakthrough research, leaving it to the private sector to build on this research and move the outcomes into the commercial development phase. The government should not prematurely focus on one approach while discouraging other approaches that may have high potential. Advanced technologies should compete on a level playing field with the American consumer ultimately making the choice of which technologies will be successful.

Our industry wants to work with government and others in the private sector to evaluate fuel cells and other advanced vehicle fuel systems from a well-to-wheels perspective. We believe that fuel cells may have an important role to play in the nation's transportation fuels future. We also believe that the fuel cell and hydrogen challenge should be viewed as a system. Each piece of the system, including the primary source of hydrogen, the production, distribution, retail delivery, and storage of hydrogen and the fuel cell vehicle itself, has challenges that must be overcome with innovative breakthroughs in order for the system to become competitive. We should take advantage of, and capture, the benefits of advanced gasoline and diesel technologies, including hybrid technology, in the near- and mid-term while the challenges of fuel cell and hydrogen technologies are being researched. The U.S. oil and natural gas industry is committed to playing a leading role in this important national effort.

STATEMENT OF JEFFREY A. SERFASS, PRESIDENT, NATIONAL HYDROGEN ASSOCIATION

The National Hydrogen Association (NHA) is an industry led trade association dedicated to removing barriers to the implementation of hydrogen energy systems. The NHA is comprised of nearly 80 members, including energy companies, automobile manufacturers, fuel cell developers, industrial gas producers, chemical companies, national laboratories, and universities. The NHA was formed in 1989 to foster the development of hydrogen technologies and their utilization in industrial and commercial applications and to promote the transition role of hydrogen into the energy field. The NHA serves as a catalyst for information exchange and cooperative projects and provides the setting for mutual support among industry, government, and research organizations.

The NHA applauds the Department of Energy's National Hydrogen Energy Roadmap. The Roadmap, developed in 2002, is a well-balanced plan with an intelligent transition strategy first relying on conventional feedstocks and optimized hydrogen fueled conventional conversion devices to pave the way for the introduction of the fuel cell, when it is market-ready.

The NHA supports the President's Hydrogen Fuel Initiative, announced in his State of the Union address on January 28. This initiative, if fully funded, will go a long way toward creating the infrastructure necessary for clean transportation using domestically-produced hydrogen.

The NHA recognizes the need for economic incentives, including tax policies, at the appropriate point in the technology development and early commercialization. The NHA advocates increasing incentives as technologies—such as hydrogen powered ultra low emission vehicles (ULEVs) and zero-emission vehicles (ZEVs) become available for buyers. The NHA advocates incentives (rather than mandates, requirements, or regulations) to ease market penetration. This includes voluntary emission credit trading schemes to begin to manage greenhouse gas emissions.

The NHA also supports initiatives involving use of hydrogen for stationary power, portable power, and transportation. The organization pledges to work to make all these visions a reality.

BENEFITS OF HYDROGEN ENERGY

The global appeal of hydrogen is that it has the potential to free most countries from the requirement to import large quantities of oil. The global markets for vehicles, aircraft, and electricity represent growth industries through the 21st Century. Estimates are that the number of vehicles worldwide could grow by a factor of 10 over the next century. Approximately 40% of the human race has no access to electricity and many of those who have access are served by electricity that is either unreliable or not available 24 hours per day. Such unfulfilled demand makes it an imperative to develop cleaner methods of transportation and power production that will be globally applicable and that can reduce environmental degradation.

Given the structural changes in electric utility markets, with their eventual globalization, and the existence of global vehicle and aircraft markets, the focus of a global hydrogen vision coincides with a shift to marketing products that could operate globally on hydrogen. Satisfying the demand for clean electricity, cars and aircraft with hydrogen-fueled products will, in turn, drive the development of adequate hydrogen production and storage to support it. It has been recognized for more than a decade that automakers must make world cars and aerospace companies must design and sell aircraft globally. With the restructuring of the electric utility industry, utilities are forming subsidiaries that are looking beyond their home territories and countries, as well as signing worldwide agreements to provide energy to industrial and commercial clients.

Five major trends have emerged that are shaping today's discussion of a hydrogen bridge.

1. There is an increasing emphasis on National Energy Security.
2. There is increased interest in climate change and the specific role of CO_2 in global warming.
3. The acceptance of renewable energy, particularly photovoltaics for niche markets, has increased dramatically.

4. Restructuring of the utility industry has allowed serious consideration of distributed generation and alternate energy delivery systems.

5. The emphasis on zero-emission vehicles (ZEVs) and ultra-low-emission vehicles (ULEVs) in Southern California and a growing interest in other parts of the world has created a clean vehicle market for auto manufacturers.

Since the 1970s, environmental concerns have continued to become more acute, especially with exploding population growth and rapid industrial development throughout the world. Issues of the environment also have become globally connected issues. Issues and concerns that were once only considered in a local or national context are now perceived as international issues. Internationally common concerns about nuclear power plant accidents, atmospheric nuclear testing, acid rain, ozone depletion, and climate change all attest to this globalization. The use of hydrogen energy in a fuel cell results in no harmful emissions at the point of use. Hydrogen produced from renewable resources also reduces harmful emissions during production. Hydrogen can be produced renewably through electrolysis of water, or through reformation of fossil fuels. This enables hydrogen to be the key to energy diversity, and sustainability.

In many countries, increasing concerns about carbon dioxide, ozone, nitrogen oxides, volatile organic compounds, sulfur oxides, and many other emissions have led to more stringent regulations. Under the increased severity of environmental regulations and the greater scope of environmental problems, the concept of a hydrogen energy system is very attractive. As an energy carrier, hydrogen is clean. In its purest form, hydrogen can be produced from water or biomass and recyclable back to water.

The tragic events of September 11, 2001 sounded a clarion call for the need for energy security. Each country has the potential to provide for its own energy needs, including economic growth, through the use of hydrogen energy.

There is strong and growing interest in using hydrogen as a transportation fuel. With the market price of transportation fuels being the largest use for petroleum and higher than the market price for other applications, this offers a unique opportunity for hydrogen to become cost competitive with conventional fuels. The NHA believes a thrust in the area of transportation will provide a large, long term opportunity for commercial application of hydrogen energy technologies and contribute to the creation of a hydrogen energy infrastructure. Automobiles provide the best opportunity to engage the public now in the benefits and reasons to move toward hydrogen energy. Buses and fleets, however, can provide an even earlier market, with fewer infrastructure considerations through use of centralized refueling and should be a central part of near term programs.

At this time of increasing industrialization and population growth, the vision of sustainably produced hydrogen, driven by an inexhaustible clean energy source for the mid-21st Century, is more attractive than ever. But is there a way to bridge from our fossil fuel, nuclear, and electric present to a hydrogen electric future? Is there an affordable, acceptable, and sensible role for hydrogen that we should be developing over the next 10 to 50 years to create a future hydrogen economy and, if so, what actions need to be undertaken?

CHALLENGES FOR HYDROGEN

Over time, expanding demand and constrained supply will make traditional fossil sources less abundant and more expensive than at present. Over the past 25 years, many environmental factors have moved much of the industrial world from a nuclear and fusion future for electricity, to one based on an increasing displacement of fossil fuels by renewables into the 21st Century. While electricity produced from renewables is very clean, electricity is not a universal energy carrier. Electricity cannot, for example, be used as aircraft fuel, for long-range road vehicles, or for manufacturing processes that require a hydrogen source. Long-term electric storage is prohibitively expensive. Hydrogen could provide storage capability for electricity, fuel aircraft and ground transportation, and still be used in the production of ammonia, hydrocarbons, plastics, and other products. The challenge will be developing commercially acceptable ways of storing, transporting, and utilizing renewably produced hydrogen.

A bridge strategy for hydrogen will only be effective if it relies on hydrogen's unique capabilities rather than forcing hydrogen to compete with lower-cost, more convenient energy carriers that meet the same needs. In considering this statement, it should be pointed out that methane (natural gas) is also a form of renewable energy; it can be produced from waste products or gasified biomass, which will not disappear as an energy carrier when the last natural gas well is depleted. Natural gas may well have a lower price than hydrogen when produced renewably. To compete with natural gas, hydrogen may have to rely on its unique chemical and physical properties.

A hydrogen bridge strategy also must consider the status of hydrogen production, storage, and end use. Today hydrogen is obtained primarily by processing fossil fuels (natural gas and oil) or recovered as a by-product from chemical and petroleum processing. Production from natural gas requires reformers. Production from coal requires carbon sequestration. Future production can be achieved through biomass gasification, by electrolysis with the electricity supplied by renewable sources, and eventually through various photobiological, photochemical, and thermochemical processes. Efficiency gains in electrolysers are desirable for this option to be economically competitive with natural gas reforming.

Pipelines designed for transportation and storage of hydrogen are in use today, but storage technology must be improved. For long-range transport, storage densities must approach 10% by weight for hydrogen. This is achievable today with liquid hydrogen storage.

Storage onboard vehicles must allow for driving ranges competitive with today's gasoline engine technologies. Compressed hydrogen gas is a viable option, and several companies are working on tanks to allow higher pressure storage than exists today.

Hydride storage is also a promising option, with a number of companies exploring various designs for portable power applications, as well as automotive applications.

New developments in gaseous and metal hydride storage technologies have not allowed sufficient storage densities. This has led to increasing consideration, particularly in Europe, of liquid hydrogen as the principal form of hydrogen storage for vehicles. Lack of progress in magnetic refrigeration has deferred consideration of distributed hydrogen liquefaction.

Nanotube technology also shows promise, but is a longer-term option in need of additional RD&D, as well as technology validation.

Utilization of hydrogen is a complicated issue. Three applications of interest are aircraft, ground transportation, and power generation. The major enabling technology for two of these options (ground transportation and power generation) is fuel cells. Current estimates are that early fuel cell production units will cost $2,500/kW. This is too expensive for widespread vehicle use by at least a factor of 10. The advantages of a fuel cell over a combustion turbine or other engine systems are the increased efficiency and reduced NO_x emissions. The development of a fuel cell vehicle operating on hydrogen might evolve from an engine hydrogen system in which at some future point the engine would be replaced with a fuel cell.

In order to realize a hydrogen energy economy, a hydrogen infrastructure must be developed. This may include traditional approaches such as trucking in hydrogen and pipelines, as well as on-site hydrogen generation from fossil fuels or electrolysis.

One challenge to creating the necessary infrastructure is the lack of hydrogen safety codes and standards. Fortunately, the U.S. Department of Energy continues to support industry's efforts to develop the necessary codes and standards to permit hydrogen production, storage, and use, including siting hydrogen refueling stations.

Market distribution channels need to be adapted to hydrogen. In addition, the public must be convinced hydrogen is safe and that conveniences (such as driving range, ease of refueling, etc.) need not be compromised by using hydrogen energy.

Partnerships between energy companies and automotive companies, such as FreedomCAR, and demonstration activities such as the California Fuel Cell Partnership, are beginning to explore how to meet these challenges.

Liquid Hydrogen Option—Today, merchant hydrogen is delivered as a liquid. The exceptions are delivery by hydrogen pipelines and over-the-fence delivery of hydrogen. No hydrogen gas transfers are inter-regional today. The ease with which hydrogen liquid can be turned into a gas allows for a scenario where all hydrogen applications that can be met by hydrogen gas also can be met by liquid hydrogen. The cost of liquid hydrogen is significantly greater than hydrogen gas. However, lower storage and distribution costs and higher storage densities for many applications of liquid hydrogen could give it a more competitive cost, in units such as cost per mile, as compared to gaseous hydrogen; the converse is not true. For instance, new high-tech liquid hydrogen containers are anticipated to lower transportation costs by as much as 50%.

If hydrogen is used in aircraft, storage volume requires that hydrogen must be liquid. The International Standards Organization (ISO) is developing standards for storing and dispensing liquid hydrogen. ISO's expectation is that liquid hydrogen will be the principal means of intercountry transfer of hydrogen. Two advantages of the liquid option are that it eliminates a basic storage issue (10% hydrogen storage by weight), and it is the prime method for the delivery of merchant hydrogen today. For industrialized countries, liquid hydrogen is the default fuel for on-board storage since more than 10% of the storage system weight would be hydrogen.

A liquid hydrogen option almost certainly requires, at least through the mid-term, a centralized option for hydrogen production since economic liquefaction plants must be large. This probably means either a national electric grid with inexpensive power or steam reforming of large quantities of natural gas. Except in countries with extensive natural gas pipelines, liquid hydrogen may be the favored method of hydrogen distribution since it offers more flexibility. Until magnetic refrigeration becomes a reality, liquid hydrogen production is not an option for small-scale production.

The economics for renewable technologies must be comparable in cost for performing the same function as the energy source that is being replaced. If photovoltaics are replacing storage batteries costing $35/kWh in the Andes so that villagers can watch a World Cup Soccer match on television, then photovoltaics or wind systems are economical. If a remote village has no power, then the price paid for renewables can be economical, even if it is a significant portion of a family's available income, as is the case in remote Alaska. In the long term, advances in PV, wind, solar thermal, and biomass technologies and manufacturing techniques will allow the penetration of these technologies into virtually all energy markets. The largest factor in decreasing prices is increases in production capacities. The deployment of these technologies in remote locations supports the development of a bridge for a hydrogen vision.

