S. HRG. 109–412

ENERGY INDEPENDENCE

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

ON

DISCUSSING THE GOAL OF ENERGY INDEPENDENCE

MARCH 7, 2006

Printed for the use of the
Committee on Energy and Natural Resources

U.S. GOVERNMENT PRINTING OFFICE

28–000 PDF WASHINGTON : 2006

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2250 Mail: Stop SSOP, Washington, DC 20402–0001

COMMITTEE ON ENERGY AND NATURAL RESOURCES

PETE V. DOMENICI, New Mexico, *Chairman*

LARRY E. CRAIG, Idaho
CRAIG THOMAS, Wyoming
LAMAR ALEXANDER, Tennessee
LISA MURKOWSKI, Alaska
RICHARD M. BURR, North Carolina,
MEL MARTINEZ, Florida
JAMES M. TALENT, Missouri
CONRAD BURNS, Montana
GEORGE ALLEN, Virginia
GORDON SMITH, Oregon
JIM BUNNING, Kentucky

JEFF BINGAMAN, New Mexico
DANIEL K. AKAKA, Hawaii
BYRON L. DORGAN, North Dakota
RON WYDEN, Oregon
TIM JOHNSON, South Dakota
MARY L. LANDRIEU, Louisiana
DIANNE FEINSTEIN, California
MARIA CANTWELL, Washington
KEN SALAZAR, Colorado
ROBERT MENENDEZ, New Jersey

BRUCE M. EVANS, *Staff Director*
JUDITH K. PENSABENE, *Chief Counsel*
BOB SIMON, *Democratic Staff Director*
SAM FOWLER, *Democratic Chief Counsel*
FRANK MACCHIAROLA, *Counsel*
JENNIFER MICHAEL, *Democratic Professional Staff Member*

CONTENTS

STATEMENTS

APPENDIX

ENERGY INDEPENDENCE

TUESDAY, MARCH 7, 2006

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

The committee met, pursuant to notice, at 9:40 a.m., in room SD–366, Dirksen Senate Office Building, Hon. Pete V. Domenici, chairman, presiding.

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

The CHAIRMAN. The hearing will please come to order.

Thank you everyone for coming and thank you, Senators, for coming. And I apologize for being late. We will try to get to the witnesses as quickly as we can.

First let me say that I am going to try to resist the lofty rhetoric and arbitrary goals that have historically tempted many when discussing this issue of energy independence. The topic today is too important to our Nation's security to reduce our discussions to soundbites.

It is clear that the United States need to reduce our dependence on foreign sources of energy. We particularly need to reduce our reliance on oil from unstable regions of the world whose values and priorities are often in conflict with America's initiatives and place in the world.

Last year, U.S. net imports equaled 59 percent of our demand. Forty-one percent of our total imports came from OPEC countries which equals 27 percent of the total U.S. consumption. Dependence to this extent can determine our national security, our economic strength, and our foreign policy.

In order to make necessary changes, we have to be realistic about what is possible in the near term, but certainly we have to look with real energy and enthusiasm toward the long-term.

By making energy self-sufficiency, the immediate goal would deny the reality of this situation and only invite discouragement and failure. This would be akin to putting all of our resources in the hopes of finding an elusive cure for a disease at the expense of taking important steps to treat and alleviate the symptoms in the interim.

To that end, I have said on a number of occasions that while I support the advancement of science technology to reduce our dependence on foreign energy sources, I think we must also build a bridge to that age by accessing the oil and gas resources available

in our country and we must reasonably and responsibly conserve our energy.

As an example, from my standpoint, I believe we should have acted on ANWAR a long time ago. The majority of the Senate believes that ANWAR brings us closer to achieving energy security and I would venture to say that not a single member of this body believes that continuing to block ANWAR strengthens our energy security. Blocking progress is not a substitute for substantive policy.

To the critics, talking about ANWAR for a minute, I remind you that it was 10 years and 3 months since that legislation to open ANWAR was vetoed by President Clinton. Ten point four billion barrels of oil sits under the domestic ground in ANWAR. The week of that veto, the average price of crude oil, Senator Craig, with $19.00.

This morning, the price of crude oil stands at approximately $62.49. I think the numbers kind of speak for themselves. Some people must be wondering what in the world the Congress can be thinking of blocking the domestic production in favor of more Middle East oil.

As we look at what our Nation can do to reduce our reliance, it is also important that the American people have a clear understanding of the steps we have already taken. Working with you, Senator Bingaman, we produced a bipartisan bill that passed with overwhelming support. It is essential that the Government works hard to implement that legislation.

As we know, that legislation provided a very, very major, major addition to the use of ethanol in the United States. Already we are seeing 34 new plants, eight existing plants being expanding, 150 plants in planning stages.

Second, a little known fact, oil shale, the establishment of a leasing program for research and development of technologies for the recovery of liquid fuel from oil shale and tar sands in Colorado, Utah, and Wyoming.

Since that policy act, which passed just a few months ago, the Interior Department has received 20 proposals, eight of them deemed viable. The United States has 75 percent of the world's shale. The future of shale is a bright one. It is little known at this point, but I believe we will learn much more about it, and it should be discussed in the context of this hearing today of this overall attempt to understand our future.

Incentives for innovative technology, which you all will testify about, the Energy Policy Act spoke of that. We promoted wind energy and many other technologies were promoted in that bill. I could go on and talk about this for a long time, but you are here for that.

In my first year in the Senate, President Nixon set a goal of energy self-sufficiency by 1980. I do not know if any of you remember that. Since that time, successive administrations, scores of members of Congress from both parties, including me, have set similar goals.

I believe that energy self-sufficiency is attainable, but I do not believe it is in the short term. Nonetheless, we must pursue it as a goal in my opinion vigorously. But that is why you are here, to

tell us what you think about it and how you think we might get there.

With that, I yield to my distinguished colleague, Senator Bingaman.

[The prepared statements of Senators Bayh, Coleman, Feinstein, Liberman, Menendez, Talent and Thomas follow:]

PREPARED STATEMENT OF HON. EVAN BAYH, U.S. SENATOR FROM INDIANA

Chairman Domenici, Senator Bingaman and Members of the Committee, thank you for having this hearing today on an issue so crucial to the well-being of our country. United States dependence on oil is the preeminent challenge of our generation. U.S. oil consumption affects more than just prices at the pump; it impacts our national security, our economy, our fiscal health and our environment.

The United States uses twenty-five percent of the world's oil but controls only three percent of the world's proven oil reserves. As of right now, our demand from oil is only expected to grow, from nearly 21 million barrels a day now to 28 million barrels per day in 2030, of which nearly 70 percent will be imported. While demand in the U.S. will grow by approximately 25 percent, demand in China, India and other developing countries is projected to grow by 66 percent. To meet the projected world demand, global output would have to expand by 57 percent in 2025.

The Energy Information Administration's (EIA) most recent forecast states that the price of crude is expected to remain high at $57 per barrel in 2030. The International Energy Agency (IEA) price forecast is even more dire. According to the IEA, if oil producing countries in the Middle East and Africa do not.make immediate investments to increase production, the price will rise to $86 barrel in 2030. Even if the region does make the necessary investments, prices could average $65 a barrel.

These forecasts assume the current projections for supply and demand but do not address the consequences of a supply disruption caused by terrorism, political unrest or weather. Last summer, the National Commission on Energy Policy and Securing America's Energy Future conducted a simulation called Oil Shock Wave to explore the potential security and economic consequences of an oil supply crisis. The event started by assuming that political unrest in Nigeria combined with unseasonably cold weather in North America contributed to an immediate global oil supply shortfall. This sent prices to over $80 barrel. The simulation then assumed that three terrorist attacks occur in important ports and processing plants in Saudi Arabia and Alaska which sent oil prices immediately soaring to $123 a barrel and $161 barrel six months later. At these prices, the country goes into a recession, millions of jobs are lost as a result of sustained oil prices, and the average household would pay almost $3,000 more each year for gasoline.

This simulation almost became reality with the failed attack on Abqaiq in Saudi Arabia last month. Had the attack been successful, it would have removed four to six million barrels per day from the global market sending prices soaring around the world and would likely have had a devastating impact on our economy.

One of the lessons from September 11th is that we can no longer be so dependent on places like Saudi Arabia, Russia and Venezuela for our energy supply. Yet we are more dependent on foreign oil from hostile countries today than we were on September 11th—making us more vulnerable and putting the United States in a uniquely disturbing position of bankrolling both sides in the War on Terror.

This goes to the heart of our security and our sovereignty. As the world confronts the prospect of a nuclear Iran, our leverage is dramatically limited by the fact that Iran is the second largest exporter of oil. We and our allies are vulnerable to energy blackmail. A few months ago, the Russians decided they weren't pleased with the Ukrainian elections, so they simply decided to stop exporting natural gas to them—nearly causing an economic crisis in the region. How can we be sure that the radicals and America-haters who control the oil will never do that to us?

Our economy is vulnerable to the price volatility of the oil market and we must do what we can to build resilience into our economy. The U.S. uses half as much oil to produce the same amount of gross domestic product (GDP) as it did in the 1970s, this is good news, but we must continue to do more. Decreasing the oil intensity of our economy will help us weather price shocks and make us more secure. We can reduce oil intensity by reducing our demand for oil.

The risks faced above ground by depending on unstable suppliers and good weather are too great and to a certain extent out of our control. If the attack on Abqaiq would have been successful, there is little that we could do to moderate its impact on our economy and lower the prices which is why it is urgent that Congress and the President act now to start reducing our dependence on oil. There is no magic

bullet to address a major shock to the oil market and we must take the steps necessary to reduce our dependence on oil which will make our nation stronger. We must bring the same urgency to energy security that we have on the War on Terror.

Concrete steps are long overdue. But some of us have already begun to take them. Last year, I introduced legislation, the Vehicle and Fuel Choices for American Security Act (VFCASA), with Senators Lieberman, Brownback, Coleman and 6 others to make significant reductions in our oil use. My bill would reduce projected oil use by two and a half million barrels per day in 2016 and seven million barrels per day in 2026. It also provides tools to meet these aggressive targets by improving the efficiency of vehicles and increasing the production and use of biofuels. VFCASA includes new approaches for manufacturers, the federal government, scientists and consumers, all designed to encourage greater energy security.

The legislation requires that in 2012, ten percent of vehicles manufactured be flexible fuel vehicles, alternative fueled vehicles, hybrids, plug-in hybrids, advanced diesels and other oil saving vehicle technologies. This percentage rises each year until 50 percent of the new vehicle fleet will be one of these oil saving technologies. It also provides tax incentives for U.S. manufacturing facilities to retool existing facilities to produce advanced technology vehicles which will help shift the vehicle fleet to more efficient vehicles while minimizing the job impact of an increased market share of advanced technology vehicles. The bill builds on the Energy Policy Act (EPAct) of 2005 by expanding the number of consumers that can take advantage of the tax credit available for the purchase of more efficient vehicles. It offers a tax credit to private fleet owners who invest in more efficient vehicles.

VFCASA contains robust research provisions in the areas of electric drive transportation, including battery research, lightweight materials and cellulosic biofuels. Each of these technologies hold great potential to play a key role in reducing our dependence on oil. For instance, lightweight materials, such as carbon composites and steel alloys, hold the promise of being able to double automotive fuel economy while improving safety without increasing the cost of the vehicle. Cellulosic biofuels, which the President mentioned in the State of the Union, have the promise to be cheaper than gasoline and produce seven to 14 times more energy than is used in its production. My bill doubles the funding for bioenergy research contained in EPAct and provides additional funding for production incentives for the production of cellulosic biofuels.

Additionally, the legislation provides the tools to expand the alternative fueling infrastructure so that all vehicles that can run on E85 are able to fill up at the pump with E85. Although there are approximately 5 million vehicles capable of running on E85, very few actually run on E85 because the fuel is not readily available to them. Of the approximately 168,000 gas stations in the country, only 615 have E85 pumps. My bill expands the alternative fueling infrastructure tax credit in EPAct to 50 percent to drive investment in this vital infrastructure.

The legislation directs the revenues received from CAFE penalties, already collected by the government from foreign manufacturers, to fund grants to finance the expansion of the alternative fueling infrastructure. These fines vary each year depending on CAFE compliance for that year but range from $21 million to $52 million a year. Since 1999, the Department of Energy has only given out $6.9 million in grants since 1999—in one year, the amount of money awarded could triple. One DOE grantee, the National Ethanol Vehicle Coalition, will able to build 300 stations with its $2 million grant this year. With at least 10 times that amount of funding available, we should be able to build at least 3,000 stations per year through this program alone.

Addressing our dependence on oil is a challenge that we can no longer ignore. Events in the world from September 11th to Hurricane Katrina to the recent attempted terrorist attack in Saudi Arabia continue to show us how urgent it is that we act immediately. I hope that this hearing today is the only the Committee's first step in tackling the challenge of American oil dependence. I look forward to working with the Committee on solutions, such as my legislation, to this critical problem facing our country.

PREPARED STATEMENT OF HON. NORM COLEMAN, U.S. SENATOR FROM MINNESOTA

Mr. Chairman, it is time we stopped treating foreign oil dependence as another abstract statistic whose consequence is far removed from Americans' daily lives. The United States is going to have to face the reality that we must break our foreign energy dependence or risk losing our autonomy.

Our nation's energy dependence is undeniably one of the greatest threats to our national security and our freedom. By 2025 it is estimated that nearly 75 percent

of America's oil supply will be imported. Also consider that two-thirds of the world's proven oil reserves are in the Middle East and that terrorists have identified oil as a strategic vulnerability—increasing attacks against oil infrastructure worldwide. One can just imagine what would happen if OPEC, which currently accounts for well over 50 percent of our oil supplies, shut off the oil spigot.

Beyond the national security implications, oil dependence also carries serious economic consequences. The total economic penalty of our oil dependence, including loss of jobs, output, and tax revenue, is estimated to exceed $300 billion annually.

This is not a crisis without a solution. We can cure this dependency affliction with a bold national vision and sincere commitment to innovative energy solutions. One of those energy solutions is renewable fuels, and I am proud to be Senator from the state leading the nation in renewable fuels production.

Mr. Chairman, first we need a plan to reduce our oil consumption. That is why, along with nine other senators, I introduced the Vehicle and Fuel Choices for American Security Act (VFCASA) that makes a goal of saving 2.5 million barrels per day by 2016, roughly the same amount of oil currently imported from the Persian Gulf region and lays out an achievable plan to reach that goal.

One facet of this plan to reach 2.5 million barrels per day of oil savings is to promote the development and use of advanced and alternative fuel efficient vehicles. Key pieces include tax credit incentives for advanced technology motor vehicles, expansion of the consumer tax credits for advanced vehicles, loan guarantees and grants for hybrid vehicle projects, and a new federal commitment to hybrid vehicle technologies and materials. The national fuel savings generated by this bill will be immense, but if we want to free ourselves from foreign oil dependence, we must produce more fuel here at home.

Let me say, I have seen Brazil's renewable fuel economy firsthand; it's truly impressive. In fact Brazil will not import a drop of foreign oil this year. Brazil's energy independence success is indicative of their strong, national commitment to renewable fuels. Brazil invested heavily and directly in ethanol infrastructure, mandated that a high percentage of gasoline include ethanol, heavily supported sugar farmers during the transition to ethanol production, and ensured flex fuel vehicles were widely available.

The Energy Policy Act of 2005 Congress passed this summer included important provisions to expand energy conservation and renewable energy production, particularly through the creation of the Renewable Fuels Standard (RFS). However, many of these provisions only support the current rate of growth for the renewable industry. If America is going to replicate Brazil's energy success, stronger, bolder policies are necessary.

I believe we need a national energy policy that increases availability of flex fuel vehicles, invests heavily in E-85 infrastructure, includes a sugar-to-ethanol program, and sets a national mandate for ethanol that matches our energy independence ambitions.

Key elements of such a renewable energy policy are present in the Vehicle and Fuel Choices for American Security Act referenced earlier. VFCASA will increase the availability of flex fuel vehicles by setting a reasonable requirement that 10 percent of vehicles sold in the U.S. are alternative vehicles, such as flex fuel vehicles, by 2012 and 50 percent by 2016. This requirement would be coupled with a new tax credit for manufacturers for upgrades necessary to begin or expand production of advanced technology vehicles—helping industry meet this requirement.

Additionally, we must dramatically increase the availability of E-85 infrastructure if we are to grow our fuel in our fields instead of importing oil from foreign deserts. VFCASA would provide the programs and resources needed for this infrastructure by:

1. Increasing the E-85 infrastructure tax credit
2. Using CAFE penalties to fund alternative fuel infrastructure
3. Creating a USDA loan guarantee program for E-85 infrastructure

Right now, about half of the nation's E-85 infrastructure is in my home state of Minnesota. While I am proud of the vision and hard work of my rural communities to promote these E-85 pumps, we need E-85 available coast-to-coast.

Brazil could not reach fuel independence without a strong sugar-to-ethanol program, and we should learn from that example. The technology is readily available and sugar's contribution to ethanol production could begin in the very near future. Importantly, VFCASA would increase Renewable Fuels Standard by 100 million gallons in 2008 for ethanol produced domestically from sugar. This would be on top of the current RFS and would not take away from the renewable mandate going to other commodities.

Yet, a mandate will not be sufficient to jumpstart a sugar-to-ethanol program in the United States. In addition to proposals included in VFCASA, Congress needs to enact a strong incentive package to match this mandate. Once a strong sugar-to-ethanol program is underway, America will have yet another abundant, reliable source for fuel. I am studying various incentive mechanisms for a sugar-to-ethanol program, and I plan to introduce legislation addressing this issue in the coming months.

Finally, America needs a renewable fuel requirement that matches our ambition, but does not exceed our potential. That's why I propose Congress enact legislation requiring 10 percent of the nation's gasoline be renewable fuel in 10 years (2016).

Today, at roughly 4 billion gallons of ethanol production, the U.S. is only using renewable fuels for 4 percent of our total fuel supply. But, at this industry's current rate of growth, the U.S. is capable of increasing its production of ethanol about 1 billion gallons a year, meaning that in ten years (2016) the U.S. should be able to produce about 14 billion gallons of ethanol, representing about 7 percent of our fuel supply. Ten percent in 10 years is aggressive and doable. Let's not forget that Brazil mandates gasoline contain at least 25 percent alcohol (ethanol), and that it is now so popular it accounts for 40 percent of all vehicle fuel in that nation.

Mr. Chairman, your work on the Energy Policy Act of 2005 demonstrated your strong commitment to this nation's energy and economic well-being. I urge you and this Committee to build on last year's achievements by moving forward a plan for oil savings through fuel conservation and promotion of innovative technologies, while building a more aggressive renewable fuel policy allowing America to grow fuel here at home.

Mr. Chairman, as always, I appreciate your leadership on energy issues and your continued willingness to offer an open ear to your colleagues. Thank you.

PREPARED STATEMENT OF HON. DIANNE FEINSTEIN, U.S. SENATOR FROM CALIFORNIA

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

The amount of oil imported into the United States has climbed from 6 million barrels of oil per day in 1973 to 12 million barrels per day in 2004 (Energy Information Administration).

And the percentage of foreign oil consumed in the U.S. has climbed from 35% in 1973 to 59% in 2004.

So while there has been a lot of talk about decreasing our nation's dependence on foreign oil, most of it has been empty rhetoric.

This week's cover story of *BusinessWeek* is "The New Middle East Oil Bonanza." With oil prices so high, partially due to fear of oil production disruptions in Nigeria, Saudi Arabia, Venezuela, and elsewhere, billions of dollars are going into the coffers of oil-producing nations.

I am seriously concerned about the impacts of America's overdependence on foreign oil. This cannot continue.

For foreign policy and for environmental reasons, the overdependence on oil is a real problem. With 5% of the world's population, we cannot continue to use 25% of the world's oil supply. Especially not with India and China developing at their current pace.

There are things we could do today to reduce our dependency on oil, and yet we need the political will to get them accomplished. Specifically, we must raise the nation's fuel economy standards.

The Consumer Federation of America estimates that increasing the fuel economy of our domestic fleet by 5 miles per gallon would save about 23 billion gallons of gasoline each year, reducing oil imports by an estimated 14%.

A fleet-wide increase of 10 miles per gallon would save 38 billion gallons, cutting imports by almost one-fifth.

That is why I have introduced a very modest bill for the past three Congresses that would close a loophole in current law that allows SUVs and other light trucks to meet less stringent fuel economy standards than other passenger vehicles.

Currently, the average SUV uses 715 gallons of gas per year. If the fuel efficiency standards were raised to equal that of a passenger vehicle, the same SUV would only use 546 gallons of gas per year, which would be an annual savings of 169 gallons of gas for only this one vehicle.

If the SUV loophole were closed, the savings would be rather dramatic. More than 480,000 SUVs were sold in the first quarter of 2005.

If those SUVs achieved an average fuel economy of 27.5 miles per gallon, we would reduce gasoline use by more than 81 million gallons of a year. And that's just for SUVs sold in the first quarter of 2005.

If this bill were to pass, the United States would save 1 million barrels of oil a day, decrease foreign oil imports by 10 percent, and prevent 240 million tons of carbon dioxide from entering the atmosphere each year.

Yet the automobile manufacturers continue to fight this proposal tooth and nail and for reasons cannot understand. The technology to make these vehicles more efficient is available today.

Furthermore, American auto companies are making vehicles to meet fuel economy standards in other countries.

China, for instance, has issued fuel efficiency standards that are more stringent than ours. If American auto companies hope to make cars that will compete in China, then they will need to make them more fuel efficient. I hope the representative from Ford will be able to address this issue in her statement.

If the Federal Government is not going to act, Congress should not stop the States from acting.

In order to address the environmental impacts that burning oil has on our environment, California has adopted a law that requires automakers to reduce their global-warming emissions by 30 percent by 2016. 57% of California's emissions come from the transportation sector—the State cannot afford to ignore the source of so much pollution.

Ten other States have followed California's lead and adopted the same standard. They include Connecticut, Maine, Massachusetts, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington.

Canada has also adopted similar standards that will require the automakers to voluntarily reduce the global-warming emissions of cars and light trucks by 5.3 million metric tons—about 25 percent—by the end of 2010.

It is time to act now to reduce our dependence on foreign oil. I hope that the witnesses can provide us with some valuable policy options. I look forward to their testimony.

PREPARED STATEMENT OF HON. JOSEPH I. LIEBERMAN, U.S. SENATOR FROM CONNECTICUT

Mr. Chairman and Members of the Committee: Please accept my thanks for the opportunity to submit this statement as part of the record of today's hearing in the issue of oil dependence—or, as President Bush put it, our "addiction" to oil. I am especially grateful that so soon after your own Herculean efforts to enact Energy legislation last year, you and the Committee are plunging into this vital issue in such a serious way. I hope that we will be able to work together closely to enact legislation—this year—that will put America on a path to energy security.

My testimony will focus on the emerging crisis we as a country face and on the legislation that I believe can unleash the technologies, fuels and strategies we must use to deal with that crisis.

At the outset, let me be clear that I am under no illusions that our economy can be completely energy independent in the literal sense of that term. We can, however, ensure that our economy grows while becoming less and less oil-intensive. We have the technology to do it, we have the homegrown fuels to do it and, more and more, I believe we have the will to do it. And, if we succeed we will be making our economy more and more resilient against the dangers and shocks of the global oil system, while freeing our national security and our foreign policy from the very real threats and distortions that our oil-dependence imposes.

On November 16 of last year, I introduced as part of a bipartisan group of 10 Senators representing the American Northeast, South, Midwest and West, S. 2025, the Vehicle and Fuel Choices for American Security Act.

We chose this title because nothing less than our national security is at stake.

Besides myself, the rest of the "Gang of Ten," or the "Energy Security Ten," as some call us are Senators Sam Brownback of Kansas, Evan Bayh of Indiana, Norm Coleman of Minnesota, Lindsey Graham of South Carolina, Ken Salazar of Colorado, Jeff Sessions of Alabama, Bill Nelson of Florida, Richard Lugar of Indiana and Barack Obama of Illinois. Since then, we have been joined by Senators Johnny Isakson of Georgia and Lincoln Chafee of Rhode Island, and we expect even more of our colleagues from both sides of the aisle will be joining us soon.

I hope that in the future we all look back on the day this bill was introduced as the beginning of a major shift in our national security strategy. I hope that history will say we saw a challenge to our national security and prosperity and then met it and mastered it.

While geologists and economists can debate when the oil supply will "peak," what is indisputable is that demand is now exploding as developing nations such as India and China increase consumption.

A recent report by the International Energy Agency, IEA, sums up the urgent need for our legislation.

According to the IEA, global demand for oil—now about 85 million barrels a day—will increase by more than 50 percent to 130 million barrels a day between now and 2030 if nothing is done.

The industrialized world's dependence on oil heightens global instability. The authors of the IEA report note that the way things are going "we are ending up with 95 percent of the world relying for its economic well-being on decisions made by five or six countries in the Middle East."

The recent attack on the Abqaiq oil processing facility in Saudi Arabia reminds us not only of our dangerous dependence on foreign oil, but that that vulnerability is recognized by our enemies.

Besides the Mideast, I would add that Nigeria is roiled by instability, Venezuela's current leadership is hostile to us and Russia's resurgent state power has ominous overtones.

In fact, we are just one well-orchestrated terrorist attack or political upheaval away from a $100-a-barrel overnight price spike that would that would send the global economy tumbling and the industrialized world, including China and India, scrambling to secure supplies from the remaining and limited number of oil supply sites.

History tells us that wars have started over such competition.

Because oil is traded globally, prices are set by the global market. While the U.S. can not unilaterally dictate the prices set on the global market, we can reduce our dependence on those prices by diversifying our energy portfolio, particularly in the transportation sector.

Left unchecked, I fear that we are literally watching the slow but steady erosion of America's power and independence as a nation—our economic and military power and our political independence.

We are burning it up in our automobile engines and spewing it from our tailpipes because of our absolute dependence on oil to fuel our cars and trucks.

That dependence on oil—and that means foreign oil because our own reserves are less than 1 percent of the world's oil reserves—puts us in jeopardy in three key ways—a convergence forming a perfect storm that is extremely dangerous to America's national security and economy.

First, the structure of the global oil market deeply affects—and distorts—our foreign policy. Our broader interests and aspirations must compete with our own need for oil and the growing thirst for it in the rest of the world—especially by China and India.

As a study in the journal Foreign Affairs makes clear, China is moving aggressively to compete for the world's limited supplies of oil not just with its growing economic power, but with its growing military and diplomatic power as well.

Second, today we must depend for our oil on a global gallery of nations that are politically unstable, unreliable, or just plain hostile to us.

All that and much more should make us worry because if we don't change—it is within their borders and under their earth and waters that our economic and national security lies.

Doing nothing about our oil dependency will make us a pitiful giant—like Gulliver in Lilliput—tied down by smaller nations and subject to their whims. And we will have given them the ropes and helped them tie the knots.

We can take on this problem now and stand tall as the free and independent giant we are by reducing America's dependence on oil. Fortunately, the U.S. "oil intensity," the amount of oil used to generate each dollar of GDP, has decreased 50% in the last 30 years. Further reducing our oil intensity is the key to reducing our vulnerability to oil supply shocks, and bolstering our national and economic security.

There is only one way to do this. We need to transform our total transportation infrastructure from the refinery to the tailpipe and each step in between because transportation is the key to energy independence.

Barely 2 percent of our electricity comes from oil.

Ninety six percent of the energy used to power our cars comes from oil—literally millions of barrels of oil per day. This is unsustainable and dangerous.

The Vehicle and Fuel Choices for American Security Act aims to strengthen America's security by transforming transportation from the refinery to the tailpipe and each step in between, thus breaking our dependence on foreign oil.

We start by making it our national policy to cut consumption by 10 million barrels a day over the next 25 years.

First, we need to rethink and then remake our fuel supplies. Gasoline is not the only portable source of stored energy. Tons of agricultural waste and millions of acres of idle grassland can be used to create billions of barrels of new fuels.

Our farmers could soon be measuring production in barrels of energy as well as bushels of food. Then we must remake our automobile engines as well. Vehicles that get 500 miles per gallon—or that use no refined crude oil—are within our grasp. I know that sounds unbelievable. I am going to tell you how we can do it.

To help us get there, our bill also requires that by 2012, 10 percent of all vehicles sold in the U.S. be hybrid, hybrid-electric plug-in or alternative fuel vehicles. That number will rise by 10 percent a year until it reaches 50 percent in 2016.

It will take time to change the composition of the U.S. automobile fleet. The average American automobile might remain in operation for 15 years or more. This means that it is essential that we begin immediately to deploy oil saving technologies.

To help spur this market along, our bill amends our current energy policy to require that one quarter of federal vehicles purchased must be hybrids or plug-in hybrids.

Our bill will detail how we can get there with available technology and previously unavailable Federal Government leadership. Coupling these new programs with the explicit oil-savings goals for the Federal Government is the key to the effectiveness of this proposal.

I can almost hear colleagues murmur, So, Senator Lieberman, what else is new? We've been hearing this for years and nothing has happened.

I can't blame you if you are skeptical. The struggle for oil independence has been going on at least since Jimmy Carter was President.

But things have changed since the days of Jimmy Carter and even since last summer. There is a new understanding of the depth of the crisis that our oil dependence is creating.

Last summer's doubling of gasoline and crude oil prices hit tens of millions of Americans with the global reality of oil demand and pricing. And Hurricane Katrina reminded us how vulnerable our supplies can become.

This reality is bipartisan. And, along with my colleagues cosponsoring this bill, I think Americans are ready to set the serious goals that eluded us in the past and take the bold steps necessary to reach those goals.

Now let me give you more details.

No single technology will resolve all our energy needs in the foreseeable future. Instead, we rely on a wide array of fuel and automotive technologies that are already on the shelf or in development.

The bill that we proposed puts our Nation's transportation system on a new road—a road where the tanks are filled with more home-grown fuel—and I do mean grown—not just American corn, but from American sugar, prairie grass, and agricultural waste.

We will push harder for more and quicker production and commercialization of biomass-based fuels. The Energy bill signed into law last summer created a new set of incentives for these fuel alternatives, including their commercial production.

What our bill would do—again, by including a mass-production mandate for alternative fuel vehicles—is ensure that the investments would be made in the facilities to produce and market these new fuels by providing big demand for them.

The bill would also create a program to guarantee that filling stations had the pumps to provide the fuel to keep pace with the growing alternative-fuel fleet produced by the mandate.

Is there a model to give us confidence we can achieve this transformation? Yes.

Brazil is now enjoying substantial immunity from current high world oil prices, thanks to a long-term strategy, launched during the oil shocks of the 1970s, to integrate sugar cane ethanol into its fuel supply. They started initially with a mandate that all fuel sold in the country contain 25 percent alcohol. They are now up to 40 percent biofuels.

In addition to the fuel mandate, Brazil offered low-interest loans and tax breaks for the building of distilleries and subsidized a fuel distribution network.

Brazil has the advantage of a substantial sugar cane industry already in place. But we have our own vast potential to develop our own biofuel supply, using feedstock like corn, crop waste, switch grass, sugarcane and fast-growing trees and shrubs such as hybrid poplars and willows.

According to the Department of Energy, if two-thirds of the Nation's idled cropland were used to grow these kinds of energy crops, the result could be dramatic. Those 35 million acres could produce between 15 and 35 billion gallons of ethanol each year to fuel cars, trucks, and buses.

That is about 2.2 million barrels of fuel a day from right here in the U.S.A.

What Brazil offers us, more importantly, is a case study of government leadership to combine technology mandates and subsidies to wean its transportation sector from foreign oil to a domestic alternative.

The Congressional Research Service estimates that in the year 2005, we sent almost $225 billion out of the country to purchase oil, while the Brazilians are now relying on home-grown fuel.

The key to their success is that they responded 30 years ago to the first storm warnings. We did not, and now the storm is at our shores, slapping against the levees of our economic strength and national security. We have to mobilize and lead a similar response as Brazil did.

If we do this right, our farmers could soon be measuring production in barrels of energy as well as bushels of food. Our energy would be guaranteed "Made in America" and the profits would be guaranteed "Kept in America."

For all these new fuels to be effective, we need the flexible fuel vehicles that can take advantage of them.

As I said earlier, our bill also requires that 50 percent of all vehicles sold in the U.S. be hybrid, hybrid-electric plug-in, or alternative fuel vehicles by 2016.

Sound ambitious? It is not. It has already happened in Brazil. Several automakers selling cars in Brazil, including our own General Motors and Ford, already manufacture a fleet that is more than 50-percent flexible fuel cars that can run on any combination of gasoline and biofuels.

The technology exists now and adds a negligible cost—about $150—to the price of each vehicle. For this we get the flexibility to power a car with fuel made from corn, prairie grass, or agricultural waste from our own heartland that will cost a lot less than gasoline does today.

Maximizing fuel efficiency and promoting energy independence even further would be a new generation of flexible-fuel hybrid cars known as plug-ins because you can plug them in at night to recharge the battery.

Hybrids that use both a gasoline engine and electric motor for power are already getting 50 miles per gallon. Making them flexible fuel cars, as I've already said, can save us more than 2 million barrels of gasoline a day.

But we can do even better—dramatically better—with the plug-in hybrid that is just now on the threshold of commercialization. Like the present hybrids, it would use both a gasoline and electric motor. But the plug-in hybrid would be able to use the battery exclusively for the first 30 miles of a trip.

Think of that for a minute. Although Americans drive about 2.2 trillion miles a year, according the Census, the vast majority of those trips are less than 15 miles.

That means a plug-in hybrid would use zero—zero—gallons of gas or any combustible fuel for the vast majority of its trips. And experts tell me it could effectively get the 500 miles per gallon on longer trips. Plugging in your car during off peak hours—when power is in surplus and cheaper—would soon just become part of the modem daily routine, like plugging in your cell phone or PDA before you go to bed.

And off-peak electricity can be the equivalent of 50 cent a gallon gasoline, I repeat—the equivalent of 50 cent a gallon fuel is feasible.

Of course, electricity does not come magically through the wires to our homes. That power would come from coal, natural gas, nuclear, solar, wind or other sources—sources that we have in abundance here at home—and a little—very little—would come from oil.

This isn't pie in the sky. These vehicles could be in your garage within a couple of years. Some of the incentives for achieving this were included in the Energy bill signed into law in August. But they did not go nearly far enough.

We need to couple these incentives with real performance standards and sales requirements to ensure that as soon as possible new cars are running not just on gasoline but on biofuels and electricity.

As always, there is a do-nothing crowd that says the ever-rising price of gasoline and crude oil are the cure—that with higher prices people will reduce consumption and the market will respond with greater investments in the supply of oil to bring prices down.

But all that would do is perpetuate the problem. Market-driven oil-dependency is still dependency on foreign oil, driving us further down the current path toward national insecurity and economic and environmental troubles.

Some say that we can ease the crisis through greater domestic drilling—in places like the Arctic Refuge and other public lands or off our shores.

But that won't make a dent in the problem. In the world of oil, geology is destiny and the U.S. today has only 1 percent of the world's oil reserves. And that small new supply wouldn't matter much in the global market, since the price of oil produced within the United States rises and falls with the global market, regardless of where it is produced.

We just don't have enough oil in the U.S. anymore. And no matter how much more we drill, we will still be paying the world price of oil—not an American price.

Our present energy and transportation systems were born at the end of the 19th and the beginning of the 20th centuries with the twin discoveries of oil extraction and the internal combustion engine. Those systems have served us well bringing growth to our Nation and the world.

But it is now the 21st century, and it is time to move on. The era of big oil is over. It is time to revolutionize our entire energy infrastructure, from the refinery to the tailpipe, and begin a new era of energy independence.

It is time to set America free by cutting our dependence on foreign oil and by doing so strengthen our security, preserve our independence and energize our economy.

PREPARED STATEMENT OF HON. ROBERT MENENDEZ, U.S. SENATOR FROM NEW JERSEY

Thank you very much, Mr. Chairman, for scheduling a hearing on an issue as important to the country as energy independence. And I'd like to thank the panelists for being here to share their views on how we can reduce our dependence on foreign oil. I was heartened to hear the president speak about the importance of ending our addition to oil in the State of the Union, but I was not at all pleased to see the budget that came out less than a week later. A budget that did not take the serious steps towards the new technologies that we need to end that addiction. A budget that shortchanges vital energy efficiency efforts such as the weatherization program that helps reduce energy costs for our low-income families and seniors. A budget that cuts funding for some promising forms of renewable energy, cuts funding for research into vehicle technologies, and even cuts funding for a program designed to make the federal government more energy efficient. Quite simply, the president has failed to match his rhetoric with real action.

OCS

Even more disheartening is the continuing efforts of the administration to dig and drill their way out of dependence on foreign oil. Shortly after the budget was released, the Interior Department's Minerals Management service unveiled their new proposed 5-year plan for the outer continental shelf, which included a plan to begin drilling off the Virginia coast. This is flatly unacceptable for my own state of New Jersey, because the ocean knows no borders, and an environmental catastrophe off the coast of Virginia would not stay confined to the waters of Virginia. The area to be leased is less than 75 miles off the southern tip of New Jersey, more than close enough to put our beaches and vital tourism industry at serious risk. The plan also shows that instead of seriously confronting our addiction, the administration would rather simply tap another vein.

CAFE

As many of our witnesses have said in the past, and will be expressing again today, the most effective way to confront our energy problems is through efficiency. We have made excellent strides in the past few decades to make our country more energy efficient, and one of the keys to that success has been Corporate Average Fuel Economy, or CAFE, standards. According to statistics compiled by the Rocky Mountain Institute, between 1977 and 1985 our oil use went down 17% and our oil imports went down 50%, and the biggest factor in that drop was the 7.6 mile-per-gallon improvement in new domestic cars over that time. But in the 20 years since then, our overall vehicle fleet has actually become less efficient. The CAFE standard for passenger cars has been stagnant for the past two decades, and the standard for light trucks is barely 1 mile-per-gallon higher than it was in 1987. Increasing fuel economy standards should be part of the energy independence solution and part of our national energy policy.

WEATHERIZATION

Another federal efficiency program that is part of the solution is Weatherization, which provides grants to states to allow them to make the homes of low-income families and seniors more energy efficient. This has a two-fold benefit. First, it lowers energy costs, which makes it easier for people to pay their heating or cooling bills, and reduces the amount of money that we need to spend on essential assistance programs like LIHEAP. Second, it reduces our overall energy needs. According to the Oak Ridge National Laboratory, every $1 invested in the weatherization program

returns $3.81 in energy and non-energy benefits, and because of the program the country saves the equivalent of 15 million barrels of oil each year. And yet, despite this track record of success, the administration has proposed cutting the program by 33%, denying over 30,000 families—families that are on the lowest rung of the economic ladder and most desperately need help—the ability to get their homes weatherized.

NEW JERSEY

Beyond becoming more efficient, we also need to shift from fossil fuels to renewable sources of energy. My own state of New Jersey has become a national leader in this field, recently enacting new incentives for the use of solar, wind, and other renewable energies, and moving towards enacting a robust renewable portfolio standard—20% by 2020. The state has put its money where its mouth is, giving over $43 million of incentives for new solar power installations over the past five years. And this has generated results, with New Jersey going from 6 solar installations in 2001 to over 1,000 today. These results could be replicated at the national level if we're just willing to make the commitment, and then we could reduce our dependence on foreign oil, become more resilient to attacks on our energy infrastructure, protect our environment, and save money in the long run. I look forward to working with my colleagues to help make this happen.

PREPARED STATEMENT OF HON. JAMES M. TALENT, U.S. SENATOR FROM MISSOURI

Mr. Chairman, Thank you for holding this hearing today. As you know, I have been a long time supporter of ethanol and biodiesel. I know that I would rather get fuel from farmers in Missouri and across the country than import it from foreign countries.

I believe that the greatest provision of the energy bill was the Renewable Fuels Standard which mandated the use of ethanol in our nation's fuel supply. The amount of biofuels to be mixed with gasoline sold in the United States is mandated at increases annually up to 7.5 billion gallons by 2012.

Since the passage of the bill, 34 new ethanol plants are under construction, with 8 existing U.S. plants being expanded. And, there are more than 150 new plants in the planning stages. This construction and investment in farming will create thousands of new jobs while making us less reliant on foreign sources of oil.

Additionally, new biodiesel facilities are coming online. I'm extremely pleased that last year, a farmer coop in Missouri broke ground on a biodiesel facility in Mexico, Missouri. This is one time when jobs going to Mexico is a good thing.