This "village path" strategy must be examined on a case-by-case basis; however, any alternative to a renewable path is likely to add to environmental problems around the world as fossil fuel use expands to meet the needs of increasing populations and intensified industrialization. As nations are forced to greatly increase purchases and use of fossil fuel, especially petroleum, energy will continue to drain their economies.

OUTLOOK

The role of hydrogen in a future sustainable energy economy is becoming clear. There is unprecedented interest from industry, as demonstrated by the active roles traditional energy companies, such as BP, ChevronTexaco, and Shell are taking in hydrogen. In addition, most of the world's leading automotive manufacturers, including BWM, General Motors, Ford, DaimlerChrysler, Toyota, and Honda, all have hydrogen R&D activities, and many have developed prototypes utilizing hydrogen internal combustion engines or fuel cells. The variety of approaches taken by this growing hydrogen industry is indicative of hydrogen's ability to meet a diverse, sustainable energy market. Industry leaders recognize that a hydrogen energy future is inevitable, and they have chosen to be a part of it.

The government has also demonstrated increased interest in hydrogen energy. In addition to growing technology development funding, the U.S. Department of Energy announced a Hydrogen and Fuel Cell initiative, FreedomCAR, and is restructuring to focus efforts on resolving the challenges of hydrogen production, storage, and use, including cost-competitiveness. Legislators are considering tax incentives for clean energy technologies, including fuel cells and hybrids. The Department of Defense has extended its fuel cell buy-down program yet again, and is investing billions of dollars into portable fuel cell applications.

In fact, the growing interest in hydrogen by various governmental agencies underscores the need for core competency in hydrogen technologies to reside in one place, as was the case in the former DOE Hydrogen Program. Basic R&D efforts often yield results that may be applicable, even revolutionary, for an application outside the intended scope of study. Only through evaluation from a knowledgeable core competency base can this information be properly transferred between agencies and programs in a way to benefit all stakeholders.

The National Hydrogen Association and its members are well positioned to work with government to meet the challenges facing the widespread adoption of hydrogen technologies. With strong membership from the energy sector, automotive manufacturers, fuel cell companies, industrial gas suppliers, and a growing number of hydrogen producers and component developers, the NHA represents the common interests of the hydrogen community. Through partnerships with the government, the NHA will continue to support the development of hydrogen safety, codes and standards to permit the siting of hydrogen energy systems. Ongoing efforts include international standards and national codes for hydrogen refueling stations, and international standards for components, including liquid and gaseous hydrogen tanks, and metal hydride canisters, as well as hydrogen production equipment.

The hydrogen industry has a growing interest in educating regulatory agencies, decision makers, taxpayers, and the public on the benefits of hydrogen technologies, as well as safety aspects of hydrogen energy systems. Too often hydrogen project developers have been stalled in attempts to implement projects because regulatory agencies (including DOT as well as local and state building, fire, and fuel gas code officials) have indicated they are not familiar with the technologies or the expertise available on hydrogen energy systems. The National Energy Policy called for hydrogen education and outreach, and the NHA is working closely with DOE and other agencies to create a cost-effective, but robust program to provide the information needed to facilitate the acceptance of hydrogen energy systems in transportation, stationary power, and portable power applications.

With all this interest focused on the creation of a diverse hydrogen energy economy, hydrogen is truly "The Freedom Fuel".

COMPONENTS OF COMPREHENSIVE HYDROGEN LEGISLATION SUPPORTING THE FREEDOMCAR PROGRAM AND THE HYDROGEN FUEL INITIATIVE

The NHA recognizes the important role of domestic fossil fuel resources including coal, gasoline, natural gas and diesel to transition to a hydrogen economy. In the near-term, a significant portion of hydrogen will be produced from fossil fuel feedstocks. The NHA supports further technological development for these processes aimed at reducing the cost of hydrogen and reducing or eliminating the environmental effects from these methods.

The NHA also supports technological and economic development of renewable energy technologies, and envisions a growing portion of future hydrogen production to come from renewables. The end point would be a diverse portfolio of hydrogen generation technologies and feedstocks, with as much hydrogen production from renewables as is practical. Longer-term continuation of fossil fuel feedstock and even nuclear production of hydrogen are possible if the environmental damage and security issues from these methods could be eliminated or sufficiently mitigated. Ultimately, society and the market will determine the energy mix consistent with its resources, social structure, population, economy, and environmental requirements.

The National Hydrogen Association embraces the House-Senate Conference resolution on the Brown and Walker Hydrogen Future Act of 2002 and its components as a starting point for new legislation authorizing work in support of the President's Hydrogen Fuel Initiative with DOE's FreedomCAR program. We would keep the concepts, update the language, add components and modify the structure to reflect both the focus of the Initiative as well as the broader hydrogen interests presented below:

- Preamble—describe this as the first five-year component of a 15-year program to make clean, cost-effective hydrogen vehicles and a hydrogen infrastructure a commercial reality.
- Lay out the vision:
  - —At the end of 5 years demonstrate that technical and life performance targets have been met. Develop the national infrastructure plan
  - —5-10 years hydrogen fuel cell cars in small fleets and reduced costs. Show at the end of 10 years that an assembly line can produce cars that satisfy the performance and life goals in quantities of 10,000. Demonstrate refueling infrastructure in the field. Show at least one commercialization success.
  - —10-15 years large vehicle fleets begin to install infrastructure continue to improve performance, reduce cost and extend life of vehicle and fuel cell.
- Program should include:
  - —Hydrogen infrastructure demonstrations in coordination with vehicle demonstrations
  - —Broad-based Educational Activity to prepare the public
  - —Develop a National Plan for infrastructure deployment
  - —Technical development plan for deployment
  - —Funding for demonstration projects
  - —Assist commercialization of early fuel cell and hydrogen opportunities in portable and stationary applications
  - —Some funding to colleges and universities to fund technologists and do fundamental research on catalysts, materials and membrane development
- How do you make it happen?
  - —Fully fund a 5 year authorization of funds for the President's Fuel Initiative:
    - —FY '04 $100 million for President's Fuel Initiative and increasing $25 million per year to FY'08.
    - —Freedom Car following its projected funding pattern.
  - —Joint programs with state and local government on:
    - —Education for code officials and motor vehicle inspectors

—Coordinate state, local and federal incentives

—Demonstration programs which involve state and local officials in the technical program and the educational activity

—Use of clean technology in national parks. This can range to only allowing in fuel cell hydrogen power tour buses to requiring RVs to use only fuel cell hydrogen generators and park vehicles only operate on fuel cells and hydrogen.

—Deployment only occurs if codes and standards exist to assure safe. A mention of the need for a rational, comprehensive and tested set of codes and standards should be included in the legislation.

- Structure the bill to focus on the following four program components:
  - —Hydrogen Production—improve existing production technologies from currently available feed stocks and develop radically better production technologies, with the ultimate goal of producing hydrogen from sustainable fuels and renewable energy.
  - —Hydrogen Infrastructure—including codes and standards and interaction with states and cities, for both distribution and dispensing of hydrogen.
  - —Hydrogen Storage—both at fueling stations and on board vehicles.
  - —Hydrogen End Uses—Fuel cells and engines in commercial vehicles and other applications.
- Address the following four functional elements:
  - —Basic Research, in areas such as electrochemistry, catalysis, storage and electronics, to improve on the existing technical knowledge, and to address problems for which no solution is in sight.
  - —Demonstrations, to validate technical readiness and gain public support at the component, full system, and integrated infrastructure levels.
  - —Early Commercialization of component, technology and product successes, with tax incentives, buy downs, etc., to provide the stimulus to the formation and continued health of emerging businesses before the entire infrastructure and set of system components are available.
  - —Education and Outreach directed toward the education system, children, the public and political leaders, well linked to demonstrations.
- Provide funding authorization consistent with the President's announced initiative, addressing all of the structural elements and functions above. We don't have the basis for generating funding numbers, but the trajectory should recognize the expensive nature of demonstrations and the role of industry cost-sharing.
- Provide incentives for manufacturers and users
  - —Technical assistance in the development of manufacturing processes (very likely the tolerance required for making a suitable hydrogen vehicle on an assembly line will require a revamping of our machine tool industry and the application of new manufacturing techniques, the national labs have the ability to assist in the development of the new unit processes needed.)
  - —Tax credits either to subsidize the vehicle sale price or as a rebate to purchasers
  - —Tax credits to subsidize the deployment of infrastructure
- Continue the independent advisory and oversight committees, and the interagency task force.
  - —An interagency committee to oversee hydrogen and fuel cell development chaired by DOE Secretary and including DOT, DOD, NASA, EPA and other agencies as thought appropriate. As a Presidential initiative, OSTP should also be a participant.
  - —An oversight committee that reviews both Freedom Car and the President's Fuel Initiative. It could be HTAP to review the both programs and provide guidance while the National Academy of Science (Engineering) provides an assessment of technical readiness to move to the next phase of activity.
- Although the President's initiative is focused on personal vehicle transportation, the legislation should embrace the supporting technical and early commercialization roles of stationary and even portable applications, and buses, off-road and industrial vehicles as precursors to commercial automobiles.
- Although the economic and environmental superiority of fuel cells is real, the use of hydrogen in internal combustion engines provides an additional, possibly earlier, path to the development of a vehicle and fueling infrastructure.
- The program's deliverables cannot be precisely timed, but must include multiple demonstrations along the path, even in this initial five-year period, including limited deployment of prototype fleets with the supporting infrastructure. In-

dustry and government will have to work together to decide on the appropriate demonstration points.

STATEMENT OF PHIL LAMPERT, EXECUTIVE DIRECTOR, NATIONAL ETHANOL VEHICLE COALITION (NEVC)

I am Phil Lampert, Executive Director of the National Ethanol Vehicle Coalition (NEVC). The National Ethanol Vehicle Coalition is the primary national advocacy association for the advancement of E85 vehicle technology, fuel utilization and infrastructure development. Established as a non-profit organization, the NEVC enjoys the membership and support of all three domestic auto companies, various state corn growers associations, the 29 states comprising the Governors' Ethanol Coalition as well as farming, other stakeholders, and individuals interested in establishing E85 as the preferred alternative transportation fuel. The NEVC appreciates the opportunity to provide comments for the record of the Committee's hearing on Transportation Energy Use.

The Mission of the NEVC is to promote the use of 85 percent ethanol as a renewable form of alternative transportation fuel while enhancing agricultural profitability, advancing environmental stewardship and promoting national energy independence.

The Department of Energy estimates that the nation is now importing 56% of our total petroleum needs and more than 70% of our nation's annual consumption of transportation fuels. Gasoline and diesel fuels power our economy and allow Americans the great mobility upon which we have become accustomed. While hydrocarbons continue to dominate the transportation fuel sector and will do so for decades to come, a number of other forms of fuels have begun to be introduced to the nation's motoring public. These alternative transportation fuels include 85% ethanol, 85% methanol, compressed natural gas, propane, bio-diesel, and electricity. Each of these alternative fuels provide advantages in that they can be produced domestically, they contribute to American jobs, and they are lower in the emissions of exhaust pollutants and greenhouse gases. We believe E85 can play a unique role in addressing our nation's energy security needs.

$3 billion to total farm income, and reduce greenhouse gas emissions significantly. As auto manufacturers continue to make significant investments to bring E85-capable vehicle technology to the marketplace, there is an urgent need for incentives and other mechanisms to expand the E85 refueling infrastructure and to build support for increased use of E85 in these vehicles.

Like all fuels, E85 has advantages and disadvantages when compared to gasoline. E85 can be produced from agricultural products, biomass, and even waste such as wood chips and municipal solid waste. E85 vehicles have traditionally been marketed with no pass-thru cost to the consumer, as the manufacturers are currently absorbing the small incremental cost to produce a vehicle that can operate on gasoline and/or E85.

Additionally, 85% ethanol fuels significantly reduce the incidence of Greenhouse Gas Emissions. In a January 1999 report titled Effects of Fuel Ethanol Use on Fuel-Cycle Enemyand Greenhouse Gas Emissions, the Center for Transportation Research at Argonne National Laboratory concluded:

> That using today's current corn to ethanol technology, for every vehicle mile traveled the use of E85 resulted in a 73-76% reduction in petroleum use, a 14-19% reduction in greenhouse gas emissions, and a 34-35% reduction in fossil energy use; and that using "NEAR FUTURE" cellulosic ethanol production, for every vehicle mile traveled the use of E85 resulted in a 73-75% reduction in petroleum use, a 68-102% reduction in greenhouse gas emissions, and a 70-79% reduction in fossil energy use.

However, even with no additional costs to the consumer for the vehicle, operating a vehicle on E85 is more costly than operating one on gasoline. (E85 contains 27% less energy per gallon than gasoline.) In order for domestic renewable fuels such as E85 to compete with gasoline, incentives are needed to make the cost of E85 comparable to that of gasoline. In addition, notwithstanding the number of E85 vehicles on the road, utilization of E85 as a motor fuel has been limited by the lack of adequate fueling infrastructure. Similar incentives are needed to expand the existing E85 refueling infrastructure.

The energy policy debate in the 107th Congress recognized the important role of E85 as a domestically produced alternative fuel. Provisions in the House-passed version provided economic incentives in the form of tax credits for alternative fuels infrastructure development, including E85. In the Senate-passed bill, provisions were included that provided incentives in the form of income tax credits for both infrastructure development and an income tax credit for the retail sale of E85 of up to 50 cents per gasoline gallon equivalent.

On behalf of the National Ethanol Vehicle Coalition, as your Committee moves forward in development of a comprehensive national energy policy, I urge the following provisions be incorporated in any final energy bill:

- A 50 cent per gallon to income tax credit to fuel retailers selling E85;
- Up to a $30,000 income tax credit for each E85 refueling station established ;
- Elimination of the Alternative Minimum Tax on income from the sale of E85;
- Authorization of $8 million annually for a period of 5 years to the Department of Energy for education, promotion and assistance programs for the advancement of E85 as an alternative fuel;
- Refundable tax credits for those companies without a tax liability, including transferability of tax credits;
- Repeal of the limitation on tax credit accumulation and value.
- Assurance that tax credits for infrastructure development are not hindered by AMT, limits on refunds, etc., and
- The permitting of tax credits for new infrastructure development to be used by an "upstream" taxable entity .

Thank you.

Taken together, these and other provisions will help provide the needed incentives for an expanded E85 vehicle fleet, refueling infrastructure, fuel utilization and consumer acceptance, all to the benefit of our farming economy, the environment and our nation's energy security.

STATEMENT OF DONALD P.H. HUBERTS, CEO, SHELL HYDROGEN

Thank you, Mr. Chairman. I am Don Huberts, the Chief Executive Officer of Shell Hydrogen.[1] I appreciate the opportunity to provide testimony to the Committee today to discuss the path to a hydrogen economy—the barriers we face and the opportunities presented in transitioning towards a hydrogen infrastructure.

As the CEO of Shell Hydrogen, I am responsible for leading the development and execution of all the global business activities of the Royal Dutch/Shell Group relating to hydrogen fuel and fuel cells. This includes our activities in hydrogen refueling and fuel cell power generation, and our development of hydrogen generation, storage, and purification technologies. Shell Hydrogen has offices in Houston, Amsterdam, and Tokyo and through its local U.S. affiliate has many activities in the United States. For example, Shell is a founding member of the California Fuel Cell Partnership, of which I was Chairman elect during 2002. Shell is also a sustaining member of the National Hydrogen Association. I will expand on our activities below.

Shell Hydrogen was established in 1999 as a global business division of the Royal Dutch/Shell Group of Companies (Shell), one of the largest energy companies in the world, with operations in over 135 countries. Shell is the leading retailer of transportation fuels in the U.S. and in many other countries throughout the world. Shell companies in the U.S. comprise 28 percent of the assets of Royal Dutch/Shell; as such, they represent a very important part of the Group's portfolio. Shell companies in the U.S. are involved in all aspects of the energy business—exploration & development, oil products, gas & power, chemicals, renewables, and hydrogen. Our heritage in this country spans more than 90 years, and while you have likely heard a lot during the past ten years about U.S. businesses "going global," we have operated that way for a long, long time. In fact, we are one of the world's first truly multinational companies.

Shell's commitment to sustainable development is demonstrated by our actions. Sir Philip Watts, the Chairman of our Committee of Managing Directors, is the cochairman of the World Business Council for Sustainable Development. Shell has incorporated the principles of sustainable development into its strategies, operations, processes, budgeting, and training and reward systems. We are developing alternative energy sources, such as renewables and hydrogen, which we aim to grow into viable businesses that will meet our customers' future energy needs.

We report annually on our actions to meet our economic, environmental and social responsibilities in our publication The Shell Report: People, Planet and Profits, a public document that is available as a booklet or on-line.

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[1] "Shell Hydrogen" refers to a global business consisting of separate companies and other organizational entities within the Royal Dutch/Shell group of companies. Each of the companies of the Royal Dutch/Shell group of companies is an independent entity and has its own separate identity.

Out of this commitment, Shell Hydrogen was established to create business opportunities related to hydrogen energy, including: developing and investing in key technologies for hydrogen storage, reforming fossil fuels, and hydrogen purification; and forming cooperative ventures and partnerships to explore commercially viable approaches to building a hydrogen economy. Shell Hydrogen is committed to the rapid development-to-market application of hydrogen energy technology by bringing together manufacturers, suppliers, distributors, legislators, investors, and consumers. This has led to a number of innovative cooperative programs, partnerships, and joint ventures on an international scale through local affiliates.

California: Shell is cooperating with more than 20 partners from the automotive, energy, fuel cell industries, and government to prepare the path for bringing commercially viable solutions to the densely populated state of California that seeks to improve environmental standards in the face of air-quality problems and increasing energy demands. In West Sacramento, the Partnership has opened a demonstration hydrogen fuel-cell project. A fleet of hydrogen-powered vehicles are serviced at a compressedhydrogen fuelling station before being operated on local highways.

Iceland: Shell is working as a partner in Icelandic New Energy Ltd. in a pioneering project that involves all phases of developing a hydrogen-based economy. It involves the manufacture of hydrogen and development of a basic hydrogen infrastructure and the study of vehicle performance under real conditions. In the first phase, three hydrogen-powered buses, fuelled by compressed hydrogen made from water, will be introduced, possibly followed by a transition to an entirely hydrogen-driven public transport fleet. The ultimate goal is that all passenger vehicles, trucks, and eventually shipping will be converted by 2030. In addition, the project envisions development of auxiliary markets for smaller fuel cells and bottled hydrogen, and longer-term, bulk exports of hydrogen.

Japan: Shell is involved in a three-year project in Atsugi laboratory to develop a liquid hydrocarbon fuel reformer capable to producing and dispensing hydrogen on the retail forecourt of an existing service station. The R&D effort will use catalytic partial oxidation (CPO) to split hydrogen from gasoline, ensuring that sulphur, carbon and nitrogen are eliminated and leaving only pure hydrogen for fuel-cell use. Another target is increasing the reformer size from the current 50-kW unit to one capable of producing 1,000 kg of hydrogen daily (capable of fuelling 200 cars).

Furthermore, together with Showa Shell Sekiyu K.K., the first hydrogen refueling station will be demonstrated in Tokyo. This is part of the Japan Hydrogen and Fuel Cell Demonstration Project, a program sponsored by the Japanese Ministry of Economy, Trade and Industry to build five hydrogen refueling stations in the Tokyo metropolitan area. The station will provide liquid and compressed hydrogen to a fleet of prototype fuel cell vehicles provided by several automotive companies, which will be used on the city's streets. Showa Shell will operate the station for two years from April 2003.

The Netherlands: In Amsterdam, Shell is involved with the Amsterdam Transport Company (GVB) to test three hydrogen fuel-cell buses for two years as part of the Clean Urban Transport for Europe, or CUTE Project. Currently the Project has fuel-cell demonstration projects in nine European cities and is an initiative of the European Union. Delivery of the first buses is expected in the 3rd quarter 2003, with a hydrogen fuelling installation in place by June. Compressed hydrogen fuel will be produced on site at an installation being developed at the GVB Bus Depot North.

Technology: In addition to these groundbreaking early fueling initiatives, Shell Hydrogen companies invest in technologies that are necessary to enable the hydrogen economy. Shell has been making significant investments in hydrogen production, as our companies are the fourth largest producers of hydrogen in the world, mostly for use in our refineries and chemical plants. The key challenge is to extend hydrogen from being used primarily for industrial purposes to becoming a transportation fuel.

Because distribution costs are high, it is likely that small-scale generation by either natural gas reforming or water electrolysis will occur. Shell is investing in reforming and purification technologies through its affiliates HydrogenSource LLC in Connecticut and QuestAir Inc in Vancouver, Canada, to ensure cheap and clean hydrogen is available when it is needed. Through our experience in these ventures, and with the promise offered by these companies' technologies, we believe that small-scale hydrogen production costs will continue to come down over the next 5-10 years.

Besides reducing the costs of cost of production, new and innovative ways must be developed to store hydrogen. To address this need, Shell and its partners are investing in Hera Hydrogen Storage Systems, which develops solid-state hydrogen storage solutions based on metal- or chemical-hydrides. The aim is to store enough hydrogen in a small space to power many different fuel cell applications. Currently, because hydrogen is such a light, diffuse gas, it is still difficult to store enough hydrogen on board a vehicle to give it adequate range between refueling. Shell intends to sell hydrogen as a fuel for fuel cell cars and other hydrogen-consuming fuel cell applications once the market develops, and our investments in Hera, HydrogenSource and QuestAir support that aim.

The pace of change and the level of research into hydrogen and fuel cells have been accelerating for a number of years. Many of the technologies in existence today hold promise for initial commercial deployment in the coming 3 to 5 years. We consider it likely that PEM fuel cells, which operate at up to 200°F, will be the first to commercialize, initially in portable power units, then for stationary power, and finally for transportation first in fleets, and then from around 2010 in passenger vehicles.

THE PATH TO A HYDROGEN ECONOMY

Today I would like to share with you two topics of direct relevance to a hydrogen economy and hydrogen infrastructure:

1. Shell's Scenarios on the future of energy, including hydrogen, to 2050;
2. The role of government in fostering the hydrogen economy.

The most important points I want you take away from my testimony are:

1. The future of our energy and hydrogen infrastructures is highly uncertain. A significant hydrogen economy may emerge by 2020 or not until 2050, depending as much on complex societal drivers and unpredictable disruptive events, as on technology breakthroughs.
2. Governments can play an important part in stimulating development of the necessary hydrogen related technologies and providing encouraging incentives during the early stages. The sustained political will of the U.S. Government is particularly important in this regard. However, governments must allow the markets and consumers the freedom to make the fundamental commercial choices. Otherwise, money and time is wasted clinging to political choices that turn out not to be commercially the best options.

SHELL SCENARIOS

Shell's views about the future of energy are shaped by scenarios that look out to 2050 in terms of energy needs, possibilities, and choices. We've been using scenarios for 30 years to help us think about the future. Scenarios are not predictions. Rather, they are ways of challenging assumptions, encouraging debate, and exploring possibilities. They are tools for focusing on critical uncertainties—the unexpected discontinuities or unknown possibilities that could transform our business environment. Our scenarios don't pinpoint future events; rather, they consider the forces that might push the future along a different path.

Scenarios are credible, relevant and challenging alternative stories about how things might develop. Credibility is essential. We harness our experience in energy businesses and technology development—as well as a wide range of outsider expertise—to develop them. What I will tell you today comes from our most recent work in this area: "Energy Needs, Choices and Possibilities—Scenarios to 2050."

Let me say before I begin that I fully understand that this House Science Committee is particularly interested in hydrogen fuels for transportation. Our scenario work includes transport, of course, but it is not confined to this sector, as important as it is. Because of the interrelationships and uncertainties associated with all energy sectors, Shell has taken a "holistic" approach to looking at the future.

What questions do our long-term energy scenarios attempt to answer?

- First, there is an overearching question about the ability of a dynamic energy system to respond to the threat of climate change in this half-century.
- Other key questions explored in the scenarios include:
- When will oil and gas resources fail to meet rising demand? What will replace oil, particularly in transport?
- Who will drive the expansion of renewables? How will energy storage for renewables like solar and wind be solved?
- How might a hydrogen infrastructure develop?
- How will the choices of consumers and citizens affect energy paths?

We looked at important influences that are likely to shape the future of energy, including demography, urbanization, income and market liberalization. And, we looked at three critical drivers that have the potential to bring about fundamental changes in the energy system—resource constraints, technology development and changing social and personal priorities.

A word or two about global resource constraints: Some people see impending limitations on the ability of fossil fuel resources to continue meeting growth in energy demand. We think scarcity of oil supplies is unlikely before 2025, and could be delayed even longer. Natural gas resources are much more uncertain. Scarcity could occur as early as 2025, or well after 2050. The more immediate issue is whether we can develop the infrastructure to deliver remote gas economically.

There is no shortage of coal, but resources are concentrated in a few countries and are becoming increasingly costly to exploit, among other reasons, due to tightening emission standards. Renewable resources, like solar and wind, will compete with food and leisure for land use and require new forms of energy storage. Technological advances are at the core of the transition to new forms of energy. These advances offer superior or new qualities—often transforming lifestyles as well as energy supplies.

In the long term, two potentially transforming energy technologies are:

- *Solar photovoltaics,* which offer the possibility of abundant direct and widely distributed energy, and
- *Hydrogen fuel cells,* which offer the possibility of high performance and clean energy from a variety of fuels.

Both are in the early stages of development and face large challenges. Energy storage is the fundamental problem. Both still have a long way to go on affordability, although they will benefit from manufacturing economies.

People's choices also affect energy development in two ways—by their personal preferences as consumers and their priorities as citizens. Personal lifestyle choices and consumption patterns drive the energy system. These forces operate within frameworks shaped by social attitudes and concerns, such as energy security, air quality and the climate change.

Now about the scenarios we've developed to the year 2050. There is no limit, of course, as to how many we could generate about the future. But our experience is that we can better engage people by limiting our thinking to two focused and thought-provoking scenarios. They are called Dynamics as Usual and the Spirit of the Coming Age. I'll talk briefly about both of them.