The American Farm Bureau has estimated that the biofuels provisions in the Energy Policy Act of 2005 will create approximately 235,000 new jobs, boost American household incomes by $43 billion and have significant reductions on our importation of crude oil.

I strongly supported these provisions and I'm pleased to see the industry growing as we knew it would. The President outlined a long term strategy for ethanol in the state of the Union, and it is time that the oil companies who fought the RFS come to terms with the use ethanol and biodiesel. These renewable fuels are good for the economy and good for the environment and they are not going away.

Many of the witnesses today talked about the need to use technology that is deployable within the current infrastructure. I couldn't agree more. While the ideas of hydrogen vehicles are exciting—they are such a long way off. Ethanol and biodiesel are the fuels of the future that we can use today.

I think our biggest challenge now is increasing the infrastructure to get the fuels to the consumers. We are constantly increasing the number of E85 fueling stations, but we still need more to support the 6 million flex fuel vehicles on the roads.

In the energy bill, Senator Obama and I sponsored a tax provision to provide tax credits to encourage fueling stations to switch from traditional petroleum based gasoline to E-85. I know that Ford had been working to promote the use of ethanol and encourage stations to offer E85. It is these incentives and industry partnerships that will go a long way toward making this domestic fuel available across the country.

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

Good Morning. I would like to thank you, Mr. Chairman, for convening this hearing to receive testimony on such an important issue. And I thank the witnesses for appearing before the Committee today.

We've been saying for decades that we need to decrease our dependence on foreign supplies of energy. The first major calls for action followed the oil embargo of 1973. In that year, we imported approximately 28 percent of the oil we consumed. A restriction of supply by a group of hostile nations caused prices to increase by an average of 40 percent during that embargo and introduced a new weapon in global conflict. In 2005, we imported roughly 59 percent of the oil we consumed. This trend of increased dependence is a troublesome one.

When Congress passed the Energy Policy Act of 2005 we reversed a trend of inaction on the issue of energy independence which had persisted for over a decade. I am confident that this hearing, the legislation we intend to pursue, and continued attention to energy issues demonstrates our strong commitment to fixing the problems that we face.

I come from a state that is very familiar with energy issues. Wyoming produces roughly 10 percent of the nation's primary energy, with far less than 1 percent of the nation's people. We have oil, natural gas, uranium, and wind resources to name a few. We also have coal—a resource with enormous potential for increasing our energy independence.

Coal is economical and abundant. It constitutes roughly half of the electricity generated in the United States. Advancement of coal gasification technologies, carbon sequestration, and improved mining techniques reduce many of the environmental concerns that people have had in the past. And greater use of cheaper Western coal makes this fuel a much more attractive choice going forward.

We have coal here in the United States and we need to use it. We continue to develop wind, we have hydroelectric dams, and we will hopefully see the construction of new nuclear plants in the near future. Oil and natural gas are the unfortunate exceptions to these upward trends.

Our level of oil consumption is the main reason we are so dependent on foreign sources of energy. The United States imported roughly 59 percent of the oil we consumed last year. Our ability to meet demand by increasing domestic production has peaked. We consume roughly two thirds of the oil we use in the transportation sector. Because of its large share of consumption, policy changes affecting the transportation sector can have a significant impact on reducing foreign dependence. Increased mileage standards, elimination of boutique fuels, lowered speed limits, and greater use of alternative fuels are just a few of the many ideas that have been advanced to decrease the transportation sector's consumption of oil. I contend that coal can make a difference in the transportation sector as well.

In addition to its proven value as a fuel for electricity, coal can reduce our reliance on foreign sources of oil for transportation needs. We have 250 years worth of coal within our own borders. Because of incentives in the energy bill we passed, a company in my home-state of Wyoming recently announced plans to construct a coal-to-liquids plant. This plant will demonstrate emerging technologies that can convert U.S. coal into clean synthetic oil at a cost of $35 to $40 per barrel compared to the current $62 a barrel cost for traditional oil. It is the first plant of its kind on U.S. soil and the National Mining Association believes that continued use of this technology could replace as much as 2 million barrels per day of oil and 5 trillion cubic feet of natural gas per day by 2025.

Another area of concern to me is our nation's electrical grid. While electricity is not something that we tend to import from hostile nations, the infrastructure associated with its delivery is vulnerable to the individuals who seek to harm us. The policies set forth in the Energy Policy Act of 2005 will make our transmission system more reliable, less congested, and cheaper for consumers. There is always room for improvement, however. I intend to continue working with the administration, the state of Wyoming, and members of Congress to ensure that our electricity becomes as reliable, efficient, and affordable as possible.

The final issue I will raise is that of price. I am a strong supporter of far-sighted programs and noble goals of independence but we have to deal with our security now and that requires attention to the issue of price. Energy is the basis upon which our economy operates and if prices are high, the economy suffers. If the economy suffers then the American people do too.

I believe that the bill introduced by the Chairman and Ranking Member for lease sales in the Gulf of Mexico's Area 181 is exactly the sort of thing we need in the short term. The PACE bill also provides much needed guidance and forward-thinking on the importance of maintaining our competitive edge and strong knowledge base.

I look forward to hearing from the witnesses on this important topic.

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

Senator BINGAMAN. Well, thank you for having the hearing, Mr. Chairman, and for bringing this distinguished group of witnesses. I appreciate the attention to the issue.

I agree with you there is a major gap between the rhetoric that we have all engaged in about the importance of energy independence and the reality of what we are actually doing legislatively, by regulation, or otherwise. I hope these witnesses can help us to understand how we could close that gap.

We had the hearing with the Energy Information Administration a couple of weeks ago and what I heard from the EIA Director was that their projections are that we are going to be using more energy in the future, more of it is going to be imported, more oil is going to be imported, more natural gas is going to be imported. The projections for where we are headed are one thing, and our rhetoric is totally different.

So I hope these witnesses can help us to figure out how to bring those two together. I think there are things that we could be doing now that would have a dramatic impact on this, but clearly we do not yet have that agenda worked out.

As I am sure many know, we wrote a letter to Secretary Bodman urging him to give us any concrete plan that he could to support the President's call for a reduction of imports of oil from the Middle East by 75 percent by the year 2025, which was what he stated in the State of the Union speech. I have not seen yet what the specifics are that are going to allow us to achieve that. I hope maybe some of these witnesses would have some insights into that.

Thank you.

The CHAIRMAN. Thank you, Senator.

Now we are going to proceed with the witnesses.

Mr. Woolsey, vice president of Booz Allen Hamilton, former CIA Director, you will be first. We welcome you here and thank you not only for joining us but all the work you have been doing in this area.

STATEMENT OF R. JAMES WOOLSEY, VICE PRESIDENT, BOOZ ALLEN HAMILTON

Mr. WOOLSEY. Thank you, Mr. Chairman. It is an honor to be before this committee on this subject. I emphasize I am testifying solely on my own behalf.

I believe that energy independence is principally an issue of oil and conventional oil. I am going to, by the way, Mr. Chairman, use my 13-page statement as a talking point since remarks are limited to 5 minutes, of course. And that is dealt with in the first couple of pages of my statement.

The dangers of petroleum dependence and the urgency, I think, are guided by some seven factors. First of all, that the current transportation infrastructure is committed to oil and oil-compatible products. And oil is now used very little to generate electricity. In the 1970's, some 20 percent or more of our electricity was generated from oil. Today it is in the range of 2 to 3 percent.

So major investments, whereas they may be wise, in electricity generation of different types, whether it is renewables, nuclear, or

whatever, has very little impact today on oil use. They are important for other reasons, but not particularly with respect to oil use.

In my judgment, hydrogen will take too long to satisfy some of the urgency that should be attached to our current oil dilemma.

And a second factor is that the greater Middle East is going to continue to be the low-cost and dominant petroleum producer for the foreseeable future. As this committee well knows, they hold two-thirds of the world's proven reserves. The growth we expect in China and India and elsewhere is going to keep demand up for a substantial time and put the greater Middle East and particularly, I think, Saudi Arabia more and more in the driver's seat.

Petroleum infrastructure is very vulnerable to terrorist attacks and other types of potential cut-offs. Ten days ago, we had the attack at Abqaiq. We have hurricane damage possible in the gulf coast. We have the possibility of regime change in the Middle East. There was almost a coo in Saudi Arabia in 1979. This reliance on this part of the world is going to be a problem for us for a long time.

The possibility exists not only of a regime change and terrorist attacks, but also of financial disruption as a result of how much we are borrowing to finance our oil habits. We borrow approximately a billion dollars every working day, $250 billion a year, about a third of our overall trade deficit, in order to import oil.

And over the last 30 years, some $70 to $100 billion of that has been provided by Saudi Arabia as a government and certainly more by individuals to causes such as the Wahhabi schools in Madras and Pakistan, and elsewhere in the Middle East.

We found when I was chairman of the Board of Freedom House, even mosques here in the United States, very, very strongly hate literature. We are paying for that, and that is essentially the same set of beliefs that are propagated by al Qaeda. The only difference between the Wahhabis and al Qaeda is who should be in charge. But the underlying hatred of other religions, democracy and the rest, we pay for in no small measure through our borrowing for oil.

As far as other economic factors are concerned, Senator Luger and I had an article some 7 years ago in *Foreign Affairs* in which we together estimated—and I think it is still a good estimate—that for every billion dollars of this now $250 billion a year that we borrow to finance oil, if we were producing it here in the United States from, let us say, biocrops and the rest, it would create ten to twenty thousand American jobs, most of them in rural areas, for each billion dollars that we spend here instead of for imports.

And for many developing countries, oil debt is a huge share of their national debt and, therefore, of their problem of poverty.

We suggest, and these suggestions were stated by former Secretary of State, George Schultz, and I in a piece last summer—we co-chaired the committee on the present danger—that one should focus on making changes that can be made within the existing infrastructure, can be made relatively soon, and which use cheap or even waste products as feedstocks.

And those are the reasons why in the last several pages of testimony, Mr. Chairman, that I suggest that we concentrate—even though there are other worthy things to do—we concentrate on such things as biofuels, particularly ethanol from cellulose, which

in the long run is going to be much cheaper than making it from corn or other starches, that we concentrate on diesel from waste products of all kinds, which is coming to be technologically quite feasible, and that we concentrate on plug-in hybrids so that one can use off-peak or nighttime electricity which where the rubber meets the road is the equivalent of something in the ballpark of 50 cents or so a gallon of gasoline.

I do not think anyone is going to have any problem recognizing consumer demand for a vehicle that could run for, say, 20 miles or so on overnight electricity for the equivalent of approximately 50 cents a gallon of gasoline.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

[The prepared statement of R. James Woolsey follows:]

PREPARED STATEMENT OF R. JAMES WOOLSEY, VICE PRESIDENT, BOOZ ALLEN HAMILTON

Mr. Chairman and Members of the Committee. It's a real pleasure to appear before this Committee today on this issue. I am appearing solely on my own behalf and represent no organization. By way of identification I served as Director of Central Intelligence, 1993-95, one of the four Presidential appointments I have held in two Republican and two Democratic administrations; these have been interspersed in a career that has been generally in the private practice of law and now in consulting. A major share of the points I will make today are drawn from an August 2005 paper by former Secretary of State, George P. Shultz, and myself, although I have updated some points due to more recent work; the two of us are Co-Chairmen of the Committee on the Present Danger and the full paper may be found at the Committee's web site (www.fightingterror.org).

Energy security has many facets—including particularly the need for improvements to the electrical grid to correct vulnerabilities in transformers and in the Supervisory Control and Data (SCADA) systems. But energy independence for the U.S. is in my view preponderantly a problem related to oil and its dominant role in fueling vehicles for transportation. For other countries, e.g. in Europe, energy independence may be closely related to preventing Russia from using against them the leverage that proceeds from its control of the natural gas they need for heating and electricity. In the U.S., however, we generally have alternative methods of producing electricity and heat, albeit shifting fuels can take time. Some of these methods are superior to others with respect to costs, pollutants, global warning gas emissions, and other factors. Technological progress continues to lead to reassessments of the proper mix—for example, there appears to be progress in affordably and reliably sequestering the carbon captured during the operation of integrated gasification combined cycle coal (IGCC) plants. And progress in battery technology to improve the storage of electricity may help us expand the use of renewables such as solar and wind, which are clean but intermittent. Change is not easy in generating electricity, but we are not locked in to a single source for it, for heating, or for most other uses of energy.

Powering vehicles is different.

Just over four years ago, on the eve of 9/11, the need to reduce radically our reliance on oil was not clear to many and in any case the path of doing so seemed a long and difficult one. Today both assumptions are being undermined by the risks of the post-9/11 world, by oil prices, by increased awareness of the vulnerability of the oil infrastructure (as illustrated in the al Qaeda attacks ten days ago on the large Saudi oil facility at Abquaiq) and by technological progress in fuel efficiency and alternative fuels.

There are at least seven major reasons why dependence on petroleum and its products for the lion's share of the world's transportation fuel creates special dangers in our time. These dangers are all driven by rigidities and potential vulnerabilities that have become serious problems because of the geopolitical realities of the early 21st century. Those who reason about these issues solely on the basis of abstract economic models that are designed to ignore such geopolitical realities will find much to disagree with in what follows. Although such models have utility in assessing the importance of more or less purely economic factors in the long run, as Lord Keynes famously remarked: "In the long run, we are all dead."

These dangers in turn give rise to two proposed directions for government policy in order to reduce our vulnerability rapidly. In both cases it is important that existing technology should be used, i.e. technology that is already in the market or can be so in the very near future and that is compatible with the existing transportation infrastructure. To this end government policies in the United States and other oil-importing countries should: (1) encourage a shift to substantially more fuel-efficient vehicles within the existing transportation infrastructure, including promoting both battery development and a market for existing battery types for plug-in hybrid vehicles; and (2) encourage biofuels and other alternative and renewable fuels that can be produced from inexpensive and widely-available feedstocks—wherever possible from waste products.

PETROLEUM DEPENDENCE: THE DANGERS:

1. The current transportation infrastructure is committed to oil and oil-compatible products

Petroleum and its products dominate the fuel market for vehicular transportation. This dominance substantially increases the difficulty of responding to oil price increases or disruptions in supply by substituting other fuels. With the important exception, described below, of a plug-in version of the hybrid gasoline/electric vehicle, which will allow recharging hybrids from the electricity grid, substituting other fuels for petroleum in the vehicle fleet as a whole has generally required major, time-consuming, and expensive infrastructure changes. One exception has been some use of liquid natural gas (LNG) and other fuels for fleets of buses or delivery vehicles, although not substantially for privately-owned ones, and the use of corn-derived ethanol mixed with gasoline in proportions up to 10 per cent ethanol ("gasohol") in some states. Neither has appreciably affected petroleum's dominance of the transportation fuel market.

Moreover, in the 1970's about 20 per cent of our electricity was made from oil—so shifting electricity generation toward, say, renewables or nuclear power could save oil. But since today only about three per cent of our electricity is oil-generated, a shift in the way we produce electricity would have almost no effect on the transportation or oil market. This could change over the long run, however, with the advent of plug-in hybrid vehicles, discussed below.

There are imaginative proposals for transitioning to other fuels for transportation, such as hydrogen to power automotive fuel cells, but this would require major infrastructure investment and restructuring. If privately-owned fuel cell vehicles were to be capable of being readily refueled, this would require reformers (equipment capable of reforming, say, natural gas into hydrogen) to be located at filling stations, and would also require natural gas to be available there as a hydrogen feed-stock. So not only would fuel cell development and technology for storing hydrogen on vehicles need to be further developed, but the automobile industry's development and production of fuel cells also would need to be coordinated with the energy industry's deployment of reformers and the fuel for them.

Moving toward automotive fuel cells thus requires us to face a huge question of pace and coordination of large-scale changes by both the automotive and energy industries. This poses a sort of industrial Alphonse and Gaston dilemma: who goes through the door first? (If, instead, it were decided that existing fuels such as gasoline were to be reformed into hydrogen on board vehicles instead of at filling stations, this would require on-board reformers to be developed and added to the fuel cell vehicles themselves—a very substantial undertaking.)

It is because of such complications that the National Commission on Energy Policy concluded in its December, 2004, report "Ending The Energy Stalemate" ("ETES") that "hydrogen offers little to no potential to improve oil security and reduce climate change risks in the next twenty years." (p. 72)

To have an impact on our vulnerabilities within the next decade or two, any competitor of oil-derived fuels will need to be compatible with the existing energy infrastructure and require only modest additions or amendments to it.

2. The Greater Middle East will continue to be the low-cost and dominant petroleum producer for the foreseeable future

Home of around two-thirds of the world's proven reserves of conventional oil—45% of it in just Saudi Arabia, Iraq, and Iran—the Greater Middle East will inevitably have to meet a growing percentage of world oil demand. This demand is expected to increase by more than 50 per cent in the next two decades, from 78 million barrels per day ("MBD") in 2002 to 118 MBD in 2025, according to the federal Energy Information Administration. Much of this will come from expected demand growth in China and India. One need not argue that world oil production has peaked to

see that this puts substantial strain on the global oil system. It will mean higher prices and potential supply disruptions and will put considerable leverage in the hands of governments in the Greater Middle East as well as in those of other oil-exporting states which have not been marked recently by stability and certainty: Russia, Venezuela, and Nigeria, for example (ETES pp. 1-2). Deep-water drilling and other opportunities for increases in supply of conventional oil may provide important increases in supply but are unlikely to change this basic picture. If world production of conventional oil has peaked or is about to, this of course further deepens our dilemma and increases costs sooner.

Even if other production comes on line, e.g. from unconventional sources such as tar sands in Alberta or shale in the American West, their relatively high cost of production could permit low-cost producers of conventional oil, particularly Saudi Arabia, to increase production, drop prices for a time, and undermine the economic viability of the higher-cost competitors, as occurred in the mid-1980's. If oil supplies have peaked or are peaking in Saudi Arabia this tactic could be harder for the Saudis to utilize. But in any case, for the foreseeable future, as long as vehicular transportation is dominated by oil as it is today, the Greater Middle East, and especially Saudi Arabia, will remain in the driver's seat.

3. The petroleum infrastructure is highly vulnerable to terrorist and other attacks

The radical Islamist movement, including but not exclusively al Qaeda, has on a number of occasions explicitly called for worldwide attacks on the petroleum infrastructure and has carried some out in the Greater Middle East. A more well-planned attack than the one that occurred ten days ago at Abquaiq—such as that set out in the opening pages of Robert Baer's recent book, Sleeping With the Devil, (terrorists flying an aircraft into the unique sulfur-cleaning towers at the same facility)—could take some six million barrels per day off the market for a year or more, sending petroleum prices sharply upward to well over $100/barrel and severely damaging much of the world's economy. Domestic infrastructure in the West is not immune from such disruption. U.S. refineries, for example, are concentrated in a few places, principally the Gulf Coast.

Last summer's accident in the Texas City refinery—producing multiple fatalities—points out potential infrastructure vulnerabilities, as of course does this past fall's hurricane damage in the Gulf. The Trans-Alaska Pipeline has been subject to several amateurish attacks that have taken it briefly out of commission; a seriously planned attack on it could be far more devastating.

In view of these overall infrastructure vulnerabilities policy should not focus exclusively on petroleum imports, although such infrastructure vulnerabilities are likely to be the most severe in the Greater Middle East. It is there that terrorists have the easiest access, and the largest proportion of proven oil reserves and low-cost production are also located there. But nothing particularly useful is accomplished by changing trade patterns. To a first approximation there is one worldwide oil market and it is not generally helpful for the U.S., for example, to import less from the Greater Middle East and for others then to import more from there. In effect, all of us oil-importing countries are in this together.

4. The possibility exists, both under some current regimes and among those that could come to power in the Greater Middle East, of embargoes or other disruptions of supply

It is often said that whoever governs the oil-rich nations of the Greater Middle East will need to sell their oil. This is not true, however, if the rulers choose to try to live, for most purposes, in the seventh century. Bin Laden has advocated, for example, major reductions in oil production and oil prices of $200/barrel or more. As a jihadist Web site has just stated in the last few days: "[t]he killing of 10 American soldiers is nothing compared to the impact of the rise in oil prices on America and the disruption that it causes in the international economy."

Moreover, in the course of elaborating on Iranian President Ahmedinejad's threat to destroy Israel and the U.S., his chief of strategy, Hassan-Abbassi, has recently bragged that Iran has already "spied out" the 29 sites "in America and the West" which they (presumably with help from Hezbollah, the world's most professional terrorist organization) are prepared to attack in order to "destroy Anglo-Saxon civilization." One can bet with reasonable confidence that some of these sites involve oil production and distribution.

In 1979 there was a serious attempted coup in Saudi Arabia. Much of what the outside world saw was the seizure by Islamist fanatics of the Great Mosque in Mecca, but the effort was more widespread.

Even if one is optimistic that democracy and the rule of law will spread in the Greater Middle East and that this will lead after a time to more peaceful and stable

societies there, it is undeniable that there is substantial risk that for some time the region will be characterized by chaotic change and unpredictable governmental behavior. Reform, particularly if it is hesitant, has in a number of cases in history been trumped by radical takeovers (Jacobins, Bolsheviks). There is no reason to believe that the Greater Middle East is immune from these sorts of historic risks.

5. Wealth transfers from oil have been used, and continue to be used, to fund terrorism and Its ideological support

Estimates of the amount spent by the Saudis in the last 30 years spreading Wahhabi beliefs throughout the world vary from $70 billion to $100 billion. Furthermore, some oil-rich families of the Greater Middle East fund terrorist groups directly. The spread of Wahhabi doctrine—fanatically hostile to Shi'ite and Suffi Muslims, Jews, Christians, women, modernity, and much else—plays a major role with respect to Islamist terrorist groups: a role similar to that played by angry German nationalism with respect to Nazism in the decades after World War I. Not all angry German nationalists became Nazis and not all those schooled in Wahhabi beliefs become terrorists, but in each case the broader doctrine of hatred has provided the soil in which the particular totalitarian movement has grown. Whether in lectures in the madrassas of Pakistan, in textbooks printed by Wahhabis for Indonesian schoolchildren, or on bookshelves of mosques in the U.S., the hatred spread by Wahhabis and funded by oil is evident and influential.

On all points except allegiance to the Saudi state Wahhabi and al Qaeda beliefs are essentially the same. In this there is another rough parallel to the 1930's—between Wahhabis' attitudes toward al Qaeda and like-minded Salafist Jihadi groups today and Stalinists' attitude toward Trotskyites some sixty years ago (although there are of course important differences between Stalin's Soviet Union and today's Saudi Arabia). The only disagreement between Stalinists and Trotskyites was on the question whether allegiance to a single state was the proper course or whether free-lance killing of enemies was permitted. Stalinist hatred of Trotskyites and their free-lancing didn't signify disagreement about underlying objectives, only tactics, and Wahhabi/Saudi cooperation with us in the fight against al Qaeda doesn't indicate fundamental disagreement between Wahhabis and al Qaeda on, e.g., their common genocidal fanaticism about Shia, Jews, and homosexuals. So Wahhabi teaching basically spreads al Qaeda ideology.

It is sometimes contended that we should not seek substitutes for oil because disruption of the flow of funds to the Greater Middle East could further radicalize the population of some states there. The solution, however, surely lies in helping these states diversify their economies over time, not in perpetually acquiescing to the economic rent they collect from oil exports and to the uses to which these revenues are put.

6. The current account deficits for the U.S. and a number of other countries create risks ranging from major world economic disruption to deepening poverty, and could be substantially reduced by reducing oil imports

The U.S. in borrows about $2 billion every calendar day from the world's financial markets to finance the gap between what we produce and what we consume. The single largest category of imports is the approximately $1 billion per working day, or $250 billion a year, borrowed to import oil. The accumulating debt increases the risk of a flight from the dollar or major increases in interest rates. Any such development could have major negative economic consequences for both the U.S. and its trading partners. For every billion dollars of this $250 billion spent at home to produce alternative fuels, Senator Richard Lugar and I estimated (in a 1999 article in Foreign Affairs, "The New Petroleum") that 10-20,000 American jobs would be created, principally in rural areas. This would mean that replacing $200 billion of the $250 billion that we borrow to import oil with alternative fuel production in the U.S. would create something on the order of 3 million American jobs.

For developing nations, the service of debt is a major factor in their continued poverty. For many, debt is heavily driven by the need to import oil that at today's oil prices cannot be paid for by sales of agricultural products, textiles, and other typical developing nation exports.

If such deficits are to be reduced, however, say by domestic production of substitutes for petroleum, this should be based on recognition of real economic value such as waste cleanup, soil replenishment, or other tangible benefits.

7. Global-warming gas emissions from man-made sources create at least the risk of climate change

Although the point is not universally accepted, the weight of scientific opinion suggests that global warming gases (GWG) produced by human activity form one important component of potential climate change. Recently in the Wall Street Jour-

nal the Nobel-Prize winning economist, Thomas Schelling, surveyed the data and concluded that we should, if effect, buy "insurance" against climate change by reducing our emissions. Oil products used in transportation provide a major share of U.S. man-made global warming gas emissions. The substitutes discussed below would radically reduce these emissions.

THREE PROPOSED DIRECTIONS FOR POLICY

The above considerations suggest that government policies with respect to the vehicular transportation market should point in the following directions:

1. Encourage improved vehicle mileage, using technology now in production

The following three technologies are available to improve vehicle mileage substantially:

Diesels

First, modern diesel vehicles are coming to be capable of meeting rigorous emission standards (such as Tier 2 standards, being introduced into the U.S., 2004-08). In this context it is possible without compromising environmental standards to take advantage of diesels' substantial mileage advantage over gasoline-fueled internal combustion engines.

Heavy penetration of diesels into the private vehicle market in Europe is one major reason why the average fleet mileage of such new vehicles is 42 miles per gallon in Europe and only 24 mpg in the U.S. Although the U.S. has, since 1981, increased vehicle weight by 24 per cent and horsepower by 93 per cent, it has actually somewhat lost ground with respect to mileage over that near-quarter century. In the 12 years from 1975 to 1987, however, the U.S. improved the mileage of new vehicles from 15 to 26 mpg.

Hybrid gasoline-electric

Second, hybrid gasoline-electric vehicles now on the market generally show substantial fuel savings over their conventional counterparts. The National Commission on Energy Policy found that for the four hybrids on the market in December 2004 that had exact counterpart models with conventional gasoline engines, not only were mileage advantages quite significant (10-15 mpg) for the hybrids, but in each case the horsepower of the hybrid was higher than the horsepower of the conventional vehicle. (ETES p. 11)

Light-weight carbon composite construction

Third, constructing vehicles with inexpensive versions of the carbon fiber composites that have been used for years for aircraft construction can substantially reduce vehicle weight and increase fuel efficiency while at the same time making the vehicle considerably safer than with current construction materials. This is set forth thoroughly in the 2004 report of the Rocky Mountain Institute's *Winning the Oil Endgame* ("WTOE"). Aerodynamic design can have major importance as well. Using such composites in construction breaks the traditional tie between size and safety. Much lighter vehicles, large or small, can be substantially more fuel-efficient and also safer. Such composites have already been used for automotive construction in Formula 1 race cars and are now being adopted in part by BMW and other automobile companies. The goal is mass-produced vehicles with 80% of the performance of hand-layup aerospace composites at 20% of the cost. Such construction is expected approximately to double the efficiency of a normal hybrid vehicle without increasing manufacturing cost. (WTOE 64-66).

2. Encourage the commercialization of alternative transportation fuels that can be available soon, are compatible with existing infrastructure, and can be derived from waste or otherwise produced cheaply

Biomass (cellulosic) ethanol

The use of ethanol produced from corn in the U.S. and sugar cane in Brazil has given birth to the commercialization of an alternative fuel that is coming to show substantial promise, particularly as new feedstocks are developed. Some six million vehicles in the U.S. and three-quarters of new vehicles in Brazil are capable of using ethanol in mixtures of up to 85 percent ethanol and 15 per cent gasoline (E-85); these are called Flexible Fuel Vehicles ("FFV") and require, compared to conventional vehicles, only a somewhat different kind of material for the fuel line and a differently-programmed computer chip. The cost of incorporating this feature in new vehicles is trivial. Between 2003 and 2005 Brazil moved from five per cent of its new vehicles being FFVs to 75 per cent being such. Also, there are no large-scale

changes in infrastructure required for ethanol use. It may be shipped in tank cars (and, in Brazil, in pipelines), and mixing it with gasoline is a simple matter.

Although human beings have been producing ethanol, grain alcohol, from sugar and starch for millennia, it is only in recent years that the genetic engineering of biocatalysts has made possible such production from the hemicellulose and cellulose that constitute the substantial majority of the material in most plants. The genetically-engineered material is in the biocatalyst only; there is no need for genetically modified plants.

These developments may be compared in importance to the invention of thermal and catalytic cracking of petroleum in the first decades of the 20th century—processes which made it possible to use a very large share of petroleum to make gasoline rather than the tiny share that was available at the beginning of the century. For example, with such genetically-engineered biocatalysts it is not only grains of corn but corn cobs and most of the rest of the corn plant that may be used to make ethanol.

Such biomass, or cellulosic, ethanol is now seeing commercial production begin first in a facility of the Canadian company, logen, with backing from Shell Oil, at a cost of around $1.30/gallon. The National Renewable Energy Laboratory estimates costs will drop to around $1.07/gallon over the next five years, and the Energy Commission estimates a drop in costs to 67-77 cents/gallon when the process is fully mature (ETES p. 75). The most common feedstocks will likely be agricultural wastes, such as rice straw, or natural grasses such as switchgrass, a variety of prairie grass that is often planted on soil bank land to replenish the soil's fertility. There will be a decided financial advantages in using as feedstocks any wastes which carry a tipping fee (a negative cost) to finance disposal: e.g. waste paper, or rice straw, which cannot be left in the fields after harvest because of its silicon content.

Old or misstated data, frequently dealing with corn ethanol, are sometimes cited for the proposition that huge amounts of land would have to be introduced into cultivation or taken away from food production in order to have enough biomass available for cellulosic ethanol production. This is incorrect. The National Commission on Energy Policy reported in December that, if fleet mileage in the U.S. rises to 40 mpg—somewhat below the current European Union fleet average for new vehicles of 42 mpg and well below the current Japanese average of 47 mpg—then as switchgrass yields improve modestly to around 10 tons/acre it would take only 30 million acres of land to produce sufficient cellulosic ethanol to fuel half the U.S. passenger fleet. (ETES pp. 76-77). By way of calibration, this would essentially eliminate the need for oil imports for passenger vehicle fuel and would require only the amount of land now in the soil bank (the Conservation Reserve Program ("CRP") on which such soil-restoring crops as switchgrass are already being grown. Practically speaking, one would probably use for ethanol production only a little over half of the soil bank lands and add to this some portion of the plants now grown as animal feed crops (for example, on the 70 million acres that now grow soybeans for animal feed). In short, the U.S. and many other countries should easily find sufficient land available for enough energy crop cultivation to make a substantial dent in oil use. (Id.)

Some also have an erroneous impression that ethanol generally requires as much fossil fuel energy to produce it as one obtains from it and that its use does not substantially reduce global warming gas emissions. This is also incorrect. The production and use of ethanol merely recycles in a different way the CO_2 that has been fixed by plants in the photosynthesis process. It does not release carbon that would otherwise stay stored underground, as occurs with fossil fuel use.

But when starch, such as corn, is used for ethanol production much fossil-fuel energy is consumed in the process of fertilizing, plowing, and harvesting. Much of this is the natural gas required to produce fertilizer. But corn ethanol still normally produces a very large (over 90 per cent) reduction in the use of oil compared to gasoline. Starch-based ethanol reduces greenhouse gas emissions to some degree, by around 30 per cent.

But because so little energy is required to cultivate crops such as switchgrass for cellulosic ethanol production, and because electricity can be co-produced using the residues of such cellulosic fuel production, the energy requirements for converting switchgrass and other cellulosics to ethanol is very small. Indeed, with the right techniques reductions in greenhouse gas emissions for celluslosic ethanol when compared to gasoline are greater than 100 per cent. The production and use of cellulosic ethanol can be, in other words, a carbon sink. (ETES p. 73)

Biodiesel and Renewable Diesel

The National Commission on Energy Policy pointed out some of the problems with most current biodiesel "produced from rapeseed, soybean, and other vegetable oils—

as well as . . . used cooking oils." It said that these are "unlikely to become economic on a large scale" and that they could "cause problems when used in blends higher than 20 percent in older diesel engines". It added that "waste oil is likely to contain impurities that give rise of undesirable emissions." (ETES p. 75)

The Commission notes, however, that biodiesel is generally "compatible with existing distribution infrastructure" and outlines the potential of a newer process ("thermal depolyrnerization") that produces renewable diesel without the above disadvantages, from "animal offal, agricultural residues, municipal solid waste, sewage, and old tires". (This was designated "Renewable Diesel" in the Energy Act of this past summer.) The Commission points to the current use of this process at a Conagra turkey processing facility in Carthage, Missouri, where a "20 million commercial-scale facility" is beginning to convert turkey offal into "a variety of useful products, from fertilizer to low-sulfur diesel fuel" at a potential average cost of "about 72 cents per gallon." (ETES p. 77)

There have also been promising reports of the potential for producing renewable diesel from algae.

Other Alternative Fuels

Progress has been made in recent years on utilizing not only coal but slag from strip mines, via gasification, for conversion into diesel fuel using a modern version of the gasified-coal-to-diesel process used in Germany during World War II.

Qatar has begun a large-scale process of converting natural gas to diesel fuel.

In the realm of non-conventional oil, the tar sands of Alberta and the oil shale of the Western U.S. contain huge deposits. Their exploitation involves issues of cost which must be resolved, both economic and environmental, but both may hold promise for a substantial increases in oil supply from other-than-conventional sources.

3. Encourage the commercialization of plug-in hybrids and improved batteries

A modification to some types of hybrids can permit them to become "plug-in-hybrids," drawing power from the electricity grid at night and using an all-electric mode for short trips before they move to operating in their gasoline-electric mode as hybrids. With a plug-in hybrid vehicle one has the advantage of an electric car, but not the disadvantage. Electric cars cannot be recharged if their batteries run down at some spot away from electric power. But since all hybrids have tanks containing liquid fuel, plug-in hybrids have no such disadvantage.

The "vast majority of the most fuel-hungry trips are . . . well within the range" of current (nickel-metal hydride) batteries' capacity, according to Huber and Mills (*The Bottomless Well,* 2005, p. 84). Current Toyota Priuses sold in Japan and Europe have a button, which Toyota has disconnected for some reason on American vehicles, that permits all-electric driving for up to a kilometer. Basically what is needed is to equip such hybrids with adequate batteries so that this capability can be extended. Over half of all U.S. vehicles are driven less than 30 miles/day, so a plug-in hybrid that can obtain that range on overnight electricity alone might go for many weeks without visiting a gasoline station. It is important that whether with existing nickel-metal-hydride batteries or with the more capable lithium-ion batteries now commercially available for computer and other applications, it is important that any battery used in a plug-in hybrid be capable of taking daily charging without being damaged and be capable of powering the vehicle at an adequate speed. Some of the electric vehicles used in California in the late 90's (indeed hundreds are still in use) provide useful data on current battery capabilities. An electric vehicle would typically have a battery several times the size and capability of a plug-in hybrid battery. The experience of Southern Cal Edison with its all-electric fleet of Toyota RAV-4's is very promising in this regard. A number of these electric vehicles' nickel-metal-hydride batteries have been charged thousands of times, daily for years, and still provide sound performance.

Indeed the California experience with electric vehicles (EV's) in the 1990's suggests that we are so close to being able to have plug-in hybrids that small businesses may move soon to converting existing hybrids. At U. Cal. (Davis) Professor Andy Frank has been designing and operating plug-in hybrids for years that now, with commercially-available batteries, operate all-electrically for 60 miles at up to 60 mph before the hybrid gasoline-electric feature needs to be used. Whether development is needed for some improvements to lithium-ion batteries or only financial incentives for mass production of them or the more mature nickel-metal-hydride batteries, such efforts should have the highest priority because plug-in hybrids promise to revolutionize transportation economics and to have a dramatic effect on the problems caused by oil dependence.

Moreover the attractiveness to the consumer of being able to use electricity from overnight charging for a substantial share of the day's driving is stunning. The av-

erage residential price of electricity in the U.S. is about 8.5 cents/kwh, and many utilities sell off-peak power for 2-4 cents/kwh (id at 83). When one takes into consideration the different efficiencies of liquid—fueled and electric propulsion, then where the rubber meets the road the cost of powering a plug-in hybrid with average-cost residential electricity would be about 40 per cent of the cost of powering the same vehicle with today's approximately $2.50/gallon gasoline, or, said another way, for the consumer to be able to buy fuel in the form of electricity at the equivalent of $1/gallon gasoline. Using off-peak power would then equate to being able to buy 25-to-50 cent/gallon gasoline. Given the burdensome cost imposed by current fuel prices on commuters and others who need to drive substantial distances, the possibility of powering one's family vehicle with fuel that can cost as little as one-tenth of today's gasoline (in the U.S. market) should solve rapidly the question whether there would be public interest in and acceptability of plug-in hybrids.

Although the use of off-peak power for plug-in hybrids should not require substantial new investments in electricity generation for some time (until millions of plug-ins are on the road), greater reliance on electricity for transportation should lead us to look particularly to the security of the electricity grid as well as the fuel we use to generate electricity. Even though plug-in hybrids would be drawing power from the grid to charge their batteries and drive the first 30, or so miles each day, ongoing studies suggest their use would sharply reduce global warming gas emissions compared to driving the same amount of mileage on gasoline.

CONCLUSION

The dangers of dependence on conventional oil in today's world require us both to look to ways to reduce demand for it and to increase the supply of alternatives.

The realistic opportunities for reducing demand soon suggest that government policies should encourage hybrid gasoline-electric vehicles, particularly whatever battery work is needed to bring plug-in versions thereof to the market, and modern diesel technology. Light-weight carbon composite construction should also be pursued. The realistic opportunities for increasing supply of transportation fuel soon suggest that government policies should encourage the commercialization of alternative fuels that can be used in the existing infrastructure: cellulosic ethanol, biodiesel/renewable diesel, and (via plug-in hyrids) off-peak electricity. Both of the liquid fuels could be introduced more quickly and efficiently if they achieve cost advantages from the utilization of waste products as feedstocks.

The effects of these policies are multiplicative. All should be pursued since it is impossible to predict which will be fully successful or at what pace, even though all are today either beginning commercial production or are nearly to that point. Incentives for all should replace the current emphasis on automotive hydrogen fuel cells.

If even one of these technologies is moved promptly into the market, the reduction in oil dependence could be substantial. If several begin to be successfully introduced into large-scale use, the reduction could be stunning. For example, a 50-mpg hybrid gasoline/electric vehicle, on the road today, if constructed from carbon composites would achieve at least 100 mpg. If it were also a Flexible Fuel Vehicle able to operate on 85 percent cellulosic ethanol, it would be achieving hundreds of miles per gallon (of petroleum-derived fuel). If it were also a plug-in, operating on either upgraded nickel-metal-hydride or newer lithium-ion batteries, so that 30-mile trips could be undertaken on its overnight charge before it began utilizing liquid fuel at all, it could be obtaining in the range of 1000 mpg (of petroleum). If it were a diesel utilizing biodiesel or renewable diesel fuel its petroleum mileage could be infinite.

A range of important objectives—economic, geopolitical, environmental—would be served by our embarking on such a path. Of greatest importance, we would be substantially more secure.

The CHAIRMAN. Our next witness is Susan Cischke, vice president, environmental and safety engineering, Ford Motor Company. We thank you very much for coming.

STATEMENT OF SUSAN M. CISCHKE, VICE PRESIDENT OF ENVIRONMENTAL AND SAFETY ENGINEERING, FORD MOTOR COMPANY

Ms. CISCHKE. Thank you. And good morning, everyone.

At Ford, we recognize that we have a responsibility to help address America's energy security needs and we are accelerating our efforts to develop innovative solutions.

Recently we committed to increase our hybrid production capabilities to a quarter million units a year by 2010 and to continue our leadership in ethanol-powered, flexible-fuel vehicles.

We believe that our Nation's energy challenges can only be properly addressed by an integrated approach that is a partnership of all stakeholders, which includes the automotive industry, the fuel industry, government, and consumers. We must all accept that these are long-term challenges and that we are all part of the solution.