Dynamics as Usual focuses on the choices that people make about clean, secure and increasingly sustainable energy that—with growing resource scarcities—drive the evolution toward renewable sources. However, this transition is anything but smooth and reflects intense competition among priorities and technologies. Dynamics as Usual explores the continuation of the dynamic which has shaped the evolution of energy toward lower-carbon fuels—with electricity as the carrier—in response to demands for cleaner, more convenient energy.

Spirit of the Coming Age focuses on the energy choices made by consumers in response to revolutionary new technologies—which arise from unexpected sources—and transform the system.

The two scenarios reflect differences in energy resources, timing and nature of technology development and social and personal priorities. However, the scenarios also have important common features, including:

- the vital role of natural gas as a bridging fuel during at least the next two decades;
- pressure on the oil market as new vehicle technologies diffuse;
- he shift towards distributed heat and power supply for economic and social reasons, and
- in the long term, the potential for renewables to be the eventual primary source of energy if robust energy storage solutions are found.

Dynamics as Usual

Let me focus on the four main elements of Dynamics as Usual:

1. existing technologies respond,
2. the 'dash for gas',
3. renewables boom and bust, and
4. the oil transition and renewables renaissance.

Let's consider each of these points in turn.

First, existing technologies respond. The demand for clean, secure and sustainable energy stimulates a drive for energy efficiency within existing technologies, particularly the internal combustion engine. Advanced internal combustion and hybrid engines deliver the same performance as standard vehicles—but use as little as half of the fuel. Fuelling inconvenience limits the appeal of fuel cell vehicles.

The spread of high-efficiency vehicles disrupts oil markets. Prices are depressed until firmed by growing developing country demand for transport and heating fuels after 2015. Oil consumption grows steadily—but weakly—for 25 more years.

Second, the dash for gas. Natural gas use expands rapidly early in the century—reflecting its economic and environmental advantages in liberalized markets. Where gas is available it fuels most new power generation and accounts for three-quarters of incremental OECD capacity up to 2015. Older coal plants cannot meet tightening emissions standards and are increasingly replaced by gas.

The rising costs and logistical complexity of expanding coal deliveries from northern mines prompts China to embark on major gas import projects. Pan-Asian and Latin American gas grids emerge. Large-scale LNG trade is increasingly competitive. By 2020 gas is challenging oil as the dominant source of primary energy. However, expansion thereafter is constrained by concerns for security of supply.

New nuclear plants have trouble competing in deregulated markets. Most existing nuclear capacity is maintained, but nuclear steadily loses market share in OECD countries.

Third, the renewables boom and bust. Strong government support in OECD countries enables renewable energy to grow rapidly for two decades through established electricity grids. The cost of wind energy continues to fall as turbines exceed 3 MW.

By 2020 a wide variety of renewable sources is supplying a fifth of electricity in many OECD markets. Then growth stalls.

Limited electricity growth constrains expansion in OECD countries and with little progress on energy storage, concerns about power grid reliability block further growth of wind and solar. In developing countries, renewables do not fully compete with low-cost conventional resources.

As renewables stagnate and gas security concerns grow, it is not clear what will fuel future energy supplies.

It is a decade of great energy policy dilemmas.

Fourth and lastly, the oil transition and renewables renaissance. Around 2040, as oil becomes scarce, advances in biotechnology together with vastly improved vehicle efficiency allow a relatively smooth transition to liquid biofuels or Fischer-Tropsch fuels. The existing transportation system can be modified at low cost.

A new generation of renewable technologies emerge. The most important is organic and thin film embedded solar materials. New ways of storing and utilizing distributed solar energy are developed.

By 2050 renewables reach a third of world primary energy and are supplying most incremental energy.

Spirit of the Coming Age

Now let me turn to three key elements of the second scenario, Spirit of the Coming Age:

1. breaking paradigms,
2. the ubiquitous fuel cell,
3. the hydrogen economy.

Let's talk about breaking paradigms.

The Sony Walkman was repeatedly dismissed by focus groups. Portable computers and mobile phones are examples of innovations that broke existing paradigms. Such developments often come from niche market fringes—ignored by incumbent suppliers—where physical constraints force innovation and consumers are willing to pay a premium.

In this scenario technological development is rapid and—critically—societies adopt new technologies more or less immediately. With abundant gas supplies, innovations push fuel cells into a variety of new applications. The outlook is bright.

By 2015, installations of both stationary and mobile fuel cells have won broad public acceptance. After all there are already hundreds of installations in place in the U.S. and in highly environmentally conscious Germany. This scenario says that by the end of the decade there is growing enthusiasm for the technology.

Automobiles manufacturers know that hydrogen fuel cell vehicles match the public mood because they are cleaner, quieter and offer high performance. They can also support more electrical services—digital communications, pre-entry heating and cooling, and in car entertainment—which consumers want but which require too much power for many traditional engines. The constraint is the fuel infrastructure and the potential health hazards of alternative fuels.

Demand for stationary fuel cells—for businesses willing to pay a premium to ensure highly reliable power—helps drive fuel cell system costs down. This provides a platform for transport uses, stimulating further cost reductions—well below conventional power and heat technologies.

In this scenario, by 2025 a quarter of the OECD vehicle fleet uses fuel cells. The global automobile industry rapidly consolidates around the new platform. Technical advances in transport and power services feed off each other, solving mutual problems. Fuel cells also benefit from broader developments in material technology.

Cars no longer need to be idle for 95 percent of the time. Through docking stations, they can provide energy to homes and buildings.

Now, let's talk about the emergence of a hydrogen economy. The advantages of the new technology push the transition to hydrogen well before oil becomes scarce. The higher the demand for fuel cells, the less oil fetches. Renewable energy makes steady but unspectacular progress until 2025. "Green energy" niches remain small in most regions.

After 2025 the growing use of fuel cells for heat and power creates a rapidly expanding demand for hydrogen. It is widely produced from coal, oil and gas fields, with carbon dioxide extracted and sequestered at source. By 2050 a fifth of carbon dioxide emissions from the production and use of energy are being sequestered.

Large-scale renewable and nuclear energy schemes to produce hydrogen by electrolysis start to become attractive after 2030. Renewable energy becomes a bulk supply business and starts to expand rapidly. Hydrogen is transported in gas grids until demand justifies dedicated hydrogen pipelines.

A century-long process of hydrogen infrastructure development begins. The need for sequestration peaks after 2050 although only a small part of the total sequestration capacity has been used. It all sounds very positive. Still, it is worth noting that even in this most optimistic scenario for hydrogen it takes another 40 years before hydrocarbons fully lose their dominance of the energy industry.

What I've just given you is an overview of our two long-term energy scenarios. They both underscore the complex interplay between scientific and technical advances and social, political and market developments. They also underscore the inherent uncertainty on the timing and nature of the hydrogen economy.

ROLE OF GOVERNMENT

Shell has extensive experience with government influence around the world, as no other industry is subject to so many policies and such political control. We know that policies can make or break projects, technologies and even whole industries. We have also learned that subsidies meant to encourage an industry can sometimes wreck it. We've learned that policies have to be intelligent and properly structured, not just well meant.

Policies related to the hydrogen and fuel cell industries are only now beginning to be formed. It is very important that the right principles are ingrained in these policies and that they are carefully framed.

This must be based on an appreciation for the challenges in producing hydrogen. Hydrogen is made either from electricity by splitting water, or extracted from natural gas or other fossil sources. Therefore, the energy in the hydrogen will always be more expensive than that of the sources used to make it. Hence, competitiveness must come from the additional benefits produced in cleaner air, lower CO_2 emissions through greater efficiency or sequestration, and improved energy supply security. These externalities need to be reflected in price signals received by the market, otherwise technology alone cannot bridge the gap in cost. The incumbent petroleum based technology already has an infrastructure in place and is made from a relatively low cost feedstock. Hydrogen can only compete in the early years with the involvement and consistent support of government.

Our participation in the California Fuel Cell Partnership has provided valuable insight into the potential social benefits resulting from the use of fuel cells, and the hurdles for implementation of a hydrogen infrastructure. Through working in partnership with car manufacturers, federal and state government agencies, and other energy companies, we have researched pathways for a transition to a hydrogen economy in California. Such co-operation is unique and essential to ensure a hydrogen transition becomes feasible.

The federal government has a key role to play in setting up the playing field for private enterprise to compete. Previous experiences with alternative fuels such as compressed natural gas (CNG) show that without prolonged government engagement and strong, visible and vocal commitment to deliver a shift in the fuel used in society, these initiatives are destined to fail and remain niche products. In addition to the sort of fiscal support and R&D funding proposed in the President's recent Hydrogen Fuel and FreedomCAR initiatives, the government should also work towards harmonized international codes and standards, increasing levels of public education, and mitigating the risk of in developing a new fuel infrastructure. Finally, as I pointed out earlier, it should ensure that the integral social, environmental, and economic costs and benefits to society of any fuel are properly considered by the market.

The transition to hydrogen will be a long and capital intensive process, and will need a sustained political will to realize the significant benefits of cleaner air, lower greenhouse gas emissions, and a decreased reliance on foreign energy sources. Many of the existing technical and cost hurdles can be overcome with sustained and consistent government support, but even so the huge investment for the infrastructure changeover can only be supported by industry if it can be done on a commercial basis. The initial investment has been estimated by Shell at around USD 20bn for the U.S. alone, to supply 2% of the cars with hydrogen by 2020 and to make hydrogen available at 25% of the existing gasoline retail stations. In the subsequent decades, further build-up of the hydrogen infrastructure will require hundreds of billions of US dollars. Support from the government in mitigating some of the risks around such large investments will clearly be indispensable. However, if the hydrogen sector is to truly take off, most of the capital will come from the private sector. Therefore, it will be consumers, and by extension, the capital markets that will ultimately determine how much money flows into this new industry.

I hope that I have convinced you that Shell believes in hydrogen and is putting its money on the table. Through the companies of Shell Hydrogen, we are already a significant investor and we are willing to invest further as opportunities arise. Shell believes that governments should promote research and development—and provide significant funding—but, that they should do so in a way that allows for innovation and competition in the marketplace, and provides customer with a choice.

I would be happy to answer any questions.

STATEMENT OF ANTHONY EGGERT, ASSOCIATE RESEARCH DIRECTOR, HYDROGEN PATHWAYS RESEARCH PROGRAM, INSTITUTE OF TRANSPORTATION STUDIES, UC DAVIS

Mr. Chairman and Members of the Committee, thank you for the opportunity to provide testimony on hydrogen and hybrid vehicles and the development of a hydrogen economy infrastructure. I recently returned to Institute of Transportation Studies at the University of California—Davis (ITS-Davis) to help develop and lead the Hydrogen Pathways Research Program. Previous to that, I was an engineer for Ford Motor Company, working on the hydrogen fuel vehicle demonstration program. In 2002, ITS-Davis established the Hydrogen Pathways Research Program to address the issues that are before your committee today, how to develop a successful, efficient and market-based hydrogen economy. UC Davis is one of the leading university research centers for the study of advanced environmental vehicles and fuels including hybrids, fuel cells and hydrogen and has a distinguished track record of over 20 years of valuable research in these areas. I was excited by the President's call to advance hydrogen fuel and power research that he outlined in the State of the Union. I hope this committee will:

1. Make hydrogen research and development the highest priority within the federal government's energy research and development portfolio.
2. Fund the DOE's Hydrogen Technology program at $100 million in FY-04.
3. Greatly expand existing federally funded university-based research programs.
4. Substantially increase the funds allocated within federal programs, including DOE's FreedomCAR and Fuels, to initiate new competitively-bid university based research and graduate education programs.
5. Focus federal research on interdisciplinary graduate research programs.
6. Develop the public knowledge base by engaging universities on the cutting edge of this new and exciting set of technologies.
7. Use the nation's universities as the primary instrument to accomplish the Education and Outreach goals of the DOE's National Hydrogen Energy Roadmap

Make Hydrogen Research a National Priority

President Bush was correct to call for a national initiative on hydrogen fuel and hydrogen technologies in his February State of the Union speech. In it, the President said:

> "I ask you to take a crucial step, and protect our environment in ways that generations before us could not have imagined. In this century, the greatest environmental progress will come about, not through endless lawsuits or command and control regulations, but through technology and innovation. Tonight I am proposing 1.2 billion dollars in research funding so that America can lead the world in developing clean, hydrogen-powered automobiles.
>
> "A simple chemical reaction between hydrogen and oxygen generates energy, which can be used to power a car—producing only water, not exhaust

> fumes. With a new national commitment, our scientists and engineers will overcome obstacles to taking these cars from laboratory to showroom—so that the first car driven by a child born today could be powered by hydrogen, and pollution-free. Join me in this important innovation—to make our air significantly cleaner, and our country much less dependent on foreign sources of energy."

His vision to lead the nation towards a hydrogen economy should be supported and where necessary, enhanced by Congress. Specifically, Congress should use the Department of Energy's Hydrogen Energy Roadmap as a guideline to support at least $100 million in FY-04 for Hydrogen Technology, as well as increased support for Department of Transportation and Department of Defense vehicle and stationary fuel cell research programs that are ongoing and producing results. Additionally, all three agencies should be aggressive in supporting a coordinated federal university-based competitive research program on the key technologies and science questions still to be answered in storage, energy conversion, hydrogen production and delivery systems, distribution strategies and stakeholder coordination, advanced materials and manufacturing techniques for fuel cells, and market development and stationary fuel cell technology. The federal government should use the nation's universities as the primary agent to address the education and training of our future engineers, scientist, business leaders, and policy makers. In addition, the nation's university can help educate and outreach challenges of educating the public on the value of developing and using hydrogen fuel. The nations universities are perfectly suited to this role because we establish research collaborations, share results for the nation's benefit and train tomorrow's engineers, scientists, policymakers and business leaders.