At Ford, we are moving ahead with a range of technological solutions because there is simply no single solution. There is no silver bullet. We know that when a customer considers purchasing a vehicle, they are concerned with numerous attributes, including price, quality, safety, performance, comfort, and utility.

And from our perspective, no one factor can be ignored in the highly competitive U.S. marketplace. As a result, we are working to accelerate the commercial application of all areas of advanced vehicle technologies, including hybrids, flexible-fuel vehicles, advanced clean diesel, hydrogen-powered, internal-combustion engines, and fuel-cell vehicles.

The portfolio approach that we are taking ensures that we are able to offer consumers a range of products that meet their specific needs and circumstances. And make no mistake. It will ultimately be the consumers who decide.

At Ford, we recognize that hybrids have an important place within this portfolio of solutions. They deliver excellent benefits in lower speed, stop-start traffic, and offer many customers breakthrough improvements in fuel economy, up to 80 percent in city driving without compromise.

Expansion of our hybrid plant is now clearly an important part of our strategy with increases in our production capacity as well as our model offerings. In fact, we want to offer hybrids on half of our Ford, Lincoln, and Mercury models by 2010.

In addition to hybrids, we believe the greater use of renewable fuels like ethanol will help reduce reliance on foreign oil. We applaud Congress' efforts that resulted in the Energy Policy Act of 2005, as well as the President's recent commitment to address our Nation's addiction to oil.

Ford has been building flexible-fuel vehicles for over a decade, and we are an industry leader in this technology. These vehicles are capable of operating on up to 85 percent ethanol or gasoline or a mixture in between.

By the end of this year, Ford Motor Company will have placed a total of nearly two million flexible-fuel vehicles on America's roads and for 2006, this includes America's best-selling vehicle, the Ford F150.

As a whole, the U.S. auto makers will have produced a total of nearly six million flexible-fuel vehicles. And if all these vehicles were operated on E-85, over two and a half billion gallons of gasoline a year could be displaced.

And we are not stopping there. A little over a month ago, we unveiled the Ford Escape hybrid E-85 research vehicle, which marries two petroleum-saving technologies, hybrid electric power and E-85 flexible-fuel capability.

Although there are many technical and cost challenges to address, we believe that if just 5 percent of the U.S. fleet were powered by E-85, HEVs, oil imports could be reduced by 140 million barrels a year.

But there is a problem. Even though the volume of E-85 vehicles continues to grow rapidly, there are less than 600 E-85 fueling stations in the United States and that is out of over 170,000 retail gas fueling stations nationwide.

For ethanol to compete, we need strong, long-term focus on policies that increase U.S. production and accelerate infrastructure development. At the same time, as the President pointed out in the State of the Union address, we need national research efforts to produce ethanol for more energy-efficient cellulosic materials like rice straw, corn stover, or switch grass.

Looking to the future, we are looking at what we think is an important transitional technology, hydrogen-powered internal-combustion engines. Ford is a leader in this technology and we think it is a bridge to the development of a hydrogen infrastructure and ultimately fuel-cell vehicles.

And we are in the process of developing hydrogen-powered shuttle buses for fleet demonstrations in North America starting later this year.

Even further down the road, hydrogen-powered fuel cells appear to be another promising technology for delivering sustainable transportation. Hydrogen can be derived from a wide range of feedstocks to increase energy diversity and fuel cells are highly energy efficient and produce no emissions, like our Ford Focus fuel cell.

We have already placed a small fleet of these vehicles in three U.S. cities as part of the U.S. Department of Energy's Hydrogen Demonstration Program.

As you can imagine, R&D investment that goes with all this work is a very big number, certainly in the billions, not the millions, and it will only grow in the future. But there is only so much we can achieve without the help of others outside the industry.

It is clear that the solution to the energy issue associated with road transport will need to come from advances in fuels as well as vehicle technology. We need the oil industry to endorse an integrated approach here in the United States just as they are beginning to do with auto makers and government officials in Europe.

Without the wholehearted involvement of the fuel industry, we cannot move forward far enough or fast enough and we obviously need key partners like the oil industry to invest in developing and marketing renewable fuels like E-85.

And there is a great deal that policymakers can do as well. Government incentives for advanced technology vehicles and E-85 infrastructure can accelerate the introduction of these vehicles and fuels into the marketplace.

And there is also a role for government in educating the public on energy efficiency. In the end, it will ultimately be the size of the car park, consumers' choice of vehicles, how many miles they drive, and driving behaviors that will determine how much fuel we consume.

The challenges of energy security are considerable, but they are not insurmountable. And there is an enormous amount we can

achieve if we act together. We have to ensure that our business is sustainable by making vehicles that continue to meet the changing needs of the 21st century. And that is a responsibility we owe our customers, our shareholders, and our employees. But at another level, all of us have an opportunity to do something about energy independence and that is a responsibility we owe future generations.

Thank you for the opportunity to address the committee.

The CHAIRMAN. Thank you very much, Ms. Cischke. We appreciate your testimony.

[The prepared statement of Ms. Cischke follows:]

PREPARED STATEMENT OF SUSAN M. CISCHKE, VICE PRESIDENT OF ENVIRONMENTAL AND SAFETY ENGINEERING, FORD MOTOR COMPANY

Members of the Committee: My name is Susan Cischke and I am the Vice President of Environmental and Safety Engineering at Ford Motor Company. Energy security is a significant issue facing our nation. I appreciate the opportunity to share with you Ford Motor Company's views on this issue.

Energy is literally the fuel that powers the industrial and manufacturing growth of the United States. The energy supply disruptions of last summer, increases in global demand, and geopolitical concerns with some of the oil rich regions of the world led to significantly higher energy prices and consumer angst at the fuel pump. It's our view that action must be taken in all sectors of course, if we are to meet these challenges as a nation.

At Ford, we recognize that we have a responsibility to do something to help address America's energy security needs, and we are accelerating our efforts to develop innovative solutions. As Bill Ford has said, "Ford Motor Company is absolutely committed to making innovation a central part of everything we do." In our recent product announcements we committed to increase our hybrid production capabilities to a quarter-million units a year by 2010 and to continuing our leadership in ethanol powered flexible fuel vehicles.

These new product initiatives are a strong commitment for Ford and our customers, and they recognize a changing marketplace. But there is a limit to what we can achieve on our own.

We believe that our nation's energy challenges can only be properly addressed by an *Integrated Approach:* that is, a partnership of all stakeholders which includes the automotive industry, the fuel industry, government, and consumers. The truth is that we must all accept that these are long-term challenges and that we are all part of the solution.

So let me set out how we at Ford Motor Company believe each stakeholder can play its part. I'll start with the automotive industry itself, because we clearly have a central role to play. The industry has taken significant steps in improving the fuel efficiency of our products. At Ford Motor Company we see this not only as being socially responsible but a business necessity, and we are moving ahead with a range of technological solutions simultaneously—because there is simply no single solution, no "silver bullet". We know that when customers consider purchasing a vehicle, they are concerned with numerous attributes including price, quality, safety, performance, comfort and utility. From our perspective, no one factor can be ignored in the highly competitive U.S. marketplace. As a result, we are working to accelerate the commercial application of all areas of advanced vehicle technologies, including hybrids, flexible fuel vehicles, advanced clean diesels, hydrogen-powered internal combustion engines and fuel cell vehicles. The *portfolio* approach that we are taking ensures that we are able to offer consumers a range of products that meet their specific needs and circumstances. And make no mistake; it will ultimately be the consumers who decide.

This diversity of customer needs within and across markets is why we are investing in a portfolio of solutions. The result is a period of unprecedented technological innovation. Innovation—in matters of the energy, renewable fuels, safety and design—is the compass by which we are setting our direction for the future.

At Ford, we recognize that hybrids have an important place within this portfolio of solutions. They deliver excellent benefits in lower speed stop/start traffic and offer many customers breakthrough improvements in fuel economy—up to 80% in city driving—without compromise. And much of this technology is also applicable to our fuel cell and ethanol vehicle development efforts. In 2004, we launched the world's

first gasoline-electric full hybrid SUV, the Escape Hybrid. In 2005, we expanded this technology to the Mercury Mariner Hybrid, and have announced plans to offer this technology on the Mazda Tribute SUV, and the Ford Fusion, Mercury Milan, Ford Five Hundred and Mercury Montego sedans, plus the Ford Edge and Lincoln MKX crossover vehicles.

Expansion of our hybrid offering is now clearly an important part of our overall innovation strategy which embraces our recent commitment to increase our production capacity to up to 250,000 hybrids per year by 2010 and to offer hybrids on half of our Ford, Lincoln and Mercury products. Nevertheless, a key challenge facing hybrids is the incremental costs—both in terms of higher prices for components and engineering investments—that must be overcome for this technology to transition from "niche markets" to high-volume applications.

In addition to hybrids, we believe that greater use of renewable fuels like ethanol, a domestically produced renewable fuel, will help reduce reliance on foreign oil. We applaud Congress' efforts that resulted in the Energy Policy Act of 2005, as well as the President's recent commitment to address our nation's addiction to oil. Ford has been building flexible fuel vehicles (FFVs) for over a decade, and we are an industry leader in this technology. These "FFVs" are capable of operating on up to 85% ethanol, or gasoline, or any mixture in between.

By the end of this year, Ford Motor Company will have placed a total of nearly 2 million FFVs on America's roads, and for 2006 this includes America's best selling vehicle—the (5.4L) Ford F-150 FFV. As a whole, the U.S. automakers will have produced a total of nearly 6 million vehicles. If all of these vehicles were operated on E85, over 2.5 billion gallons of gasoline a year could be displaced.

And we are not stopping there. A little over a month ago we unveiled the Ford Escape Hybrid E85 research vehicle which marries two petroleum-saving technologies—hybrid electric power and E85 flexible-fuel capability. Though there are many technical and cost challenges to address, we believe that if just 5% of the U.S. fleet were powered by E85 HEVs, oil imports could be reduced by about 140 millions barrels a year.

But there is a problem. Even though the volume of E85 vehicles continues to grow rapidly, there are less than 600 E85 fueling stations in the U.S.—and that's out of over 170,000 retail gasoline fueling stations nationwide. For ethanol to compete as a motor fuel in the transport sector and play an increasingly significant role addressing our nation's energy concerns, we need strong, long-term focus on policies that increase U.S. ethanol production and accelerate E85 infrastructure development. At the same time, as the President pointed out in the State of the Union address, we need national research efforts to pursue producing ethanol from more energy-efficient cellulosic materials like rice straw, corn stover, switch grass, wood chips or forest residue.

Ford is also working on advanced light duty diesel engines. Today's clean diesels offer exceptional driveability and can improve fuel economy by up to 20-25%. This technology is already prevalent in many markets around the world—nearly half of the new vehicles sold in Europe are advanced diesels—and Ford continues to accelerate our introduction of diesel applications in these markets. There are, however, many hurdles that inhibit wide scale introduction of this technology in the U.S. We are working to overcome the technical challenges of meeting the extremely stringent Federal and California tailpipe emissions standards, and to address other issues such as fuel quality, customer acceptance and retail fuel availability.

Looking to the future, we are working on what we think is an important transitional technology to sustainable transportation—hydrogen-powered internal combustion engines. Ford is a leader in this technology. We think it's a "bridge" to the development of a hydrogen infrastructure and, ultimately, fuel cell vehicles, and we are in the process of developing hydrogen powered E450 H_2ICE shuttle buses for fleet demonstrations in North America starting later this year. Ford is also working on applying this engine technology to stationary power generators and airport ground support vehicles to further accelerate the technology and fueling infrastructure development.

Even further down the road, hydrogen powered fuel cells appear to be another promising technology for delivering sustainable transportation. Hydrogen can be derived from a wide range of feedstocks to increase energy diversity, and fuel cells are highly energy-efficient and produce no emissions. Our Ford Focus Fuel Cell vehicle is a state-of-the-art, hybridized fuel cell system—sharing much of the same hybrid technology we developed for our Escape Hybrid SUV. We have already placed a small fleet of these vehicles in three U.S. cities as part of the U.S. Department of Energy's hydrogen demonstration program collecting valuable data.

As you can imagine, the R&D investment that goes with all this work is a very big number—certainly in the billions, not the millions—and it will only grow in the

future. Many of our competitors and suppliers are also investing heavily. But there is only so much we can achieve without the help of others outside our industry. We need an *integrated approach.*

It is clear that the solution to the energy issues associated with road transport will need to come from advances in fuels as well as vehicle technology. We need the oil industry to endorse an *Integrated Approach* here in the U.S., just as they are beginning to do with automakers and government officials in Europe. We at Ford are clearly excited about the potential role of renewable fuels. However, the fact is that without the whole-hearted involvement of the fuel industry, we cannot move forward far enough or fast enough. We obviously need key partners like the oil industry to invest in developing and marketing renewable fuels like E85—and we need it to do so now and rapidly. We fully support government incentives to encourage the industry or others to accelerate this investment.

There is a great deal that policy makers can do at all levels as well. We would like to see more R&D support for vehicle technologies and renewable fuels. Government incentives for advanced technology vehicles and E85 infrastructure can accelerate the introduction of these vehicles and fuels into the marketplace. Government must play a critical role to promote U.S. innovation and can do so by expanding and focusing R&D tax credits for a broad range of energy efficient technologies. We would also like to see greater investment in improved road traffic management infrastructure in order to reduce congestion and save fuel. According to the American Highway Users Alliance, about 5.7 billion gallons of fuel are wasted annually due to congestion. Effective traffic light synchronization is a good example of a change that could lead to big reductions.

There is also a role for government in educating the public on how to drive in an energy efficient manner. In the end, it will ultimately be the size of the car park, and consumers' choices of vehicles, how many miles they drive, and driving behaviors that will determine how much motor fuel we consume. A person who drives in an energy-conscious way—by avoiding excessive idling, unnecessary bursts of acceleration and anticipating braking—can enjoy much better fuel consumption, today. And government can play a key role to raise public awareness. We believe that *awareness* is a simple and effective early step which is why we have introduced driver training programs in Europe and recently developed on-line training for all Ford Motor Company employees.

Consistent implementation of an *Integrated Approach* will allow us to achieve much more in a shorter timeframe and at a significantly lower cost than if each stakeholder were to pursue its own agenda in isolation, however well-intentioned they might be.

The challenges are considerable but not insurmountable, and there is an enormous amount we can achieve if we act together in an *integrated* manner. We have to ensure that our business is sustainable by making vehicles that continue to meet the changing needs of the 21st century. That's a responsibility we owe to our customers, shareholders and our employees. But at another level, all of us have the opportunity to do something about energy independence—and that's a responsibility we owe future generations.

Thank you again for the opportunity to address the Committee.

The CHAIRMAN. Frank Verrastro, director and senior fellow, Center for Strategic and International Studies, we welcome you. We have seen your testimony and we thank you so much for your ideas.

STATEMENT OF FRANK VERRASTRO, DIRECTOR AND SENIOR FELLOW, ENERGY PROGRAM, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES

Mr. VERRASTRO. Thank you, Mr. Chairman.

I would also like to note at the outset that the last time I appeared before this panel, you characterized the presentations of myself and fellow witnesses as comparable to the warnings of the Paharo Dimaro Swartee, the bad news birds.

Regardless of whether my current invitation attests to the accuracy of those past predictions or simply a reflection of the fact that the committee has new staff members, I nonetheless appreciate the opportunity to come back before you today.

Since you have copies of my prepared remarks, let me use this time to highlight a few of the major points. And I agree with much of what has been said already.

Page two of my testimony contains a pie chart indicating the EIA's projections for global energy demand growth in 2025, as well as the relative share of the major fuel groups. Similar forecasts have been published the IEA, OPEC, and others. And while the exact share numbers differ under each of the forecasts, the trends are always the same.

Global energy demand is predicted to increase by 50 percent over the next 25 years, yet the relative shares of the five major fuel groups, oil, natural gas, coal, nuclear, and renewables, are expected to remain remarkably constant.

A snapshot of just North America would mirror this global projection as we comprise about 30 percent of worldwide demand. Europe would show a greater concentration of nuclear and, hence, a lower share of fossil fuels.

But in the developing world, those countries least able to utilize cutting-edge technology and the area's largest projected area where we see a doubling of demand over the next 20 years, fossil fuels continue to exceed 90 percent, carrying obvious consequences for consumer competition and for the environment.

Analyzing this forecasted future leads to two seemingly inescapable conclusions. The first is that absent major technological breakthroughs, significant changes in consumption patterns and policy, or massive dislocations to alter the course of events, consumption trends depicted by this chart are simply unsustainable for the long term.

Second, even assuming a significant contribution from a wide range of alternative fuels, conventional energy sources will continue to dominate the landscape for at least the next several decades.

I would also add that since the topic of this hearing focuses on energy independence, that despite the obvious political attraction, such a notion may, in fact, be a misguided quest and that we might be better served by recognizing the reality of our current energy interdependence while mapping out a strategy for managing the transition to a different energy future.

Rising oil prices in recent years have heightened interest in a variety of alternative sources of liquid and nonliquid fuels, including natural gas, fuel cells and batteries, methanol, ethanol, biodiesel, coal to liquids, gas to liquids, industrial, municipal, and agricultural waste streams, other forms of biomass conversion, hydrogen, and electricity. All have great promise, but most have problems, both aspects of which are outlined in greater detail in my testimony.

Bio refineries, digesters, and other waste energy process facilities are clearly in the sights of investors, although their most significant supply impacts may be felt on a regional rather than national basis, at least until expanded distribution and delivery infrastructure is put in place.

Analysis performed by EIA and the National Renewable Energy Lab estimates that even under optimistic assumptions, alternative transport fuels, excluding electric hybrid plug-ins, can be expected

to displace or replace a maximum of 10 percent of conventional liquid transport fuels by 2030, leaving petroleum-based fuels, new technologies, conservation, and improved efficiency gains to deal with the remaining 90 percent.

For purposes of comparison, a billion gallons of alternative fuels per year roughly translates to 65,000 barrels a day of conventional gasoline and maybe less depending on energy context. And we currently consume over nine million barrels a day of gas every day.

In short, while contributions from alternate fuels will be helpful as a component in meeting increased consumer demand, petroleum-based fuels are likely to remain the overwhelming fuel of choice for at least the next 20 years.

At the same time, however, we cannot ignore preparations for transitioning to the inevitable post-oil world, a transition which former Energy and Defense Secretary, Jim Shlesinger, has characterized as the greatest challenge this country and the world will face outside of war.

As with any transformational change, issues surrounding the approach, time horizon, and leverage designed to accomplish this objective remain the keys to success. Dealing with an energy transition is no less daunting.

To the extent practicable, every effort should be made to pursue policies and changes that fully take into account investment in market practices and utilize as much as possible existing infrastructure and currently available technologies.

Minimizing uncertainty, avoiding conflicting and contradictory policy signals and selecting options based on economic efficiency and merit rather than political efficacy are also highly recommended.

And fuels alone are not the answer. We need radical changes to our motor vehicles, both in terms of energy and design and construction material, as well as to the way we transport goods and people.

In conclusion, let me add that the oil market is truly a global market. Reducing America's oil consumption can potentially have a dampening effect on prices, but will not completely insulate us from supply disruptions or price volatility.

We frequently speak about politically unstable sources of supplies from around the globe, but the largest protracted losses of global oil and gas output in both 2004 and 2005 were the results of hurricanes in the U.S. Gulf of Mexico.

The Stone Age did not end because we ran out of rocks. Something better came along. The oil age will similarly be overtaken when a better solution or series of component solutions emerge. We can and should accelerate that process, but need to do so carefully and prudently by introducing cost-effective substitutes, using available market mechanisms, and educating the public on the need for change, and, in the meantime, by better managing demand and our global relations with suppliers and consumers alike.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much.

[The prepared statement of Mr. Verrastro follows:]

PREPARED STATEMENT OF FRANK VERRASTRO, DIRECTOR AND SENIOR FELLOW, ENERGY PROGRAM, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES

Mr. Chairman, Members of the Committee, I appreciate the opportunity to appear before you today to discuss the broad ranging topic of America's energy independence. I currently serve as Energy Program Director and Senior Fellow at the Center for Strategic and International Studies (CSIS), but my professional background also includes a variety of energy policy positions in the White House, and the Departments of Interior and Energy, as well as senior executive positions dealing with both upstream and downstream issues in the energy sector, first as Director of Refinery Policy and Crude Oil Planning for TOSCO Corporation, and more recently as a Senior Vice President at Pennzoil Company.

Given the composition of this morning's panel, the bulk of my remarks will be directed at the issue of oil import dependence and prospects for replacing and reducing petroleum demand for transportation fuels, but more generally I will also touch on the U.S. energy balance and proffer the view that we would be well advised to pursue a broader array of options for ensuring that our energy needs are met. These options should include:

- stimulating additional supplies of conventional and traditionally non-conventional fuel sources, including renewables and alternatives;
- improving energy efficiency and conservation efforts;
- promoting research and technology development, and where applicable, accelerating the deployment of useful technologies;
- addressing infrastructure needs to facilitate the delivery of fuel choices;
- pursuing the development of a more comprehensive energy strategy that recognizes the potential for simultaneously introducing transformational policies while managing the realities of our existing energy interdependence in a global energy market, and
- performing the above activities consistent with current investment and market practices.

I would also add that focusing on Energy Independence, while politically attractive, may in fact be a misguided quest and that we would be better served by mapping out a strategy for managing the transition to a different energy future as our current path is clearly unsustainable.

OUR EVOLVING ENERGY WORLD

Mr. Chairman, the events of the past few years have served to refocus attention on the critical role which energy plays in our national and global economies. Rising global oil demand, concern over the adequacy, reliability, and pricing of energy supplies, the environmental implications of increased use of fossil fuels, the cost of those supplies for developed and developing economies alike, trade and capital flows, and global geopolitics are issues that preoccupy business and governments around the globe.

Faced with these evident realities, concern over the continued ability of this nation to secure energy supplies from an increasing list of inaccessible, high risk or less than reliable parts of the world has prompted policymakers to once again raise the issues of both the desirability and achievability of energy independence.

U.S. consumers have come to both enjoy and expect a healthy domestic economy, which is underpinned by an energy supply that is at once available, affordable, secure, and environmentally benign. In this new world are those criteria able to be satisfied or are they just beyond the reach of current energy paradigms and policies?

Global energy demand is projected to increase by 50 percent over the next 25 years, yet the relative shares of the five major fuel groups—oil, natural gas, coal, nuclear and renewables—are expected to remain remarkably constant, with fossil fuel consumption still accounting for over 85 percent of total energy demand in 2025. In the developing world, that figure exceeds 90 percent (see figure below),* carrying obvious consequences for consumer competition and the environment.

As we consider our energy options, I would strongly urge that we not forget the substantial contributions that conservation and improved efficiency can make to achieving our future energy goals. In the power generation sector, it currently takes three to four units of primary energy to produce one unit of delivered electricity. Conservation, efficiency and infrastructure delivery improvements coupled with additional contributions from renewable energy sources can obviate the need for additional, incremental production of fossil fuels for power generation purposes. Simi-

*All graphs have been retained in committee files.

larly, improving auto efficiency and accelerating the deployment of proven technologies into the auto fleet can, over time, make a substantial contribution to reducing transportation fuel demand.

Analyzing this forecasted future leads to two seemingly inescapable conclusions. The first is that absent major technological breakthroughs, significant changes in consumption patterns and policies, or massive dislocations that alter the course of events, the consumptions trends depicted by this chart are simply unsustainable for the long term. Secondly, even assuming a significant contribution from a wide range of alternative fuels, conventional energy sources will continue to dominate the landscape for at least the next several decades.

THE ROLE OF THE UNITED STATES IN A GLOBAL ENERGY MARKETPLACE

For the past thirty years, U.S. oil policy initiatives have centered around 4 major themes: increasing and diversifying sources of conventional and unconventional energy supplies both at home and abroad; encouraging, wherever practicable and politically achievable, the adoption of improvements in conservation and fuel efficiency; the expansion of the strategic petroleum reserve; and reliance on Saudi Arabia to balance oil markets and moderate prices.

For the most part, in an era of surplus supply, this strategy has largely worked. Times and market conditions, however, may well be changing. Global demand for all energy forms is accelerating, and resources are increasingly controlled by national players, whose primary national objectives may not conform to traditional market practices or concerns.

It took the world 18 years (from 1977-1995) to grow global oil demand from 60 to 70 million barrels per day (mmb/d); eight years to grow from 70 to 80 mmb/d; and if current projections are correct, global oil demand will exceed 90 mmb/d by 2010. Forecasts for oil consumption in 2030 approximate 115-120 mmb/d—roughly half again as much as we currently consume. Setting aside the debate about resource availability or so called "peak oil," market growth of that magnitude will require huge investments, place enormous strains on transportation and infrastructure needs, and carry significant implications for security, global geopolitics and the environment.

In addition, the entry of new market players, like China and India, with growing energy appetites and expanding economies may pose competitive threats to America's market dominance. Added to that are heightened security concerns about threats to infrastructure and facilities posed by terrorist groups and insurgents. Taken together, these changing circumstances have the potential to re-order the marketplace and fundamentally alter the geopolitical balance that has governed the past half century. Such changes may also warrant a thoughtful recalibration of our economic, security, environmental, energy and foreign policy calculations and policy choices.

The United States is currently the world's largest producer, consumer, and net importer of energy. We are home to roughly 5 percent of the world's population and produce 17 percent of the total energy supplied. Yet in the process of generating some 30 percent of global GDP, America consumes nearly a quarter of the world's energy.

In terms of energy self-sufficiency, the United States in 2004 produced (domestically) roughly 71 percent of the total energy it consumed. Today, the United States remains self-sufficient in meeting virtually all of its energy needs with the exception of two key energy forms—petroleum, and increasingly, natural gas—both of which are critical commodities.

In its recently released 2006 Annual Energy Outlook, the U.S. Energy Information Administration (EIA) forecasts that overall energy usage in the United States will continue to increase at an annual growth rate of 1.2 percent for the next 25 years. U.S. energy demand for all fuels is projected to increase from roughly 100 quadrillion Btus (Quads) to over 127 quads by 2030 with oil, gas and coal leading the way. Projected incremental growth for non-hydro renewables will also be substantial, but starting from such a small base, is expected to account for about 7 percent of total domestic energy demand by 2025, with 60 percent of that amount devoted to grid-related electricity generation.

In contrast, total U.S. demand for petroleum products, largely driven by increases in transportation fuel needs, is projected to increase by over 30 percent from current levels (slightly below 21 mmb/d in 2005) to just over 27.5 mmb/d in 2030. Demand for all forms of petroleum fuels except for the bottom of the barrel increase, and total gasoline demand increases to about 12.5 mmb/d. Petroleum fuels currently supply 97 percent of all domestic transportation needs.

After a brief period of increased output (from 2006-2015, largely as a result of additional production from the deep water of the Gulf of Mexico) domestic crude oil production is expected to resume its gradual decline. And with U.S. refineries running at or near capacity, absent substantial new investment, increased domestic demand means expanding reliance on imported petroleum, both for crude oil and, increasingly, refined petroleum products.

In 2025, net petroleum imports are expected to account for 60 percent of demand (up from 58 percent in 2004), although that figure could increase to almost 70 percent depending on assumptions about price and economic activity. Net imports of refined petroleum products increase from 17 to 22 percent of total oil imports by 2030.

The rise in oil import levels, both in absolute and relative terms, carries important infrastructure, logistical, environmental, financial, trade, security, and foreign policy implications. Assuming investment continues to lag in the creation of additional domestic refining capacity, the projected rise in imports of refined petroleum product increases U.S. vulnerability to supply disruptions and potentially undermines the value of the Strategic Petroleum Reserve (SPR).

A similar picture emerges for domestic natural gas, although demand continues to grow between now and 2015 before leveling off as coal demand for power generation accelerates. As demand for natural gas increases, the United States will increasingly rely on nonconventional domestic production (e.g., tight sands and coal seam gas), gas from Alaska, on increased imports of pipeline gas from Canada (to the extent they are available), and on LNG from sources in Latin America, the Caribbean, Africa, the Middle East, Australia, and Russia.

Projected supplies of LNG imports assume that additional regasification capacity will be permitted and constructed either within the United States or in areas proximate to U.S. borders—an uncertain assumption. In addition to environmental, safety, competition, and siting issues, opponents of additional LNG regas projects increasingly cite security and foreign policy concerns about exposing the U.S. electric grid system to reliance on imports from countries, many of which are oil exporters found in troubled regions of the world. (Global gas reserves data is shown in the next figure.)

AN INCREASING ROLE FOR ALTERNATIVE FUELS

Rising oil prices in recent years have heightened interest in a variety of alternative sources of liquid fuels. At present, two biologically derived fuel forms, ethanol and biodiesel, are used in the United States to supplement supplies of conventional gasoline and diesel. In principle, biodiesel can be blended into conventional diesel or heating oil in fractions compatible with the fuel system and/or its construction materials. On the plus side, biodiesel's blending promotes flexibility and reduces carbon monoxide emissions. Unfortunately, depending on the precise chemical composition of the solvent, too high a concentration can damage certain plastics and rubber (system) components and may contribute to increased emissions of nitrogen oxide.

Ethanol can be readily blended into gasoline. Since the late 1970s, cars and light trucks built for the U.S. market are capable of running on a 10 percent ethanol blend. A limited number (roughly 5 million) of the 220 million vehicles currently on the road are also capable of running on blends of up to 85 percent ethanol. Most fuel ethanol currently produced in the United States is distilled from corn. Since corn is also a food crop, however, there are questions related to the volume of ethanol that can be readily produced from corn without affecting crop prices, as well as limitations on the amount of acreage available to dedicate to fuel crop planting.

In addition, since only a portion of the plant material can be used to produce ethanol, issues have been raised about how to handle the residual waste material—e.g., stalks, leaves and husks. A partial answer to this dilemma has resulted in research into what is called cellulosic ethanol, but transportation and energy content issues still remain to be resolved. For example, since a gallon of ethanol contains less energy than a comparable gallon of gasoline, poorer mileage ratings and more frequent fuel stops are impediments that need to be overcome. Additionally, cold weather start problems and transport in carriers other than pipelines may complicate gasoline substitution on a national scale.

There have also been promising breakthroughs in creating other forms of fuels from a wide variety of sources, including biomass, agricultural, industrial and municipal waste streams, coal to liquids (CTLs), gas to liquids (GTLs), "synfuels" made from oil sands, shale and extra heavy crudes, and biomass to liquids (BTLs) processes that derive fuels from waste wood and other non-food plant sources.

Biorefineries, digesters and other waste to energy process facilities are clearly in the sights of investors, although their most significant supply impacts may be felt on a regional rather than national basis, at least until expanded distribution and delivery infrastructure comes on line. In this regard, better data collection would be most helpful. The National Renewable Fuels Laboratory (NREL) and EIA have been discussing data improvements to better capture a more complete picture of how biofuels activity is developing within the U.S., but resource limitations affecting data collection and modeling have limited that effort.

It is worth noting, however, that based on current government data, the capital investment costs for most, if not all, of these synthetic fuel technologies is considerably more than that required for a traditional crude oil refinery (see page 57, of EIA's 2006 Annual Energy Outlook). Further, for purposes of comparison, EIA estimates that there is currently some 300,000 b/d of installed corn ethanol capacity in the United States and an additional 12,000 b/d of biodiesel capacity. Additionally, excluding "pilot" facilities, the latest EIA statistics indicate that there are currently no commercial BTL, GTL or CTL plants in the United States. In contrast, U.S. refining capacity currently exceeds 17 million barrels per day and domestic gasoline demand averages over 9 million barrels per day.

The mandated target of producing 7.5 billion gallons of ethanol (fuel) by 2012 translates into roughly 490,000 b/d, representing approximately 3 percent of projected domestic transportation fuel needs in 2012 and less than 5 percent of total gasoline demand. Analyses performed by EIA and NREL estimate that even under optimistic assumptions, alternative transport fuels (excluding electric hybrid plug-ins) can be expected to displace/replace a maximum of 10 percent of conventional liquid transport fuels by 2030, leaving petroleum based fuels, conservation and improved efficiency gains to deal with the remaining 90 percent.

A 2004 report prepared by the bi-partisan National Commission on Energy Policy came up with similar results, projecting a 10-15 percent reduction in U.S. oil consumption in 2025 by substituting non-petroleum transportation fuel alternatives in combination with the adoption of more stringent CAFE standards for cars and light trucks and providing incentives to encourage the production and purchase of fuel efficient vehicles. In reaction to the Commission's report, EIA analysis attributed a 7.3 percent reduction in petroleum fuel usage to the adoption of tougher fuel efficiency and CAFE standards.

In short, while contributions from alternative fuels will be helpful as a component in meeting increased consumer demand for transport fuels, for at least the mid-term, absent significant policy and regulatory changes to promote increased fuel efficiency, major technological breakthroughs, and substantial changes in consumer/driver behavior (based on environmental, security or foreign policy considerations), petroleum based fuels will remain the overwhelming fuel of choice for at least the next 20-30 years.

Given projections for increasing fuel demand, the inescapable conclusion is that oil imports will also be with us for decades to come. In that context, we would do well to ratchet down the political rhetoric surrounding the notion of achieving energy independence and instead refocus our efforts to deal with an inter-dependent energy future and simultaneously prepare for the (longer term) transition to a post-oil world, a transition which former Energy and Defense Secretary James Schlesinger has characterized as ". . . the greatest challenge this country and the world will face—outside of war."

U.S. OIL IMPORTS—SOURCES AND CONCERNS

In his State of the Union address, President Bush advanced the challenge of reducing this nation's "addiction to oil" and reducing by 75 percent our reliance on oil imports from the Middle East. At best, this line was a thinly veiled attempt to drum up domestic political support for a valiant yet difficult effort to reduce petroleum consumption. At worst, it showed a decided lack of understanding of U.S. import sources, global oil markets and reserve holders.

In 2005, the primary oil suppliers (crude oil and refined product) to the United States were, in volumetric order, Canada, Mexico, Venezuela, Saudi Arabia and Nigeria. Imports from Iraq ranked a distant sixth. The top 5 suppliers provide over 60 percent of total U.S. oil imports. The entire Middle East, by contrast, accounted for roughly 17 percent of last year's imports (representing about 11 percent of total domestic petroleum consumption).

Looking forward, imports of Canadian and Mexican oil are expected to decline as their respective production levels decline and/or domestic requirements increase. In contrast, imports from the Middle East and OPEC sources generally (in part because these countries represent the several of the largest reserve holders in the

world, both for oil and gas) are expected to increase. Managing relationships with these suppliers should be a priority under any policy the U.S. devises for dealing with future energy requirements.

PITFALLS AND WARNINGS

As with any transformational change, issues surrounding the approach, time horizon and levers designed to accomplish the objective remain keys to success. Dealing with an energy transition is no less daunting. To the extent practicable, every effort should be made to pursue policies and changes that fully take into account investment and market practices and utilize as much as possible existing infrastructure and currently available technologies. Minimizing uncertainty, avoiding conflicting or contradictory policy signals, and evaluating/selecting options based on economic efficiency and merit rather than political efficacy are also are highly recommended.

A few examples:

Less than eight months ago, the Congress adopted the Energy Policy Act of 2005. The Act was notable in many respects, but when read against the oil reduction challenges laid out by the President in the State of the Union address may unintentionally lead to uncertainty and paralysis in terms of energy investment. The energy legislation specifically included provisions designed to encourage additional refinery capacity construction within the United States, yet the President's challenge to displace petroleum usage could likely have a chilling impact on both international upstream investments and domestic refining additions, both expensive and long-lived investments.

Similarly, after much debate and deliberation and for a wide variety of reasons, the single MTBE-related provision (repeal of the oxygenate mandate) that survived the energy conference has resulted in a reduction in available octane enhancing components and will likely produce higher ethanol and gasoline prices while reducing gasoline availability.

A third example relates to the permitting of additional LNG regasification facilities in the United States to handle increased volumes of imported natural gas. As indicated earlier, as we strive to reduce reliance on imported oil, we appear to be simultaneously encouraging increased import dependence of natural gas—the bulk of which may come from similar import sources.

And finally, at a time when policymakers are intent upon encouraging specific types of large scale energy investments, does it really make sense to hamstring major industry players by proposing tax changes that ultimately reduce their ability to pursue those investments?

Altering the trajectory of future demand for petroleum based fuels is prudent policy for a wide variety of reasons. But in doing so, we should not confuse displacing oil with the larger objective of tempering overall consumption and improving efficiency as the main priorities. Crop growing also requires energy. Plug in vehicles that run on electricity require energy sources to generate that power—the bulk of which currently comes from coal, although nuclear, natural gas and renewables also play significant roles.

The oil market is a truly global market. Reducing America's oil consumption can potentially have a dampening effect on prices, but it will not completely insulate us from supply or price volatility. We frequently speak about "politically unstable" sources of oil supplies around the globe, but the largest protracted losses of global oil and gas output in both 2004 and 2005 were the result of hurricanes in the U.S. Gulf of Mexico.

The Stone Age did not end because we ran out of rocks—something better came along. The Oil Age will similarly be overtaken when a better solution or a series of component solutions emerge. We can and should accelerate that process, but need to do so carefully and prudently—by introducing cost effective substitutes, while employing (insofar as possible) existing infrastructure and delivery systems, minimizing uncertainty, using available market mechanisms and educating the public on the need for change.

CONCLUSION

Over the past 50 years, U.S. energy policy has been faithfully diverse, often internally inconsistent, amazingly flexible in adjusting to public, market and commercial pressures, and incomprehensible to most observers. It is likely to retain many of these unique elements.

The 1970s provided the last clear articulation of an attempted national energy strategy—and this was largely in response to global energy events. The 1973 Arab Oil Embargo prompted the development of the SPR, the adoption of CAFE (Corporate Average Fuel Efficiency) standards, and the formation of the International

Energy Agency (IEA). Domestic natural gas shortages and the prospects for declining oil supplies prompted President Carter's decision to lift oil price regulation and pursue energy sector transformation, ushering in a new era in U.S. policy driven by the market.

In short, economics has prevailed over the past 25 years. Until recently, oil prices have remained relatively low and U.S. energy efficiency has increased. However, changing market and political conditions may complicate America's policy agenda going forward, and these include:

- Energy security, broadly defined in terms of attacks on infrastructure, and greater vulnerability to imported energy supply threats, either physical or financial, due to growing production concentration;
- Market developments, particularly in alternative fuels and with respect to climate change. In the future, markets may drive policy more than policy drives markets;
- Less multilateral cooperation in the international oil trading and investment market places as governments pursue specific narrow interests;
- Increased vulnerability to supply disruptions due to growing natural gas import dependence in the power sector; and
- Political hostility to U.S. policy in specific regions as allies and friends abandon the United States to ensure their own political survival.

The role of the United States as an energy producer, consumer, and importer has already been noted in some detail. The energy future of the country seems at once very clear but very worrisome: declining domestic production and rising domestic demand, with the gap to be covered by imports from suppliers whose national interests may not and historically have not coincided with our own.

This almost inevitable growth in reliance on foreign supplies would, to the casual observer, seem to be a call to action, to define and implement policies that would concomitantly expand domestic supplies while setting demand management efforts in motion. To do so, however, requires a certain political will on the part of both the U.S. consumer and the government. And, to date, despite higher energy prices, real and threatened interruptions in supply, environmental damage, hurricanes and blackouts, that critical ingredient remains lacking.

All energy producer/exporters and consumer/importers are bound together by a mutual interdependency. All are vulnerable to any event, anywhere, at any time, which impacts on supply or demand. This means that the U.S. energy future likely will be shaped, at least in part, by events outside of our control and beyond our influence. Calls for energy independence, absent major technological breakthroughs and a national commitment, ring hollow, and in the near term are both unrealistic and unachievable. In the absence of decisive political will to undertake those steps necessary to improve efficiency, promote conservation, encourage the development of domestic energy resources and renewable energy forms, learning to manage the risks accompanying import dependency may be the only reasonable course of action.

It is against this backdrop that future U.S. environmental, economic, foreign, energy and security policies must be fashioned.

Thank you.

The CHAIRMAN. Mr. Lovins, chief executive officer of the Rocky Mountain Institute, we welcome you and your testimony will be made a part of the record.

STATEMENT OF AMORY B. LOVINS, CHIEF EXECUTIVE OFFICER, ROCKY MOUNTAIN INSTITUTE

Mr. LOVINS. Mr. Chairman, thank you for this opportunity to provide a broader context amplified in my written testimony for how to achieve energy independence without compromising national security.