Greatly Expand Existing Federal Research Programs Directly Addressing the H_2 Economy

In the area of university research, there are several programs that are small but have been demonstrated to be effective in the area of advanced environmental vehicles and fuels. The Department of Energy has several programs of note within their FreedomCAR program (previously PNGV). DOE's Graduate Automotive Technology Education (GATE) program is a small ($500K total) but effective program that funds 10 university centers nationwide focusing on advanced automotive technologies including fuel cells and hydrogen. DOE's FutureTruck program is a 4-year university program that brings together the resources of the university, industry and government to design and produce ultra-clean high-efficiency sport utility vehicles. NSF's Integrative Graduate Education and Research Traineeship supports a significant transportation research effort integrating transportation policy and technology at UC Davis.

While these programs are to be commended, they are dwarfed by a number of federal research programs that support federal research in a variety of areas including astronomy, medical technology, microelectronics and fusion power. To use one example, current federal support for university-based hydrogen vehicle research and hydrogen economy infrastructure is less than one percent of the $4.6 billion in federal research that will be spent on cancer research by NIH in 2004. If we as a nation truly want to lead in the area of developing a hydrogen economy, hybrid vehicles and hydrogen powered vehicles and fuel cells, we need to dramatically increase our funding for university and federal laboratory research in this area. The federal government will benefit from a continued and consistent government allocation of funds directed towards university-based research and education in the field of advanced environment vehicles and fuels.

A Robust Competitive University Federal Government Research Program is Vital

Many of the benefits of hybrids and fuel cell vehicles such as clean air, reduced carbon emissions, and energy security are conferred to the public realm. Therefore, it is appropriate for the public to participate in this process and encourage a rapid transition to these technologies through federal research support. A robust federal university research program provides multiple benefits of research results, collaboration with industry and training the future engineers, scientists, policymakers and business leaders on the complex issues of hydrogen for transportation. Federally supported university research is crucial to addressing the large challenges and problems that still face us in the next ten to forty years. Many of the hurdles will be solved through new technologies and reducing manufacturing costs through new materials, new vehicle design and cost reduction strategies for storing and making hydrogen in a clean, efficient manner. I am confident these hurdles will be overcome, but at present, many of the research needs are too risky and costly for single companies and industry consortiums to solve without long-lead support by the federal government. Federally supported university research can reduce technology cost and develop a new workforce to lead the nation and the world into a hydrogen fuel economy. Locating a significant fraction at universities allows the federal government to competitively select the best proposals maximize industry collaboration and develop the future hydrogen economy workforce through grants that support graduate and undergraduate research.

Focus on Interdisciplinary Graduate Research

Today's transportation issues are extremely complex and require that both industry and government effectively integrate the knowledge from a variety of disciplines in order to make intelligent and informed business and policy decisions. Transition to a hydrogen fuel economy will be difficult and require enormous coordination and the development of a new generation of professionals to help lead the transition. To address this need, ITS-Davis has established an interdisciplinary research institution with contribution from numerous academic departments including, but not limited to: engineering, economics, business, and environmental science and policy. We see this as an increasing and encouraging trend in universities around the country that should be strongly supported through competitively awarded federal research support.

Develop the Public Knowledge Base

Due to concerns over intellectual property and competitive advantage, it is often extremely difficult to know the state of technology within the private industry. By funding research at public universities, knowledge is developed, published and disseminated within the public realm. This allows everyone, including the public, access to a knowledge base from which informed decisions can be made. Additionally, universities have no vested interest in the outcome of research and are therefore often considered to be a good objective source of knowledge.

One of our core responsibilities at ITS-Davis is to educate the next generation of engineers, scientists, policy-makers, professors, and business leaders in the areas of advanced environmental vehicles and fuels. Anyone with research experience realizes that the knowledge contained within the final research report pales in comparison to the knowledge imparted to the researcher throughout the process. For this reason, it is important to establish the expertise within people (i.e. students) who will carry their knowledge with them and disseminate it throughout their future careers in industry, government and academia.

Another advantage of performing research at universities with graduate students is that students develop a passion for the subject matter during the course of their studies. I realized the importance of this during a previous position within the automotive industry where I had some responsibility for college recruitment. Prior to these programs, automotive engineers coming out of colleges just eight years ago only wanted to work on one of two programs—fast cars or fast trucks. Now, because we have university students learning and applying their knowledge within these environmental vehicle research programs, we find that they develop a passion for the technology. We now have graduates requesting, "I want to work on your hybrid program; your emissions-reduction program, or your fuel cell program". This is ultimately what is going to change the industry—the passion of the people who work there.

HOW UC DAVIS IS CONTRIBUTING TO THE NATIONAL EFFORT TO DEVELOP A HYDROGEN FUEL ECONOMY

I want to share with you the ways that UC Davis is making a difference in developing the technology, people and infrastructure to create a hydrogen economy, advance the hydrogen fueled vehicle program and partnering with industry. We are developing the students, analytical tools and policy roadmaps that are necessary to create a hydrogen fuel economy in the future.

Hydrogen Pathways Research Program

The Hydrogen Pathways Research Program is a multi-year program designed to look at the near to mid-term introduction of hydrogen as a transportation fuel from a technical, economic and policy perspective. Bringing together people already working on these issues, the Hydrogen Pathways Research Program has already engaged a broad consortium of leading industry partners, federal stakeholders and state agencies.

Due to the long transitional time associated with vehicle turnover and fuel infrastructure introduction, business and policy decisions, like those this committee is considering, are being made today. These near-term decisions will affect the transportation sector for many years to come. It is very important that your work on federal energy policy and the surface transportation reauthorization legislation are shaped by the current knowledge and that future policy is shaped from the best available objective research.

Brief Description of Additional Related ITS-Davis Research

About 35 graduate students and ten faculty members are involved in advanced environmental vehicle and fuels research on the UC Davis campus. Graduates of our interdisciplinary Transportation Technology and Policy (TTP) program have obtained positions within the automotive and energy industries, academia, environmental NGO, and government. The following is a sampling of our larger programs:

Fuel Cell APUs: A $3 million project under the direction of Dr. C.J. Brodrick is developing and testing fuel cell auxiliary power units (APUs) that power truck-trailer refrigeration and other auxiliary systems. The new APUs could eliminate the need for idling big-rig diesel engines, which is inefficient, expensive, noisy, and polluting and could power electric systems in aircraft, leading to fuel savings in the nation's future commercial aircraft fleet.

Advanced Vehicle Modeling: ITS-Davis researchers conduct extensive computer modeling of vehicle and heavy-duty truck emissions, fuel economy and performance. ITS-Davis is completing a five-year, $3 million fuel-cell-vehicle modeling program, directed by Dr. Robert Moore, which was sponsored by 20 companies and three government agencies.

Advanced Vehicle Power System Evaluations: Researchers at ITS-Davis, headed by Dr. Andrew Burke, study energy storage and conversion technologies (including ultracapacitors) for electric, hybrid-electric and fuel cell vehicle applications for a variety of government and industry sponsors.

Hybrid Vehicle Prototypes and Component Evaluations: The UC Davis Hybrid Vehicle Driveline Research and Design Center, directed by Dr. Andrew Frank, designs and builds vehicles that demonstrate improved overall efficiency, high fuel economy and low emissions. The HEV Center's current efforts focus on plug-in hybrid-electric vehicles (HEV's) and continuously variable transmissions (CVTs).

New Advanced Environmental Vehicle Laboratories: The UC Davis College of Engineering and ITS-Davis are planning to build a new advanced environmental vehicle facility. This project would create large synergies by clustering UC Davis clean-vehicle research and education programs. The facility would include high-bay vehicle laboratory space, a distributed computing facility and a hydrogen refueling station. Co-funding by public and private sources is currently being sought.

We are especially proud of the success of our expanding graduate education and research program—much of it directed at electric-drive vehicles. The National Science Foundation awarded ITS-Davis a $2.6 million Integrative Graduate Education and Research Traineeship (IGERT) grant for our innovative Transportation Technology and Policy graduate program, the only transportation institute in the country to be funded. In addition, the U.S. Department of Energy awarded UC Davis two (of ten nationally) Graduate Automotive Technology Education (GATE) Centers—to ITS-Davis for fuel cell vehicles and to the Department of Mechanical and Aeronautical Engineering for Hybrid Electric Vehicles. UC Davis won the first two (1998 and 2001) FutureCar and FutureTruck competitions sponsored by the U.S. Department of Energy and the USCAR program of the U.S. auto makers, and placed third overall in the 2002 FutureTruck competition.

In conclusion, I thank you for the opportunity to present my views and help advance the interest in the nation and your committee in developing and promoting our nation's future hydrogen fuel economy and infrastructure. I am confident that a federal leadership role in this area is crucial to advancing the state of technology and speed the development of the research, workforce and infrastructure needed to develop a hydrogen economy infrastructure.

STATEMENT OF STEPHEN S. TANG, PH.D., PRESIDENT & CEO, MILLENNIUM CELL

As the troop buildup continues for Iraq, we are reminded all too often about our dependence on foreign oil. President Bush said it best when announcing the new Freedom CAR and Fuel Initiative, "We import over half of our crude oil stocks from abroad. It jeopardizes our national security to be dependent on sources of energy from countries that don't care for America, what we stand for, what we love. It's also a matter of economic security, to be dependent on energy from volatile regions of the world." The President's plan to invest $1.2 billion in research on developing a clean, hydrogen-powered automobile has the potential to give Americans new options. But unless we align the development effort with market realities, the hydrogen-powered automobile will join its battery-powered brother as just another doomed solution for achieving environmental, geopolitical, and economic goals.

When it comes to vehicles, American consumers have made their preferences clear. They want roominess, high performance, convenience and comfort. Those preferences drive the market in SUVs, minivans, light trucks, and luxury cars. Unfortunately, hydrogen proponents often believe that consumers will accept higher costs, greater inconvenience, and compromises in comfort and performance to convert to hydrogen out of a sense of altruism.

A development effort that doesn't target consumer preferences from the beginning is unlikely to attract the kind of serious investments that will be required to make hydrogen cars technologically possible and to commercialize them. The $1.2 billion proposed by the president in his State of the Union address provides much-needed seed money for research—but at some point, large infusions of private capital will be required.

Gasoline is a dirty fuel, but it is otherwise unequalled for convenience and performance. If fuel cells are to replace gasoline, consumers will require a familiar liquid fuel and a technology that turns it into usable hydrogen energy on demand. Every other storage and delivery technology requires unacceptable compromises with performance and convenience, all likely to be fatal in the marketplace.

The federal government has an important role to play in nurturing this technology and bringing it to market. The government can be most constructive as a super-consumer—adopting hydrogen fuel in military applications and supporting public/private partnerships for commercially viable applications.

It need not be out of a sense of charity or environmental virtue: A military vehicle that runs on hydrogen from a chemical hydride storage system, whether it burns it in an internal combustion engine or processes it through a fuel cell, has tremendous tactical advantages—the fuel tanks won't explode or catch fire.

Public buildings could use hydrogen fuel cells that operate stand-alone power plants, impervious to disruptions in the power grid. Cars did not replace horses because cars were cleaner or more virtuous, but because they provided superior convenience, freedom, and performance. Hydrogen cars will replace gasoline-powered vehicles for the same reasons—or not at all.

Statement of Preston Chiaro, President and CEO, U.S. Borax

U.S. BORAX—MILLENNIUM CELL PARTNERSHIP

About U.S. Borax

U.S. Borax supplies nearly half the world's demand for refined borates from its mine in California's Mojave Desert—one of the richest deposits on the planet. Borates are minerals containing boron, the fifth element on the Periodic Table. They are essential for plants and part of a healthy diet for people. Borates are also key ingredients in the manufacture of glass, ceramics, fiberglass insulation, detergents, fertilizers and wood preservatives. Thousands of household products—from barbecue charcoal to contact lens solution, and from brake fluid to kitchenware—also contain borates.

Borax got its start 131 years ago in California's Death Valley. The twenty mule teams used to haul ore out of the remote desert lives on as a symbol of Borax's commitment to innovation. To this day, the company pioneers the majority of borate production, distribution and application advances around the world—and continues to prospect for opportunities that benefit the company, its customers and consumers at large. Borax is also an industry leader in ensuring that its operations and products contribute to a sustainable future as defined in social, environmental and economic terms.