Both energy independence and its purpose, energy security, rest on three pillars. First, making domestic energy infrastructure, notably electric and gas grids, resilient because domestic is not necessarily secure. Second, phasing out, not expanding, vulnerable facilities and unreliable fuel sources. And, third, ultimately eliminating reliance on oil from any source.

Listing those three pillars in the order I did emphasizes that achieving the third goal without the first two creates only an illusion of security. Hurricane Katrina might as well have read my 1981 finding for DOD that a handful of people could cutoff three-quarters of the oil and gas supply to the Eastern States in one evening without leaving Louisiana.

We should worry not only about already attacked Saudi oil choke points like Abqaiq and Ras Tanura but also about the all-American Strait of Hormuz proposed in Alaska.

DOE policy that did not undercut DOD's mission would shift from brittle energy architecture, the next major failure inevitable, to more efficient, resilient, diverse, dispersed, renewable systems that make it impossible.

It would avoid electricity investments that are meant to prevent blackouts, but instead make them bigger and more frequent. It would stop creating attractive nuisances for terrorists from vulnerable LNG and nuclear facilities to over-centralized U.S. and Iraqi electric infrastructure. And it would acknowledge the nuclear proliferation correctly identified by the President as the gravest threat to national security is driven largely by nuclear power.

Each of these self-inflicted security threats can be reversed by cheaper, faster, more abundant, and security-enhancing alternatives available both from comprehensive energy efficiency and from decentralized supply.

For example, nuclear power has already been eclipsed in the global marketplace by resilient, inherently peaceful, lower cost and lower risk micro power. That is a big win for national security and profitable climate protection and a vindication of competitive markets over central planning.

Energy independence is not only about oil. Many sources of LNG raise similar concerns of security, dependence, site vulnerability, and cost. I do not expect that Iran and Russia would be more reliable, long-run sources of gas than Persian Gulf states are today of oil.

Fortunately, half of U.S. natural gas can be saved by end-use efficiency and electric demand response with average costs below a dollar per million BTU, four times cheaper than LNG, thus making LNG needless and uncompetitive.

America's oil problem is equally unnecessary and uneconomic. Seventy-seven weeks ago, my team published "Winning The Oil End Game," an independent, peer-reviewed, detailed, transparent, and uncontested study co-sponsored by the Office of the Secretary of Defense and the Chief of Naval Research. It shows how to eliminate U.S. oil use by the 2040's and revitalize the economy led by business for profit.

Welcomed by business and military leaders, our analysis is based on competitive strategy for cars, trucks, planes, and oil, and on military requirements.

Our study shows how the United States can redouble the efficiency of using oil at an average cost of $12.00 per saved barrel and can substitute, save natural gas, and advance biofuels, chiefly cellulosic ethanol for the remaining oil at an average cost of $18.00 per barrel. Thus eliminating oil use would cost just one-fourth its

current market price, conservatively assuming that its externalities are all worth zero.

Side benefits would include a free 26-percent reduction in CO_2 emissions, a million new jobs, three-fourths in rural and small-town America, and the opportunity to save a million jobs now at risk. America can either continue importing efficient cars to displace oil or make efficient cars and import neither the cars nor the oil. A million jobs hang in the balance.

The key to wringing twice the work from our oil is tripled efficiency, cars, trucks, and planes, integrating the best 2004 technologies for ultra-light steels or composites, better aerodynamics in tires, and advanced propulsion can do this with 2-year paybacks.

For example, new low-cost carbon composite manufacturing techniques can cut in half the weight and fuel use of our cars and light trucks, improve their safety, comfort, and performance, and not raise their manufacturing costs.

Just for illustration, I brought along a little piece of such a material to illustrate that plastics have changed since "The Graduate."

Oil elimination's compelling business logic will drive its eventual adoption, but supported public policy could accelerate it without requiring new taxes, subsidies, mandates, or Federal laws. This could be done administratively or by the States.

Many innovative policies could also transcend gridlock. Size and revenue-neutral feebates could speed the adoption of super-efficient cars far more effectively than gasoline taxes or efficiency standards and would make money for both consumers and auto makers.

While the policies could also support automotive retooling and retraining, super-efficient planes, advanced biofuels, low-income access to affordable personal mobility, and other key policy goals all at zero net cost to the Treasury.

Early implementation steps are encouraging. Our analysis has already led Wal-Mart to launch a plan to double its heavy truck fleets' efficiency and to consider tripled efficiency a realistic goal.

The Department of Defense is also recognizing fuel-efficient platforms as a key to military transformation. Military needs for ultra-light, strong, cheap materials, and the science and technology commitments that that implies can transform the civilian car, truck, and plane industry as much as DARPA created the internet, GPS, and the chip and jet engine industries, and thus can lead the Nation off oil so we need not fight over oil, net negamissions in the Persian Gulf, mission unnecessary.

I believe the shortest path to an energy policy that enhances security and prosperity is free-market economics, letting all ways to save or produce energy compete fairly at honest prices, no matter which kind they are, what technology they use, where they are, how big they are, or who owns them.

That would make the whole energy security, oil, climate, and most proliferation problems fade away and would make our economy and our democracy far stronger.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much for your comments.

[The prepared statement of Mr. Lovins follows:]

PREPARED STATEMENT OF AMORY B. LOVINS,[1] CHIEF EXECUTIVE OFFICER, ROCKY MOUNTAIN INSTITUTE[2]

Both energy independence and its purpose, energy security, rest on three pillars:

1. Making domestic energy infrastructure, notably electric and gas grids, resilient.
2. Phasing out, not expanding, vulnerable facilities and unreliable fuel sources.
3. Ultimately eliminating reliance on oil from any source.[3]

Listing them in this order emphasizes that achieving the third goal without the first two creates only an illusion of security. Hurricane Katrina might as well have read my 1981 finding[4] for DoD that a handful of people could cut off three-fourths of the Eastern states' oil and gas supplies in one evening without leaving Louisiana. We should worry not only about already-attacked Saudi oil chokepoints like Abqaiq and Ras Tanura, but also about the all-American Strait of Hormuz proposed in Alaska.[5] DOE policy that didn't undercut DoD's mission would:

- shift from brittle energy architecture that makes major failure inevitable to more efficient, resilient, diverse, dispersed systems that make it impossible;[6]
- avoid electricity investments that are meant to prevent blackouts but instead make them bigger and more frequent;[7]

---

[1] Published in 29 books and hundreds of papers, Mr. Lovins's work has been recognized by the "Alternative Nobel," Onassis, Nissan, Shingo, and Mitchell Prizes, a MacArthur Fellowship, the Benjamin Franklin and Happold Medals, nine honorary doctorates, and the World Technology, Heinz, Lindbergh, Jean Meyer, and Time "Hero for the Planet" Awards. He's a longtime advisor to the Departments of Energy and Defense and major energy firms worldwide.

[2] RMI is an independent, nonpartisan, entrepreneurial, nonprofit applied research center that creates abundance by design. Working mainly with the private sector, it fosters the efficient and restorative use of resources to make the world secure, just, prosperous, and life-sustaining. In recent years, RMI's consulting team has redesigned $20 billion worth of facilities for advanced energy efficiency and has served or been asked to serve over 80 Fortune 500 firms.

[3] Since oil is a fungible commodity in a global market, national energy policy correctly recognizes that the problem is oil use, not imports: see n. 13, p. 14. For example, even if the U.S. imported no oil, it would still be a price-taker in the world market, so its economy, like its trading partners', would still be buffeted by oil-price volatility. Oil infrastructure is also inherently vulnerable even if it is domestic (n. 4).

[4] A.B. & L.H. Lovins, Brittle Power: Energy Strategy for National Security, Brick House (Andover MA), 1981, and Rocky Mountain Institute, 1989; OCR scan reposted at www.rmi.org/sitepages/pid1011.php; summarized in A.B. & L.H. Lovins, "The Fragility of Domestic Energy," Atlantic, pp. 118-126, Nov. 1983 (Attachment One hereto. Attachment one has been retained in committee files).

[5] Former Director of Central Intelligence R. James Woolsey, an Oklahoman not per se hostile to petroleum, testified against Arctic National Wildlife Refuge drilling on national-security grounds (Energy Subcommittee of USHR Science Committee, 1 Nov. 2001), and wrote that such drilling's "real show-stopper is national security. Delivering that oil by its only route, the 800-mile-long Trans-Alaska Pipeline System (TAPS), would make TAPS the fattest energy-terrorist target in the country Uncle Sam's 'Kick Me' sign. / TAPS is frighteningly insecure. It's largely accessible to attackers, but often unrepairable in winter. If key pumping stations or facilities at either end were disabled, at least the above-ground half of 9 million barrels of hot oil could congeal in one winter week into the world's biggest ChapStick®. / The Army has found TAPS indefensible. It has already been sabotaged, incompetently bombed twice, and shot at more than 50 times. Last Oct. 4 [2001], a drunk shut it down with one rifle shot. / In 1999, a disgruntled engineer's sophisticated plot to blow up three critical points with 14 bombs, then profit from oil futures trading, was thwarted by luck. He was an amiable bungler compared with the Sept. 11 attackers. Connect the dots: Doubling and prolonging dependence on TAPS hardly seems a prudent centerpiece for what advocates whimsically called the Homeland Energy Security Bill./ Reliance both on Mideast oil and on vulnerable domestic energy infrastructure such as TAPS imperils the security of the U.S. and its friends." (R.J. Woolsey, A.B. & L.H. Lovins, "Energy security: It takes more than drilling," Chr. Sci. Mon., 29 Mar. 2002, www.rmi.org/images/other/EnergySecurity/S02-05—TakesMareThanDrill.pdf. For documentation, see hyperlinks to p. 73 in A.B. & L.H. Lovins, For. Aff., pp. 72-85, July/Aug. 2001, www.rmi.org/images/other/Energy/E01-04 FoolsGoldAnnot.pdf, and later supplementary references at www.rmi.org/sitepages/pid171.php#E01-04.)

[6] N. 4; "Surprises and Resilience," RMI Solutions, pp. 1ff, spring 2006, www.rmi.org/sitepages/pid1200.php.

[7] Bigger power plants sending bigger bulk power flows through longer transmission lines tend to make the grid less stable (id.). Leading engineering analysts of electric-grid theory are reaching similar conclusions, e.g., http://eceserv0.ece.wisc.edu/~dobson/PAPERS/carrerasHICSS03.pdf. FERC doesn't let resilient options compete.

- stop creating attractive nuisances for terrorists, from vulnerable LNG and nuclear facilities to overcentralized U.S. and Iraqi electric infrastructure;[8]
- acknowledge that nuclear proliferation, correctly identified by the President as the gravest threat to national security, is driven largely by nuclear power.[9]

Each of these self-inflicted security threats can be reversed by cheaper, faster, more abundant, and security-enhancing alternatives, available both from comprehensive energy efficiency and from decentralized supply. For example, nuclear power has already been eclipsed in the global marketplace by resilient, inherently peaceful, lower-cost, and lower-risk micropower.[10] That's a big win for national security and profitable climate protection,[11] and a vindication of competitive markets over central planning.

Energy independence is not only about oil. Many sources of LNG raise similar concerns of security, dependence, site vulnerability, and cost: Iran and Russia won't be more reliable long-run sources of gas than Persian Gulf states are of oil. Fortunately, half of U.S. natural gas can be saved by end-use efficiency and electric de-

---

[8] See n. 4 for discreet details. Since the invasion of Iraq, private recommendations that its electricity infrastructure be rebuilt in decentralized form, virtually invulnerable to insurgent attack, have been repeatedly rejected.

[9] A.B. & L.H. Lovins and L. Ross, "Nuclear Power and Nuclear Bombs," For. Aff. 58(5):1137-1177, Summer 1980. Had that article's recommendations been adopted, we would not today be worrying about Iran and North Korea. In brief, nuclear power makes widely and innocently available the key ingredients—fissile materials, equipment, technologies, skills—needed to make bombs by any of the ~20 known methods (other than stealing military bombs or parts). (New reactor types and the proposed reversal of the Ford-Cheney non-reprocessing policy greatly intensify these perilous links.) But in a world that took economics seriously, nuclear power would gracefully complete its demise, due to an incurable attack of market forces (n. 10), so these ingredients of do-it-yourself bomb kits would no longer be items of commerce. This would make them harder to get, more conspicuous to try to get, and politically far costlier to be caught trying to get, because for the first time the reason for wanting them would be unambiguously military. This would not make proliferation impossible, but would make it far more difficult and much easier to detect timely: intelligence resources could focus on needles, not haystacks. The U.S. example is critical because if a country with such wealth, technical skill, and fuel resources claims it cannot meet its energy needs without nuclear energy and reprocessing, then it invites every other less fortunate country to make the same spurious claim. Yet the U.S. could still offer to meet the intent of the Non-Proliferation Treaty's Article IV bargain by sharing today's cheaper, faster, more effective energy technologies (n. 10) to boost global development. The NPT's specifically nuclear bargain was written by nuclear experts, in a nuclear context, around 1969-70, when nuclear energy was widely believed to be cheap and indispensable. Now that the market has decided otherwise, Article IV should be reinterpreted to achieve the same electricity-for-development goal by more modem, speedy, and affordable means, starting immediately with U.S./Indian energy cooperation: improving the non-nuclear 97% of India's electricity system could produce enormously greater, wider, faster, and cheaper development benefits.

[10] Low-carbon cogeneration plus decentralized no-carbon renewables surpassed nuclear power's global capacity in 2002 and its annual electricity output in 2005, and they are far outcompeting central stations despite typically lower subsidies and bigger obstacles. In 2004, micropower worldwide added ~2.9 times as much output and ~5.9 times as much capacity as nuclear power did (or at least ten times if electric efficiency were also included). Industry projects that in 2010, micropower will add ~160 times as much capacity as nuclear power adds. Micropower comprises cogeneration (combined-heat-and-power using 1-120 MWe gas turbines, 1-30 MWe engines, and steam turbines only if in China), plus renewables excluding big hydro (>10 MWe). Electricity savings are probably even bigger than micropower additions but are not being well tracked. See A.B. Lovins, "Mighty Mice," Nucl. Eng. Intl., pp. 44-48, Dec. 2005 (Attachment Two. Attachment two has been retained in committee files), www.rmi.org/sitepages/pid171.php#E05-15, and for details, "Nuclear power: economics and climate-protection potential," 11 Sep. 2005 / 6 Jan. 2006, www.rmi.org/sitepages/pid171.php#E05-14. Statistics at www.rmi.org/sitepages/pid171.php#E05-04 and .www.ren21.net/dobalstatusreport/issue Group.asp.

[11] Choosing the best buys first could relieve climate concerns not at a cost but at a profit, because efficiency generally costs less than the energy it saves: A.B. Lovins, "More Profit With Less Carbon," Sci. Amer., pp. 74-82, Sept. 2005, www.sciam.com/media/pdf/Lovinsforweb.pdf (Attachment Three. Attachment three has been retained in committee files), and its extended bibliography, www.rmi.org/images/other/Climate/C05-05a—MoreProfitBib.pdf. Reducing global energy intensity not by the normally assumed 1%/y but by 2%/y would eliminate CO_2 growth; slightly faster improvement would stabilize climate. Both the U.S. and certain states have sustained intensity reductions well over 2%/y, and attentive companies around 6%/y, all at a handsome profit. Yet climate politics focus on cost, burden, and sacrifice rather than on profit, jobs, and competitive advantage. Fixing this sign error is the key to crafting a profitable climate solution. Of course, buying carbon-free resources judiciously, not indiscriminately, yields the most climate solution per dollar and per year. Expanding nuclear power would reduce and retard climate protection, simply because it's costlier and slower than its key competitors—cogeneration, certain renewables, and efficient end-use. See Lovins papers in n. 10.

mand response with average costs below $1 per million BTU—four times cheaper than LNG[12]—making LNG needless and uncompetitive.

America's oil problem is equally unnecessary and uneconomic. Seventy-seven weeks ago, my team published Winning the Oil Endgame—an independent, peer-reviewed, detailed, transparent, and uncontested study cosponsored by the Office of the Secretary of Defense and the Chief of Naval Research.[13] It shows how to eliminate U.S. oil use by the 2040s and revitalize the economy, led by business for profit. Welcomed by business and military leaders, our analysis is based on competitive strategy for cars, trucks, planes, and oil, and on military requirements.

Our study shows how the U.S. can redouble the efficiency of using oil at an average cost[14] of $12 per saved barrel, and can substitute saved natural gas and advanced biofuels (chiefly cellulosic ethanol) for the remaining oil at an average cost of $18 per barrel. Thus eliminating oil would cost just one-fourth its current market price, conservatively assuming that its externalities are worth zero. Side-benefits would include a free 26% reduction in CO_2 emissions, a million new jobs (three-fourths in rural and small-town America), and the opportunity to save a million jobs now at risk. America can either continue importing efficient cars to displace oil, or make efficient cars and import neither the cars nor the oil. A million jobs hang in the balance.

The key to wringing twice the work from our oil is tripled-efficiency cars, trucks, and planes. Integrating the best 2004 technologies for ultralight steels or composites, better aerodynamics and tires, and advanced propulsion can do this with two-year paybacks.[15] For example, new low-cost carbon-composite manufacturing techniques can halve cars' weight and fuel use, improving safety, comfort, and performance without raising manufacturing cost.[16]

Oil elimination's compelling .business logic would drive its eventual adoption. But supportive public policy could accelerate it without requiring new taxes, subsidies, mandates, or federal laws; this could be done administratively or by the states.

Many innovative policies could also transcend gridlock. Size- and revenue-neutral feebates[17] could speed the adoption of superefficient cars far more effectively than

---

[12] Saving 1% of U.S. electricity, including peak hours, can save 2% of total U.S. natural gas consumption and cut the gas price by 3-4% (see n. 13, pp. 112-116, 219-220). In this decade, such straightforward efficiencies could cut $50 billion off the Nation's annual gas and power bills and relieve many gas and electricity constraints without costly, controversial, and vulnerable supply-side investments. The main obstacles are that gas efficiency isn't on the federal policy agenda, and that 48 states reward utilities for selling more electricity and gas while penalizing them for cutting customers' bills. Scores of other barriers, too, block wider purchases of energy efficiency in all sectors (see pp. 11-20 in www.rmi.org/images/other/Climate/C97-13—ClimateMSMM.pdf), but each obstacle can be turned into a business opportunity if policy focuses systematically on "barrier-busting."

[13] Winning the Oil Endgame: Innovation for Profits, Jobs, and Security, RMI, 20 Sep. 2004, by A.B. Lovins, E.K. Datta, 0.-E. Bustnes, J.G. Koomey, & N.J. Glasgow; Forewords by George Shultz and Sir Mark Moody-Stuart; .PDF download free at www.oilendgame.com. That site also posts the Executive Summary (Attachment Four. Attachment four has been retained in committee files), 24 Technical Annexes, lay summaries from Ripon Forum (www.rmi.org/sitepages/pid171.php#OilDependence) and Fortune (www.rmi.org/images/other/Energy/E04-21__FreeFromOil.pol), Robert C. McFarlane's Wall Street Journal op-ed (http://online.wsj.com/public/page/0,,public__home__search,00.htm1#SB110350663319704480), and many other articles and reviews, and offers the 331-page hard-copy book for $40.

[14] Refiner's acquisition cost on the short-run margin, 2000 $, 5%/y real discount rate.

[15] Compared with EIA 1/04 Reference Case vehicle characteristics and fleet mix, fuel economy could be improved by 69% for cars at a levelized Cost of Saved Energy of 57¢/gal, by 65% for Class 8 trucks at 25¢/gal, and by ~65% for planes at ≤46¢/gal. The first 25% of truck and 20% of airplane fuel savings are free. Please see n. 13 and its Technical Annexes 4-6 and 12 for full analytic details and documentation.

[16] Because the advanced composites' higher cost is offset by simpler automaking and smaller powertrains. See n. 13, pp. 44-73, Tech. Annex 5 (www.oilendgame.com/TechAnnex.html), and Intl. J. Veh. Des. 35(1/2):50-85 (2004), www.rmi.org/images/other/Trans/T04-01__HypercarH2AutoTrans.pdf. One cost-competitive carbon-composite structural manufacturing process, being commercialized by a small firm, Fiberforge®, of which (full disclosure) I'm Chairman and a small shareholder, is described at www.fberforge.com/DOwNLOADS/FiberforgeACCE05.pdf and in trade press articles at www.fiberforge.com/PAGES/DETAIL__PAGES/inthenews.html.