Borax invests in collaborative and independent research to develop new applications and to advance society's understanding of borates' properties and potential. One of the most promising new developments features borates acting as a hydrogen carrier in safe, clean-burning fuel cells, built to power zero-emission vehicles. (For more information on Borax, borates and our commitment to sustainable development, please visit www.borax.com)

U.S. Borax Partnership with Millennium Cell

In 2001 U.S. Borax entered into a partnership with Millennium Cell, a development-stage company that has created a proprietary technology to safely generate and store hydrogen or electricity. Millennium Cell's core business strategy is to partner with market leaders in the four business areas of micropower, transportation, batteries and the borohydride fuel supply chain. Along with Borax, Millennium

Cell's partners include Ballard Power Systems, a leading global fuel cell manufacturer, DaimlerChrysler, and Air Products and Chemicals; they also have a research agreement with Oak Ridge National Laboratory.

Millennium Cell has invented and developed a proprietary process called Hydrogen on Demand™ that safely generates pure hydrogen from environmentally friendly raw materials. In the process, the energy potential of hydrogen is carried in the chemical bonds of a sodium borohydride, which in the presence of a particular catalyst, releases hydrogen.

The primary components of the reaction are water and sodium borohydride, a derivative of sodium borates. The process supplies pure hydrogen for energy applications without the need for compression or liquefaction. Hydrogen from this system can power fuel cells, or be fed directly to internal combustion engines.

DaimlerChrysler has a conventional minivan that runs on this technology. The van runs up to 300 miles on a single tank of sodium borohydride fuel—the only system so far to demonstrate that it is safer and provides similar miles to the gallon as gasoline. What makes it superior to gasoline is that the fuel is nonflammable, its only waste product is water, and—because the spent fuel is recyclable—the system is sustainable. Unfortunately, at present, sodium borohydride fuel is considerably more expensive to produce.

Despite the economic hurdle, Hydrogen on Demand™ technology solves three critical problems related to the use of hydrogen: generation, storage and safety. The system stores the energy of hydrogen in an inert, non-flammable liquid, and releases its hydrogen only when passed over a catalyst. Because hydrogen is produced and consumed on demand, no storage technology is required. Finally, the system features an on-board fuel cell that is safe for drivers and passengers.

Hydrogen on Demand™ technology also addresses three critical problems associated with fossil fuels: finite resources, foreign dependence and environmental impact. The advantage lies in the fact that sodium borohydride fuel can be recycled. When the system and necessary infrastructure are fully developed, recycling spent fuel would be handled in a closed-loop system, resulting in zero loss. The environmental effect would be replacing millions of mobile sources of greenhouse gases—automobiles—with a smaller number of stationary sources—recycling plants. Any emissions from those plants would be much easier to control. Finally, world reserves of borates are more than sufficient to fill the fuel cycle and to keep up with growth (a study on borate reserves is available from U.S. Borax). In fact, U.S. Borax's California mine alone could meet the needs of the nation's fleet of automobiles.

Although, the Hydrogen on Demand™ technology shows great social and environmental promise, the cost is still prohibitively expensive. Millennium Cell and its partners, including Borax, are working to develop a more efficient, cost-effective process for producing sodium borohydride. Borax, as the world leader in borate technology, has already made strides in this process, but more funding is needed to transform this possibility into a reality.

U.S. Borax is very supportive of the President's visionary announcement of a $1.2 billion research initiative for hydrogen-fueled automobiles. The Department of Energy's support in this field of research is key to its success and a hydrogen future for the transportation sector. U.S. Borax looks forward to being a part of this new, visionary initiative in its partnership with Millennium Cell.

Statement of the American International Automobile Dealers Association

Mr. Chairman, and distinguished Members of the Committee, AIADA appreciates the opportunity to submit comments regarding energy use in the transportation sector, specifically as it relates to automotive sales and consumer needs.

The American International Automobile Dealers Association (AIADA) is the national trade association representing over 10,000 American dealers who hold franchises for international nameplate automobiles and who employ nearly 433,000 American workers who sell and service some of the finest automobiles and trucks available in the world. Franchised automobile dealers are engaged in the business of offering new and used vehicles for sale to the retail public. Auto dealers also service these vehicles to satisfy the needs of customers as well as meet the standards of their manufacturers, and/or government agencies. AIADA members are independent, American-owned businesses. While they maintain contractual franchise agreements with various manufacturers, there is no direct connection between the entities.

Automobile dealers also play an integral role in their communities. Not only do dealerships provide hundreds of thousands of jobs across the country, dealers take great pride in their civic involvement. Additionally, dealers donate millions of dollars annually to a variety of charitable and civic causes, greatly benefiting their communities.

AIADA members strongly support reasonable and workable efforts to increase energy efficiency and to encourage drivers to buy and drive energy efficient automobiles and trucks. In fact, our members sell some of the most energy efficient automobiles and trucks in the world, like the Honda Civic hybrid and Toyota Prius. Whether its evolutionary technology, designed to make the existing fleet more efficient, or revolutionary technology such as electric vehicles or hybrid vehicles, international nameplate manufacturers and dealers have stood at the forefront in bringing high-quality fuel-efficient vehicles to the American consumer. Today, consumers can enter thousands of dealerships across the United States and buy or lease exceptionally efficient and safe cars and trucks. And more can and will be done in the years to come to see that Americans drive safe, non-polluting and efficient personal transportation. Our members will remain in the vanguard of that effort.

As Congress moves forward on ways to encourage energy efficiency in the transportation sector, AIADA supports the ability of the consumer to choose the vehicles that best meet their transportation and lifestyle needs. Automobile dealers are the final link in the retail chain that begins in the design of automobiles and flows through production, distribution and sale to the retail consumer. In the entire process of bringing automobiles from the drawing board to the customer, the dealer and dealership employees are where the “rubber hits the road” between the automobile industry and the motoring public. As such, dealers have a unique and important story to tell regarding consumers and vehicle safety.

GOVERNMENT MUST CONSIDER COMMERCIAL VIABILITY WHEN PROMOTING ADVANCED TECHNOLOGY

Ultimately the American consumer will steer the changes in advanced fuel technology. Consumers must feel confident that these vehicles will meet their transportation needs while having access to the fuel infrastructure necessary for operation. By partnering with the auto industry, the government can better recognize the challenges that lay ahead in delivering these vehicles to the public.

As manufacturers and the broader industry develop new technologies, the government should consistently offer benefits, regardless of technology, in order to spur overall investment in cleaner fueled vehicles. An open process that supports and encourages the development of such research and development will allow for the best possible products to come to market, rather than targeting one advancement over another.

Auto manufacturers are working on future technologies such as hybrid, advanced leanburn, hydrogen fueled internal combustion engines, and fuel cell vehicles that may lead to substantial improvements in efficiency and emissions performance without sacrificing safety, utility, and performance. These new and emerging technologies all share the need for cooperative efforts that bring all the key stakeholders together, from automakers to energy providers, government policy makers and most importantly, the customer. Consumers will be able to choose the automobile that is right for them based on their safety, transportation and fiscal needs.

Nevertheless, ultimately it is the consumer who drives demand. As noted by the National Academy of Science in the 2001 report on CAFE, “automotive manufacturers must optimize the vehicle and its powertrain to meet the sometimes-conflicting demands of customer-desired performance, fuel economy goals, emissions standards, safety requirements and vehicle cost within the broad range of operating conditions under which the vehicle will be used. This necessitates a vehicle systems analysis. Vehicle designs trade off styling features, passenger value, trunk space and utility. These trade-offs will likewise influence vehicle weight, frontal area, drag coefficients and powertrain packaging, for example. These features together with the engine performance, torque curve, transmission characteristics, control system calibration, noise control measures, suspension characteristics and many other factors, will define the drivability, customer acceptance and marketability of the vehicle.”

CONSUMER TAX INCENTIVES ARE NEEDED FOR ADVANCED TECHNOLOGY VEHICLES

AIADA supports market-oriented tax incentives for the purchase of qualifying advanced technology, hybrid, electric-powered and alternative fuel vehicles. The NAS report noted that these vehicles “face significant cost hurdles.” (ES-8) Tax incentives could “jump start” the market penetration of these highly fuel-efficient vehicles.

While automakers begin to manufacturer more highly fuel-efficient vehicles, huge cost disparities exist between these and other automobiles in the marketplace. Consumers often buy vehicles that fit their budget over every other need, and tax credits to manufacturers and consumers help level the playing field for the new technologies.

Such incentives would first encourage manufacturers to develop and introduce advanced technologies by enhancing the market for vehicles that use such technologies. Advanced fuel-efficient technologies are the most costly in their first years of introduction, so incentives would facilitate the introduction of these items by helping to bridge the price differential between these vehicles and conventional vehicles.

Today, hybrid and other fuel-efficient technologies are available in the automobile market. Consumers currently have options between low and highly efficient vehicles, and financial considerations often drive the vehicle purchase. By getting tax credits to consumers immediately, we can help get even more fuel-efficient cars on the road.

Congress has considered a variety of technology-based incentives in recent years to encourage consumers to purchase advanced technology vehicles, notably the CLEAR Act provisions that were included in last year's comprehensive energy bill. AIADA has generally supported these incentives. However, ideally, we believe that such incentives should be performance-based and technology-neutral, i.e., they should be designed to encourage the production and sale of fuel-efficient vehicles, regardless of the technology selected by the manufacturer to achieve high fuel efficiency, and benefit the consumer.

THE INTRODUCTION OF HYBRID VEHICLES AND OTHER ADVANCED TECHNOLOGY INTO THE MARKETPLACE DEMONSTRATES THE INDUSTRY'S COMMITMENT TO FUEL EFFICIENCY

Consumers have a variety of fuel-efficient vehicle choices in the marketplace including hybrid vehicles. The voluntary investment by the industry to produce these vehicles demonstrates the willingness to provide cleaner car options.

Hybrid vehicles run on two sources of power: electric and internal combustion. These products capture power through regenerative braking. When decelerating an internal combustion vehicle, the brakes convert the vehicle's kinetic energy into heat, which is lost to the air. By contrast, a decelerating hybrid vehicle can convert kinetic energy into stored energy that can be reused during the next acceleration. Because of the dual source of power, vehicle emissions are dramatically reduced.

Hybrids also form a bridge technology between the internal combustion engine and fuel cell vehicles. While these vehicles sell at higher prices due to the technology in the automobile, prices are much more modest than hydrogen fuel cell vehicles, and they do not require the investment in fuel infrastructure.

Additionally, lean-burn diesel provides further energy savings. Advanced lean-burn technology enhances the existing advantages of lean-burn internal combustion engines (diesel and gasoline direct injection). With future emission control technologies, the development of advanced lean-burn technology will provide the necessary reductions of nitrogen oxides (NO_x) and particulate matter emissions to meet the new stringent EPA Tier 2 levels.

Advanced lean-burn direct-injection technology, including diesel and gasoline direction-injection engines, offers important advantages in both fuel savings and cleaner emissions. Advanced lean-burn direct-injection technology has the potential to meet or exceed the fuel savings realized by other vehicle technologies, including hybrid electric vehicles, reducing fuel consumption between 20-60% compared to conventional gasoline engines. Moreover, the technology's fuel economy benefits are immediate and will improve as this technology comes to market with the introduction of near zero sulfur fuels.

This Tier 2 compliant technology also offers reductions in NO_x and particulate matter, traditionally unattainable in lean-burn engines. Advanced lean-burn direct-injection technology will help reduce pollutants and greenhouse gases, since it produces fewer HC, CO, $C0_2$, and evaporative emissions than conventional gasoline engines. Overall, the technology will offer benefits matching those of low emitting gasoline and hybrid vehicle technologies.

Advanced lean-burn technology diesel and gasoline vehicles' conservation and environmental benefits are complemented by exceptional overall engine performance characteristics, including high torque power, application to various vehicle categories and classes, and low maintenance costs-all of which will help ensure consumer acceptance when the technology becomes available in the marketplace.

KEY TECHNICAL AND COST BARRIERS FOR FUEL CELLS MUST BE LOWERED

There is still work to be done to overcome the technological and financial barriers to the development of commercially viable, emissions-free fuel cell vehicles. Hydrogen is four times as expensive to produce as gasoline, and fuel cells are now ten times more expensive than internal combustion engines.

Storage systems for hydrogen are also inadequate for use in the wide range of vehicles that consumers demand. Two leading fuel cell tanks store hydrogen at 5,000 and 10,000 pounds per square inch, powering a car for 182 miles and 300 miles, respectively. Currently, tanks cost between $20,000 and $50,000 each. In order to be commercially viable for the average consumer, costs need to be lowered to $200 and $500.

While there are a variety of options to make hydrogen fuel for automobiles, most are not viable yet for the mass market. Currently, companies that traditionally provide fuel for vehicles are focusing on outfitting gas stations to reform natural gas into hydrogen on-site.

Companies estimate that in order for fuel to be widely available for consumer use, the fuel needs to be available at 30% of the gas stations in a given area. The cost to refit a gas station is about $400,000, according to BP PLC, a nationwide oil company. Furthermore, estimates by the Society of Automotive Engineers show that a nationwide hydrogen fueling system would cost up to $300 billion.

The technology needs to improve and the infrastructure needs to come to the market at the same time in order for consumers to invest in these automobiles.

PUBLIC-PRIVATE PARTNERSHIPS

The President recently announced a hydrogen fuel initiative to complement his FreedomCAR program, and NHTSA has expressed support for continued targeted government research spending. Government supported research can help provide a bridge to market introduction for advanced technologies that may be considered to be of too high a development risk for individual companies to pursue.

AIADA believes any such programs must be open to all manufacturers that have a substantial research capability within the U.S. With the increasing globalization of the world auto industry, distinctions based on historic geographic bases of companies have less and less relevance. There are nearly 433,000 taxpaying Americans nationwide involved in retailing the automobiles manufactured by companies with a substantial research presence in the U.S., and there is no justification for categorically barring such companies from participation in joint government-industry research programs. This practice puts AIADA American workers at an unfair disadvantage in the competitive marketplace, and ultimately harms the American consumer.

CONCLUSION

AIADA supports energy efficient technology and other alternative methods to power vehicles, so long as the government does not hinder the consumer's right to choose the vehicles that meet their transportation needs. From bringing down vehicle manufacturing costs to ensuring alternative fuels are available in the marketplace, more work is needed to make some technology cost-effective for use in cars, trucks, homes or businesses, and the government should not mandate its use before the marketplace is accepting. Additional research and development is needed to spur rapid commercialization of these technologies so they can provide clean, domestically produced energy for transportation and other uses.

Again, thank you for this opportunity to share our stand on energy in the transportation sector. Should you have any questions, please contact us at 703-519-7800.

Sincerely,

HEIDI BLUMENTHAL,	JUDY OSTRONIC,
Director of Legislative Affairs.	*Director of Legislative Affairs.*

PREPARED STATEMENT OF STEPHEN A. EVERED, DIRECTOR, LEGISLATIVE AND REGULATORY AFFAIRS, HONEYWELL

While hydrogen fuel cells have gained wide coverage as the front-running technology in the race to reduce America's dependence on foreign oil, researchers agree that the timetable for fuel cells' mass-market introduction is stretching well into the next decade. In the near term, variable valve timing, cylinder deactivation and five and sixspeed automatic transmissions are leading candidates to improve efficiency, although these evolutionary improvements amount to modest gains.

In Europe, much higher fuel prices and strict standards for carbon dioxide emissions mean that automakers must offer vehicles with much higher fuel efficiency than in the North American market. There, a recently reinvented technology—the turbocharger—has realized tremendous fuel economy gains for both gasoline &

dieselpowered vehicles. The turbocharger is set of two connected fans, or turbines, that recycle the energy from wasted exhaust gases by forcing more air into the engine, thereby increasing power.

At the same time that fuel efficiency has become an important topic again here in the United States, turbodiesels and gas turbos are enjoying a quiet renaissance in this market. The reason is simple: turbos allow consumers—and automakers—to have their cake and eat it, too.

Consumers get the benefit of improved fuel economy full-time with power on demand when needed. And unlike efforts in the past to force consumers into smaller, lighter vehicles to achieve high fuel economy, turbo-powered vehicles don't compromise safety, utility, performance or size in order to achieve sizeable efficiency gains. This is the case for turbo diesels, but also for modern turbo gasoline engines.

Along with direct injection and common rail fuel systems, the modern turbocharger is largely responsible for the European diesel boom of the last decade. Virtually all-modern diesel engines use turbochargers. These enable diesel-powered vehicles to achieve 30-50 percent better fuel economy than conventional gasoline-powered vehicles.

Today, turbodiesels represent more than 40 percent of all new vehicle sales in Europe. In heavier vehicles like multi-purpose vehicles (Europe's answer to the minivan) and luxury sedans, the number is roughly 70 percent.

Gasoline turbocharging has long been associated with high-performance vehicles in both the U.S. and Europe. Some consumers hold negative perceptions about gasoline turbochargers based upon their sins of the past: "on or off" turbo boost, poor reliability and durability, and higher insurance rates.

But gasoline turbos have advanced to the point today where many consumers wouldn't know they're driving a turbocharged car until they noticed that their responsive, fun-to-drive cars sipped fuel like a much smaller, economy car.

Automakers today, led by the Europeans, are turbocharging and often downsizing gasoline engines. This gives vehicles the performance of a much bigger engine, with the increased fuel economy and lower emissions of the smaller turbo engine.Today, fully 10 percent of gasoline cars are turbocharged in Europe, that number is expected to rise to nearly 30 percent by 2010. In America, only 1 percent of the market is gas turbo, but that number is also poised to rise quickly through the end of the decade.

Contrary to the race-ready image of the previous generation of turbo cars, some companies are demonstrating that turbochargers are perfectly compatible with mainstream, family vehicles. Every Saab vehicle sold in North America has a gas turbo engine. Most Volvo vehicles either are equipped with a standard gasoline turbo engine, or offer one as an option.

Turbos can give automakers an edge in manufacturing cost savings because the same basic engine can be tuned to deliver more or less power, depending upon the application. In the U.S., where many four-cylinder engine manufacturing plants are underutilized, turbos allow more of this manufacturing capacity to be used because the turbo engines can power a broader variety of vehicles. Also, by switching from a complex dual overhead cam V6 to turbo four-cylinder, the car becomes less expensive to build. Automakers also like the opportunity to build brand equity-and profits-afforded by the turbo option.

To see how the gas turbo compares in the real world, Volkswagen proves a good example. VW's most popular vehicle sold here, the Jetta, has several optional engines. Two of these are the naturally-aspirated (i.e. non-turbo) 2.0 liter four-cylinder and a smaller 1.8 liter turbo.

Both achieve similar fuel economy ratings of 27 mpg in mixed city and highway driving, but the turbo motor makes 150 horsepower, while the non-turbo makes only 115. Carbon dioxide emissions are identical at .74 lbs. per mile driven. The turbo motor makes 162 foot-pounds (ft./lbs.) of torque; the non-turbo 2.0 liter makes only 122 ft./lbs. These differences translate to 0-60 mph times of 8.2 seconds for the smaller turbo, compared to only 10.6 seconds for the non-turbo.

One achieves great gas mileage. The other drives like a much more responsive European sedan and gets great gas mileage. At similar levels of performance, gas turbos yield a 10 to 20 percent fuel economy improvement. Another version of the same 8 liter turbo motor sold in the Audi TT sports coupe produces an overachieving 225 horsepower. To put that in perspective, the BMW 330i makes exactly the same horsepower from a 3.0 liter six-cylinder that is 66% bigger.

What's driving this turbo boom? According to Rob Gillette, President and CEO of Garrett Engine Boosting Systems, "Some are looking to increase fuel economy and reduce emissions. Other people are asking for more power. We satisfy both, and unlike so many technologies you read about, this technology is available today." Part of the Honeywell Corporation, Garrett is the largest supplier of turbos for diesels worldwide, and second largest for gas turbos. They're working on the next generation of turbochargers that will further increase fuel economy, performance and decreased emissions.

Turbocharging technology can be further improved to enhance performance and fuel efficiency of the 3 major powertrain envisioned for the short, mid and longer term: Internal combustion (gasoline and diesel), hybrids, and fuel cells engines.

Honeywell recommends support for the following R&D projects to bring three major technologies to the market.

- Variable geometry turbochargers for gasoline engines: already used successfully on diesel engines, variable geometry needs to be adapted to gasoline engines; Variable geometry enables the optimization of airflow at low engine speed and acceleration that starts of the turbo effect.
- Electric boosting: the turbocharger is assisted by electricity enabling to totally suppress turbo lag (boost on demand), and answering the needs of larger vehicles and/or of vehicles used for towing. The electric turbo is also beneficial to the hybrid powertrain as the turbo can be used as a generator when boost is not needed by the engine (the turbo "gives back" some electric power to the hybrid engine in steady state mode). Electric boosting also applies to fuel cell engines that need boosting devices to improve efficiency and reduce the number/size/weight of fuel cells needed for vehicle motion. The exhaust temperature in a fuel cell engine is lower than that in an internal combustion engine. As a consequence, the overall energy that can be extracted from the exhaust is lower, and an electric device must assist the turbocharger.
- Oil-less turbochargers: Using aerospace technology, Honeywell is able to develop air bearings that run on foils, suppressing the need for oil as a lubricant. Eliminating oil enables more flexibility in packaging the engine (the turbo can be placed anywhere), permitting better utilization of space under the hood. Moreover, oil-less turbos are a must for fuel cell engines that cannot tolerate the risk of contamination by oil (a drop of oil causes degradation of the chemical process generated by the fuel cell engine).

The ultimate device for fuel cell engines would be an oil-less-electric turbocharger.

Another way to accelerate the penetration of smaller/more fuel efficient boosted engines would be to promote their purchase by the end-consumer. For example, significant tax incentives based on how fuel efficient a vehicle is, in its category, compared to the average fuel efficiency level of all vehicles in its category (or compared to any standard determined for this category), would be a positive tool to get people to favor fuel efficient engines over less fuel efficient engines in all vehicle categories.

STATEMENT OF THE ALCHEMIX CORPORATION, CAREFREE, AZ

INTRODUCTION

The world's largest transportation and energy companies recognize that hydrogen atoms have the potential to fuel the world as a sustainable energy resource. The prospects for many applications, especially in transportation are exciting. The vision is that air combined with hydrogen produces electricity in fuel cells at two to three times the efficiency of gasoline burned in the internal combustion engine. Instead of carbon dioxide and carbon monoxide emissions, water vapor is produced, effectively creating a drainpipe instead of a tailpipe. But before a hydrogen economy can be realized, hydrogen must be readily available at low cost to replace fossil fuels.

Alchemix Corporation has invented and is pursuing the commercialization of the HydroMax technology, a process which will achieve these goals by producing hydrogen at very low cost, utilizing steam and carbon as primary inputs. Alchemix has filed over 100 claims of invention in the United States and internationally to protect its break-through technology, which has been demonstrated on a laboratory scale and is currently being demonstrated in a pilot plant scale.

The key to the economics of the HydroMax technology is the use of carbon feedstocks that have little or no value such as petroleum coke, high sulfur coal, municipal waste, discarded tires, biomass and sewage sludge.

A HydroMax plant becomes a cogeneration facility when high volumes of excess steam produced in the process are routed to a steam turbine to make electricity. The HydroMax technology can also be used to produce other products including ammonia for fertilizer and tailored syngases (mixtures of hydrogen and carbon monoxide tailored to the desired percentage of hydrogen). Tailored syngas can be routed to existing refining processes in order to make diesel, methanol, ethanol, methane or gasoline. HydroMax plants can be built today to economically provide electrical power generation as well as alternate fuels for conventional engines. As hydrogen demand escalates, these same plants can be converted to produce pure hydrogen.

Aker Kvaerner, the world's second largest engineering company, has developed preliminary engineering and cost data indicating that the HydroMax technology will create hydrogen for a fraction of the cost of hydrogen currently available through competing processes. At present, Alchemix Corporation is seeking to site its first plant in cooperation with a strategic partner.

Today, the world consumes roughly 16 trillion standard cubic feet (scf) of hydrogen annually having a market value of roughly $60 billion. Over 92% is used for the refining and desulfurization of oil in refineries and the production of ammonia and methanol.[1] The remainder is used primarily for industrial processes, chemical manufacturing and the preparation of food. Over the next decade, hydrogen demand for current uses is expected to grow at double-digit rates. A great deal of this growth will stem from the need for more hydrogen to refine the increasingly heavier, higher sulfur crude oils that are being produced today. More hydrogen will also be needed by refineries to meet regulations that require lower levels of sulfur in gasoline and diesel fuel. Far larger growth in the demand for hydrogen will occur when it begins to replace oil in the transportation sector (66% of all oil used in the United States is for transportation).

PROCESS DESCRIPTION

The HydroMax technology is a two-step process. First, steam contacts a molten metal to form metal oxide and produce hydrogen. The hydrogen produced requires no further separation or purification after the un-reacted steam is condensed. In the second step, metal oxide reduction, the metal oxide is reduced with a carbon source into metal. Both process steps occur in the same reactor, but at different times. A production plant requires at least two furnaces operating in tandem in order to produce hydrogen continuously. Metal smelting furnaces that are commercially available today can be adapted for use as the reactor vessel.

Metal is not consumed in the process. It simply acts as a carrier for the oxygen from one part of the process to the other. The choice of metal is critical for the economic viability of the process. The metal must have a high affinity for oxygen to maximize the yield of hydrogen. The metal oxide formed in the hydrogen production step must also be readily reduced by carbon.

After some experimentation, Alchemix has selected a mixture of iron and tin. Iron strongly attracts the oxygen in steam to form iron oxide. The iron oxide is then reduced back to iron by reacting with carbon and air. Carbon dioxide is formed in this process. The tin does not oxidize but allows operation at lower temperatures and helps to remove sulfur at low cost. The following simplified Figure 1* Diagram shows the principal reactions.

The tin contained in the melt reacts with sulfur to form tin sulfide (SnS). Tin sulfide is then combusted to form stannic oxide (SnO_2) and sulfur dioxide (SO_2) in the post combustion zone of the furnace. The stannic oxide is recycled back to the furnace while the sulfur dioxide is removed by scrubbing and then used to produce ammonium-sulfate, a high value fertilizer. Since sulfur is removed in the process and becomes a valuable by-product, low value high sulfur coal and petroleum coke can be used as feedstocks.

Both reactors are maintained at approximately 1300°C, a temperature at which any carbon compound is quickly reduced to elemental carbon. This feature enables the use of universally available carbon sources having little or no value such as petroleum coke, automobile tires, high sulfur coal, municipal waste, biomass and sewage sludge. Characteristically, such feedstocks can be secured with long-term contracts that will also secure stable low costs for hydrogen.

The basis of the HydroMax technology involves the reduction of iron oxide to pure iron. Alchemix has adapted widely used metal smelting reactors to both produce hydrogen and reduce iron oxide back into iron. Furnace reactors are currently operating in more than twenty commercial installations worldwide using this top-submerged lance design. These furnaces routinely convert the oxide ores of tin, lead, copper, zinc and iron into metal. The principal function and attraction of these reactors is to create efficient contact between gases and molten liquids so that the oxygen in the liquid metal oxides can react quickly with carbon leaving only metal. The natural ores processed in these furnaces frequently contain more than 50% gangue (rock or other materials associated with the metal oxides). The absence of gangue

[1] Source: SRI Chemical and Health Business Services per Chemical Engineering magazine, "The Utility of Hydrogen," September, 2001.

* Figures 1-4 have been retained in committee files.

substantially simplifies the HydroMax process relative to existing smelter operations.

To date, Alchemix has demonstrated its ability to produce hydrogen and reform metal oxide efficiently in laboratory (kilogram scale) reactors. At present, work is being conducted in a pilot plant (0.3 meter) at CSIRO (Commonwealth Scientific and Industrial Research Organization) in Melbourne, Australia. These plants were chosen and adapted to the HydroMax technology, demonstrating the viability of the lance injection technology for hydrogen production while relying on the proven success of lance injection to reform a variety of metals. Current initiatives are focused on the demonstration of hydrogen production and iron ore reduction rates.

PLANT PRODUCTION CAPACITY

The commercial scale plant assumed for modeling is capable of producing 47 million standard cubic feet per day (MMscd) of hydrogen (40,000 metric tons per year) and 1.6 million metric tons per year of steam. This represents a mid-sized plant when compared to SMR hydrogen plants in the United States. The operating plan is based on 98% availability with 351 days of operation per year. The plant would be shut down two weeks per year for furnace re-bricking, boiler inspection and other longer repairs. The availability of the HydroMax plant is consistent with lance injection smelter experience where 98% availability is routine. A process flow diagram for hydrogen production is shown in Figure 2.

COMPETITION

The leading method of producing commercial hydrogen today is Steam Methane Reformation (SMR) which requires natural gas (methane) as a feedstock. Drawbacks to this process are the relatively high cost of natural gas and its price volatility. Another is that hydrogen produced by SMR is commingled with carbon gases. These gases must be removed in additional process steps that are not required when HydroMax technology is used.

SMR is a three-step process. The first step is the reaction of methane with steam to produce a gas mixture containing mostly carbon monoxide and hydrogen (i.e. syngas). The second step is the conversion of the carbon monoxide to carbon dioxide by the addition of more steam (water gas shift). Gas produced in this reaction contains hydrogen, steam and carbon dioxide. In order to provide a clean hydrogen gas, a third process step, typically Pressure Swing Absorption (PSA) separates and purifies the hydrogen.

By contrast, HydroMax generates separate streams of hydrogen and carbon dioxide so that a process step to separate these gases is not required. The HydroMax process is 82% efficient in converting energy input to hydrogen and steam as compared to 78.5% for SMR.

ECONOMICS

When natural gas is at current low levels of $4.00 per thousand cubic feet (MCF), the operating cost of producing hydrogen via SMR is about $0.45 to $0.50 per pound. Capital recovery (i.e. depreciation) adds about $0.03 per pound to the cost. For every $1.00 increase in the price of natural gas, the cost of producing hydrogen via SMR will increase by about $0.08/lb.

The cost of producing hydrogen via the HydroMax process is substantially below that of SMR. This conclusion is based on modeling done by Aker Kvaerner. Data for the model came from experimental work at CSIRO, Pittsburgh Mineral and Environmental Technologies and HIsmelt, a subsidiary of Rio Tinto that designs furnaces.

A HydroMax plant producing 47 MMSCFD of hydrogen (40,000 metric tons per year) will also produce more than 36 megawatts of power from excess steam. When carbon sources with a negative net cost are available, such as municipal waste or sewage sludge, it is possible to produce hydrogen at even lower costs. Larger HydroMax plants can be built and will benefit from increasing economies of scale.

While lower costs will stimulate increased demand for hydrogen, the ability to secure long-term contracts for coal, waste or petroleum coke insures hydrogen cost stability even during periods of price volatility for oil and natural gas. Predictable long-term, low cost supplies of hydrogen from abundant local carbon sources are essential to creating a shift to a hydrogen based economy.

HYDROMAX PROCESSES FOR SYNGAS AND AMMONIA

Before a hydrogen-as-fuel economy can be achieved, reasonably priced hydrogen must be available in large quantities. The HydroMax technology can successfully address this challenge because it has multiple applications that can be accommodated from a single plant. The same HydroMax plants that are built today to provide hydrogen for oil refineries or to produce ammonia or syngas can be used tomorrow to produce clean hydrogen for the transportation sector as demand increases. In the interim, these plants can stand on their own as viable economic entities producing lower cost and cleaner energy as compared to contemporary fuels.

HydroMax is a process that can also combine low cost hydrogen with hydrocarbons to produce tailored syngases which can then be easily refined into a variety of high value products including methanol and gasoline. This is done simply by injecting a hydrocarbon together with steam which produces tailored syngas as shown in Figure 3. By measuring and controlling the amount of steam and hydrocarbon with on-line analyzers and controllers, engineered syngas can be produced. Subsequently, the tailored syngas can be routed to existing refining processes in order to make diesel, kerosene (jet fuel), methanol or gasoline.

When needed for electricity, syngas can be burned in combined-cycle gas turbine power plants which are far more efficient and cleaner than any solid fuel boiler. (Hydrogen turbines also exist, and may prove competitive for electricity generation without the need to make syngas.) Excess steam created by the HydroMax process can produce additional electricity from a steam turbine.

When air is injected with steam instead of carbon as shown in Figure 4, an ammonia precursor gas is produced. This can be introduced into a synthesis loop for the production of ammonia (NH_3). Ammonia constitutes the largest world market for hydrogen today. The agricultural community requires hydrogen as a chemical feedstock for the production of crop fertilizers such as ammonium nitrate (NH_4NO_3).

ENVIRONMENTAL IMPACT

Eventually, the HydroMax technology can play a key role in the transition to a much cleaner environment that is based on a global hydrogen economy. During this transition, low cost and reliably priced syngas from HydroMax gasification plants can stimulate increased use of existing gas-to-liquid synfuel processes available from ExxonMobil, Shell, Sasol/Chevron, Syntroleum and others.

The environmental impact of carbon dioxide (CO_2) emissions from a HydroMax plant is measured on the amount of CO_2 emitted per unit of total output which includes both hydrogen and steam used to produce electricity. CO_2 emissions from a HydroMax plant will exceed those from an SMR plant of equivalent hydrogen capacity; however, a great deal of energy is produced without any CO_2 emissions when excess steam is used to generate electricity. When both hydrogen and electricity production are considered, the HydroMax technology is competitive with SMR. When biomass, sewage sludge or municipal waste is used as the carbon source, HydroMax is clearly the superior environmental choice as hydrogen and steam are produced using only renewable inputs. In this case, the process yields no net CO_2 emissions in the production of hydrogen, syngas or ammonia.

An application with huge environmental implications for the United States and other coal-rich, oil-poor nations is the conversion of coal-fired power stations to plants that burn hydrogen or syngas. Coal is a dirty, solid fuel which creates pollution when it is burned. Major emissions during combustion include airborne particulates, sulfur oxides, nitrous oxides, heavy metals, carbon dioxide and solid waste. With the exception of carbon dioxide, these pollutants can be nearly eliminated by converting the energy in coal to either hydrogen or syngas prior to combustion.While not eliminated, CO_2 emissions can be reduced significantly.

The 750 coal-fired power plants currently operating in the United States generate 52% of this country's electricity, but their efficiency in converting fuel to electricity is less than 30% on average. By installing a HydroMax plant at these sites, overall coal-to-power efficiency can be increased economically from 30% to 48% while reducing net carbon dioxide emissions by 37.5%. This is explained in Appendix I—Reducing Emissions by Re-powering the Coal-fired Electric Utility Industry.

The ability to produce syngas from coal and biomass at low cost creates a large market for the HydroMax process. In addition, the identical plant can be converted to produce pure hydrogen when demand warrants.

SUMMARY

Hydrogen is now the focus of intense international interest due to current efforts to develop fuel cells for clean transportation and distributed power generation. However, hydrogen must first be made available in large quantities to supply the hydrogen fuel when needed. Alchemix has developed the HydroMax process to produce hydrogen at low cost from steam and carbon sources such as coal, petroleum coke and biomass. HydroMax plants can provide the additional hydrogen needed by oil refineries today to refine and desulfurize increasingly heavy crude oils to progressively more stringent specifications. Later, these same plants can be converted to produce hydrogen as demand warrants. These multiple capabilities insure that the HydroMax Technologies can provide the bridge to a hydrogen based economy. There is a compelling case to be made politically, environmentally and economically for the adaptation of the HydroMax technology. The ability to convert high sulfur coal into hydrogen or syngas cleanly and economically provides a path to energy independence for coal-rich, oil-poor nations such as the United States, China, India and Indonesia. The flexibility to use biomass as a feedstock provides a large source of renewable energy that yields no net increase in carbon dioxide emissions.

Alchemix is currently soliciting help to build a small commercial plant which will prove the scalability of the HydroMax Technologies. After this plant has been in operation for about six months, full scale commercial plants of virtually any size can be built.

Appendix I

REDUCING EMISSIONS BY RE-POWERING THE COAL-FIRED ELECTRIC UTILITY INDUSTRY

An application of the HydroMax process that has significant environmental implications is the conversion of coal-fired power plants to generating stations that burn hydrogen or syngas. Coal is a dirty, solid fuel that creates considerable pollution when it is burned. The primary emissions during combustion include airborne particulates, sulfur oxides, nitrous oxides, heavy metals and carbon dioxide plus solid waste. These pollutants, with the exception of carbon dioxide, can be nearly eliminated by converting the energy in coal to either hydrogen or syngas via the HydroMax process prior to combustion. Even CO_2) emissions can be reduced substantially.

Today, there are 750 coal-fired power plants operating in the United States. These facilities generate 52% of the electricity in this country,[2] but their efficiency in converting fuel to electricity is less than 30% on average. In contrast, when gases are burned in combined-cycle turbines, the energy in fuel can be converted to electricity at a rate of 50% or more.

In the HydroMax process, 82% of the original energy contained in coal is converted to syngas and steam. Syngas represents 52.5% of the plant's output while steam represents 29.5%. Syngas is converted to electricity in a combined-cycle gas turbine which operates at 50% efficiency or better. The steam is converted to power in a steam turbine which operates at 75% efficiency. So, the overall coal-to-power efficiency is 48% (52.5 x 0.50 + 29.5 x 0.75). This means that existing coal-fired power plants can boost power output by 60% if an Alchemix syngas plant and combined-cycle turbine are added. It also means that existing coal-fired power plants could generate the same amount of power they are producing today with 37.5% less coal. This would reduce their current CO_2 emissions by 37.5%.

There is an additional incentive to use HydroMax for the many coal-fired power plants that were built near sources of high sulfur coal. Many of these plants are precluded from using the lower cost, high sulfur coal due to the high capital costs associated with installing large scrubbers to remove sulfur dioxide emissions. Instead, they burn higher priced, low sulfur coal. Since HydroMax removes the sulfur and other pollutants economically, these plants can return to the use of high sulfur coal and reduce fuel costs substantially while also reducing emissions.

As an example, high sulfur bituminous coal with high Btu content can be delivered and cleaned for $22 per short ton (see the table below). At 12,500 Btu/lb or 25 MMBtu/short ton, the price of such high sulfur coal is $0.88 per MMBtu. A low sulfur coal of comparable Btu value would cost at least $40 per short ton delivered or more than $1.60 per MMBtu. Thus, there is an additional economic incentive to make the conversion to HydroMax. The cost of coal per MMBtu drops by 45%. In this case, total fuel costs are reduced by 65% while producing the same amount of electricity. The ability to combine lower cost fuel and higher conversion efficiency provides overwhelming benefits that are environmentally compelling.

[2] "Fuel Sources for Electricity Generation in 2000", U.S. Department of Energy, Energy Information Administration.

COST OF HIGH SULFUR COAL

($/Short Ton)

Mining	$12.00
Royalty	$1.00
Local Transport	$2.00
Dee Cleaning	$7.00
Total	$22.00

About 639 of the total amount of energy consumed in the United States comes from oil and natural gas while 3790 comes from coal. The HydroMax technology reduces CO_2 emissions by 37.5% over conventional coal-fired boilers. If a sufficient number of coal-fired power plants are converted to HydroMax, the U.S. would experience a substantial reduction in carbon dioxide emissions. This would significantly advance efforts to meet limits on greenhouse gas emissions stipulated by the Kyoto Treaty. HydroMax will also bring power producers into compliance with environmental regulations on SO_X, NO_X, heavy metals and airborne particulates. In addition, the doubling of coal use to replace imported oil would create a boom in domestic employment and substantially reduce the United States' imbalance of trade.

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