[17] Such feebates (= fee + rebate) would broaden the price spread within each size class by charging fees on less efficient vehicles and using the revenue to pay rebates on more efficient vehicles. Whether you pay a fee or receive a rebate depends on your efficiency choice within the size class you prefer. A typical feebate slope—$1,000 per 0.01 gallon/mile difference from the "pivot point" efficiency level set within each size class—would arbitrage the spread in discount rate between consumers and society, so a car buyer would consider full lifecycle fuel savings (nominally ~14 years) rather than just the first 2-3 years. DOE/ORNL modeling, closely

Continued

gasoline taxes or efficiency standards, and would make money for both consumers and automakers.[18] Novel policies could also support automotive retooling and retraining, superefficient planes, advanced biofuels, low-income access to affordable personal mobility, and other key policy goals, all at zero net cost to the Treasury.[19]

Early implementation steps are encouraging. Our analysis led Wal-Mart to launch a plan to double its heavy truck fleet's efficiency and to consider tripled efficiency a realistic goal.[20] The Department of Defense is also recognizing fuel-efficient platforms, as a key to military transformation. Military needs for ultralight, strong, cheap materials can transform the civilian car, truck, and plane industries—much as DARPA created the Internet, GPS, and the chip and jet-engine industries—and thus lead the Nation off oil so we needn't fight over oil: negamissions in the Persian Gulf, Mission Unnecessary.[21]

The surest path to an energy policy that enhances security and prosperity is free-market economics: letting all ways to save or produce energy compete fairly, at honest prices, no matter which kind they are, what technology they use, where they are, how big they are, or who owns them. That would make the energy security, oil, climate, and most proliferation problems fade away, and would make our economy and democracy far stronger.[22]

The CHAIRMAN. I am going to start with Senator Thomas and come back to me at a later date.

Senator Thomas.

Senator THOMAS. Mr. Chairman, thank you very much.

Thank you, ladies and gentlemen, for your comments. Certainly this is an area we are all concerned with. We talk about it in fairly broad terms, but I think we have to talk about it and how we move. We have a policy now. The question is how do we implement that policy.

I wanted to talk about something a little different. It seems to me we have long-term issues that are going to take a while. We have a problem, however, in the short term, and that is dealing with, for example, I think we have a real opportunity to convert coal, which is our largest fossil resource, to diesel fuel, for example. We can do that very shortly.

As a matter of fact, we have plants prepared to do that right now. Unfortunately, I think our budgets and so on do not show much effort to give incentives to do that short-term thing.

In the bill, the policy bill, I put in there that we need plants like this and some of them in areas over 4,000 feet so that we get out where the coal is. But, unfortunately, we do not have much support for that in the budget and so on.

---

matching RMI's, shows that such feebates yield both producer and consumer surplus. See n. 13, pp. 186-190.

[18] See n. 13, pp. 169-190.

[19] See n. 13, pp. 178-226. The 2005 Energy Policy Act's 3-5-year biofuel credits are too brief for investment horizons; any serious incentive, especially in an area fraught with investment uncertainties, should last at least a decade. However, I generally prefer abolishing energy subsidies to adding new ones, and I fear that the same broad policy conditions that created the energy market collapse of 1984-85 are now being repeated.

[20] L. Scott, "Twenty First Century Leadership," 24 Oct. 2005, www.walmartstores.com/Files/21st%20Century%20Leadership.pdf.

[21] Fuel-efficient platforms offer huge benefits in force protection, tens of billions of dollars' annual savings in fuel logistics, and multi-divisional realignments from tail to tooth: n. 13, pp. 84-93, 221, and 261-262; Defense Science Board, More Capable Warfighting Through Reduced Fuel Burden, 2001, www.acq.osd.mil/dsb/reports/fuel.pdf.

[22] Both a quick low-budget experiment (www.nepinitiative.org) and the National Commission,on Energy Policy (www.energycommission.org) revealed a broad ground for trans-ideological consensus on these general lines. The former effort found that a bipartisan group of private- and public-sector energy leaders could readily agree on a comprehensive, visionary, but practical framework for national energy policy by focusing on what they already agreed about thus making what they disagreed about largely superfluous.

So at any rate, Mr. Woolsey, it seems like some of these things, ideas that you have are pretty long term. What do we do in the next 4 of 5 years?

Mr. WOOLSEY. Well, Senator, cellulosic ethanol is now coming on the market, Iogen in Canada, backed by Shell oil, diesel from waste products such as turkey carcasses from a Canagra slaughter house——

Senator THOMAS. Tell me about the volume of that, however. Oil from turkey carcasses obviously is not going to amount to much of anything.

Mr. WOOLSEY. No. But that process works for used tires, for animal waste, for chicken litter, for billions of tons of waste of all kinds. And it has been so demonstrated in a pilot plan.

And the cellulosic ethanol, the Wright brothers have already flown on this. The enzymes and genetically modified biocatalysts are working and they are producing cellulosic ethanol.

It is a question of getting these—and I think the same thing is true of plug-in hybrids—the question is getting these up on the step of moving into large-scale production. It is not that one has to collect people for that project.

Senator THOMAS. Okay. Thank you.

Let us talk about automobiles. We are going to have this business going on. How are you going to move, again, in a fairly short time, to make a conceivable difference between what we are doing now and what we are going to do—I just do not think we can——

Mr. WOOLSEY. Well, let me give one example, Senator. Brazil will——

Senator THOMAS. Well, I have moved to the next witness.

Mr. WOOLSEY. Sorry.

Ms. CISCHKE. Well, we have two million vehicles on the road today from Ford Motor Company and six million in the industry. But if they cannot get E-85, then it becomes a problem.

We are working with a company called Verisun Energy to increase the number of stations in the United States. And I mentioned before, we have 600 today and that is out of 170,000 gas stations.

So some of the investment can happen very quickly in terms of getting dedicated fuel and then that would help quite a bit in the vehicles that we operate today.

Senator THOMAS. What is the balance between the cost of ethanol production in terms of particularly if it is done through crops and what we save in the final analysis?

Ms. CISCHKE. Yes. Well, as you know, there is less energy in ethanol than there is in gasoline, there is about 28 percent less energy. So the fuel economy would be reduced by about 25 percent. But right now the cost of ethanol is cheaper than gas.

And we believe that, as was mentioned before, in the cellulosic ethanol, that there could be a lot more done to develop that in a very cost-effective manner, and then that has even more benefit from a——

Senator THOMAS. What can we do about CAFE standards?

Ms. CISCHKE. Well, as you know, we are working very closely with NITSA to get to the maximum feasible CAFE standard, as well as reforming CAFE so that we cover a number of different

product lines and it does not penalize the full vehicle manufacturers.

But we have had CAFE for over 30 years and the whole desire for CAFE was to reduce our dependence on foreign oil. And it really has not had that effect because people are driving more.

Senator THOMAS. Well, you have not gotten CAFE standards, however. You have not reduced that. We have not seen a market change in automobiles.

Ms. CISCHKE. Well, we have. We have increased CAFE quite a bit. In fact, we have improved energy efficiency of the vehicles quite bit, but we have also——

Senator THOMAS. Tell me what the CAFE standards are now.

Ms. CISCHKE. Well, it is 27½ for cars and it will be 22.2 for trucks in the next couple years.

Senator THOMAS. But it is not now.

Ms. CISCHKE. Pardon?

Senator THOMAS. Is it not now.

Ms. CISCHKE. For trucks?

Senator THOMAS. No. For 27 miles. That is not in place now.

Ms. CISCHKE. Twenty-seven and a half, yes.

Senator THOMAS. Most of the cars out on the street are not 27 miles a gallon.

Ms. CISCHKE. By law, the average CAFE fleet for each company is 27½ miles per gallon for the car——

Senator THOMAS. For new ones, for new ones.

Ms. CISCHKE. Yes, exactly. For new ones, right.

Senator THOMAS. All right. Mr. Lovins, you sort of indicated that there is no role for nuclear power?

Mr. LOVINS. I think it has died of an incurable attack of market forces despite a great deal of devoted talent and effort that have been put into it.

Senator THOMAS. You think it has died?

Mr. LOVINS. Yes, sir. I think the effect of the new subsidies you voted last year, which will pay roughly the entire capital costs of the next six plants, if any, will be roughly the same as that of defibrillating a corpse. It will jump, but it will not revive.

And you may have noticed, Senator, that after those subsidies were voted, Standard & Poors put out two research reports saying they thought it would have no material effect on the builders——

Senator THOMAS. Don't you think the availability of the fuel and the cleanliness in the air impact will have some method of using nuclear fuel?

Mr. LOVINS. Well, as explained in the attachment for Nuclear Engineering International to my testimony, Senator, what matters is not simply the attributes of any particular technology, but its economic competitiveness within a market where there are many other technologies.

Senator THOMAS. None of which are now being used?

Mr. LOVINS. Senator——

Senator THOMAS. See, my problem is——

Mr. LOVINS [continuing]. Please be so kind as to look at the attachment because what it shows from industry data and government data is that micro power, some renewable, some fossil fueled cogen worldwide is already bigger than nuclear power in both out-

put and capacity and is really many times faster. So those technologies not only do exist, but——

Senator THOMAS. I have not seen those kind of facts before.

Mr. LOVINS. That is why I submitted——

Senator THOMAS. And it comes back to the matters. All right. Thank you.

Mr. LOVINS. Thank you.

The CHAIRMAN. Thank you very much, Senator.

Senator Bingaman.

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

Let me ask Ms. Cischke?

Ms. CISCHKE. Yes.

Senator BINGAMAN. Ms. Cischke. Mr. Lovins says in his testimony new low-cost carbon composite manufacturing techniques can have cars' weight and fuel use, improving safety, comfort, and performance without raising manufacturing cost.

Has Ford looked at the benefits that might be achieved through moving to these low-cost carbon composite materials and, if so, what have you concluded? Why are we not seeing a move toward this by U.S. manufacturers?

Ms. CISCHKE. Well, we are looking at all areas of where we can take weight out of the vehicle without compromising safety as well as improvements in today's internal combustion engines. And all that does take investment. You know, when we tool up for a vehicle and we do research and development, it takes a long time to get that into the system.

And so overall, we are always looking at ways that we can reduce the weight of the vehicle, improve aerodynamics, a number of different things. But from an overall standpoint, we share many of the body styles. We share a lot of components. So it takes time to be able to put that across the whole fleet.

Senator BINGAMAN. But do you agree that once the investment is made to make the transition that, in fact, the manufacturing cost of cars from these new materials would be less than is currently the cost using the materials you have now?

Ms. CISCHKE. I think it is something we would have to study. I have seen some of the data that I was shown by Mr. Lovins earlier. And we are looking at it in our research area, but I do not think that we have costed that out in terms of what it would take for our manufacturing plants and whether there would be a savings.

Senator BINGAMAN. Back in, I believe it was April of last year, your company and the other U.S. manufacturers, auto manufacturers, I think all auto manufacturers, not just U.S. auto manufacturers, but all manufacturers, entered into a Memorandum of Agreement with the government of Canada to reduce greenhouse gas emissions from vehicles by 2010.

Is there any reason why that same agreement would not make sense in the United States, that the same commitments that the companies have made with regard to vehicles sold in Canada should not apply also here in the United States?

Ms. CISCHKE. Well, actually, it does in many ways. When we looked at the whole agreement with Canada, it is based on total greenhouse gases, so it involves more than just fuel economy. It is not a fuel economy standard.

But if you take a look at what we have done in all areas and apply the fuel economy we are getting today in the United States, it would be equivalent to what we are shooting for in Canada.

So the differences have a lot to do with how they are quantified in terms of greenhouse gas savings. And it is very similar to what we have.

Senator BINGAMAN. So you do not really think there is any difference between what you agreed to do in Canada and what you are doing in the United States?

Ms. CISCHKE. That is correct.

Senator BINGAMAN. Okay. Let me just ask Mr. Lovins if he would take a minute and explain this proposal that he has for revenue-neutral feebates. That is an interesting proposal and an alternative way to get increased efficiency in automobiles alternative to CAFE standards.

Could you just explain that briefly for us?

Mr. LOVINS. Yes, Senator. Gasoline taxes are a pretty good signal to drive less if you have alternatives, but they are a very weak signal to buy an efficient car because that price signal in the fuel is diluted many fold by the other costs of buying and running a car and then heavily discounted at consumer discount rates.

So consumers really only look at the first 2 or 3 years of fuel savings. CAFE standards, we all know about and are pretty well gridlocked.

We found that a more effective method would be to take each size class of light vehicles and institute forward a feebate system. That is a combination of a fee and a rebate, so that within each size class separately, the less efficient vehicles pay a fee according to how inefficient they are and the more efficient vehicles get a rebate paid for by the fees according to how efficient they are.

So you would have an incentive within each size class to buy a more efficient vehicle, but no incentive to buy a different size than you wanted. And widening the price spread has the effect that you would look at the whole life cycle, say 14 years of fuel savings, not just the first 2 or 3 years. So you would make an investment decision that is efficient for society.

The Oakridge DOE modeling of feebates comes to the same conclusions we did and adds that it would make more money for auto makers. At least one major auto maker already agrees with that.

Senator BINGAMAN. Which auto maker is that?

Mr. LOVINS. I am not at liberty, Senator, to say which, but it is one that might surprise you.

Senator BINGAMAN. Okay. My time is up, Mr. Chairman.

The CHAIRMAN. Senator Bunning.

Senator BUNNING. Thank you, Mr. Chairman.

First of all, I would like to put my opening statement into the record.

The CHAIRMAN. It will be admitted.

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.

It has been a difficult year for Americans who are facing higher gasoline costs and home heating expenses. Instability in foreign nations, like Iraq and Nigeria, and the

devastation along the gulf coast at home have caused significant spikes in energy prices. I think that with energy prices at these highs, we can see clearly that our national security is threatened by our continued reliance on imported oil.

Last year, we were finally successful in passing a comprehensive national energy plan. This wide-ranging legislation will impact nearly every facet of the energy industry and will encourage the development of cleaner technologies and renewable fuels and is the first step toward energy independence. I know my colleagues are aware that it will take time and the vigilance of Congress to ensure that the Energy Policy Act is properly implemented and funded.

I think one of our top priorities should be on our most abundant domestic fossil fuel: Coal. New technologies will make burning coal both cleaner and more efficient. We are even developing coal-to-liquid technology that can create a synthetic transportation fuel from coal. American coal reserves will be our best tool to overcome our reliance on Middle East oil.

We also have other domestic energy reserves, like ANWR and the Outer-Continental Shelf. I believe we can tap these oil and natural gas reserves in an environmentally sound way. That is way I have fought for ANWR and OCS legislation that will provide America with a new domestic source of fuel.

I think we also need to develop our renewable fuels, especially stimulating biodiesel and ethanol production. In some parts of the world—and a few places in Western Kentucky—people drive their cars and trucks on a blend of fuel that is 85% ethanol. That means only 15% of the fuel is based on oil. The potential for this technology is great, and it is up to us to help it off the ground.

We can use these domestic fuel sources to meet the energy challenges of the next 25 years. I look forward to developing these ideas further with the panel before the Committee today.

Thank you Mr. Chairman.

Senator BUNNING. Many of you have focused on biodiesel and transportation fuels, but coal is our most abundant domestic fossil fuel and accounts for half of our electric generation.

The Energy Information Administration predicts coal will continue to be the centerpiece of our energy production for the next 25 years. That is not me. That is our Energy Information Administration.

I believe we can lessen our dependence on imports by using clean coal power and nuclear energy to replace the imported natural gas and oil that currently goes to producing electricity.

Do you believe that developing more efficient and cleaner coal technologies should be a priority, Jim?

Mr. WOOLSEY. Senator Bunning, I think that since only 2 to 3 percent of our electricity now comes from oil, that whether it is clean coal or nuclear or renewables has a very limited effect to use those for electricity production. And the debates between them are important debates.

I think that has very little impact on our oil dependence, which I think is the heart of the matter. I think that clean coal, particularly integrated gasification combined cycle coal with carbon sequestration has real promise. And we so said at the National Energy Policy Commission.

Senator BUNNING. I want to ask a question about that. Following up, I have been impressed with the new coal to liquid technology that you are talking about that can turn coal into synthetic liquid fuel. Other parts of the world like South Africa have been using this technology for decades.

Mr. WOOLSEY. Yes, sir.

Senator BUNNING. I know there are several pilot facilities here in America, but what do we need to do to push this industry into full commercial-scale operations?

Mr. WOOLSEY. Well, that is the German Fisher Trofe's process developed in the air war years and used by the Germans in World War II to generate their diesel fuel. And as you say, the South Africans have substantially improved it in the intervening years.

But I think one has to be able, if one is going to produce diesel fuel that way, to make sure that one can sequester successfully the carbon. And I think there is some promise of that with the integrated gasification combined cycle coal technology, but I am not sure whether there has been substantial progress sequestering the carbon for Fisher Trofe.

And one of the other witnesses may know more than I about Fisher Trofe. But in principle, using coal to produce diesel fuel is certainly an option and one that we ought to vigorously explore further.

Senator BUNNING. Let me ask the Ford Motor representative. In some parts of the world and a few places in west Kentucky, people drive their cars and trucks on a blend of fuel that is 85 percent ethanol. And you spoke about that.

Some of you on the panel have mentioned that the best case scenario for biodiesel is that it will only replace 10 percent of gasoline use for transportation.

What are the limiting factors? Can the Government help address the problem like infrastructure and efficiency?

Ms. CISCHKE. Well, certainly for the E-85, which is 85 percent ethanol, we do need infrastructure help. As I mentioned, there are only 600 stations and we need to have that help.

We believe that by introducing a very popular vehicle like the F150 that will be able to run on E-85, it will do a lot to drive the demand for it because there is a lot of volume there.

Senator BUNNING. But didn't we have the same trouble with diesel when we first started out?

Ms. CISCHKE. Well, I am a little confused.

Senator BUNNING. I mean, I can just remember gasoline stations all of a sudden adding diesel pumps.

Ms. CISCHKE. Right. Now, that is true. In Europe, as you know, almost 50 percent of the vehicles over there take diesel fuel so they have a lot more diesel than we do gasoline.

The difference, though, is the oil industry can determine the balance between gas and diesel. But now when we are adding ethanol, it is a totally different process and a different supplier. And so we do need the oil industry to be behind increasing the ethanol production. So we have got a little bit different situation.

Senator BUNNING. But we are not going to get that. As you well know, they are not going to sell ethanol to replace their own product.

Ms. CISCHKE. Well, they could. We are working with our partners, BP, and they are looking at biofuels in the future. It may not be ethanol. It might be another type of biofuel that could eventually replace gasoline. It is just that we need this research to happen and we need some incentive to make it happen. And we are seeing that now——

Senator BUNNING. But I thought we did that in the energy bill.

Ms. CISCHKE. Yes. And I think you are seeing some benefit of gas stations right now putting in capital investment for dedicated

pumps. In companies like Verisun that I mentioned, we are trying to support. But we need the whole oil industry to be doing this research as well.

Senator BUNNING. Go ahead. My time is expired, but go ahead.

Mr. LOVINS. Senator, you may be surprised, but Shell is the world's largest seller of biofuels.

Senator BUNNING. Right now?

Mr. LOVINS. Right now. Shell, BP, and others are making major investments in that area. And about half of Europe's biodiesel, which in 2003 was 17 times our biodiesel production, is sold by oil companies as a brand new product.

Senator BUNNING. But is it produced by Shell or is it bought outside the company?

Mr. LOVINS. They use both models, sir. But my point is that an increasing number of major oil companies see biofuels as a logical transitional product and are making major investments both to produce and to sell it.

Senator BUNNING. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

Senator Feinstein.

Senator FEINSTEIN. Thank you very much.

I would like to ask the representative from Ford this question. If Ford is saying that it can meet Canada's greenhouse gas reduction regime, which is approximately 25 percent by 2010, why is the company fighting California's law to reduce greenhouse gas from vehicles by 30 percent by 2016?

Ms. CISCHKE. Well, overall, the Canadian agreement is a national agreement. And the difficulty we have with California is it is a State agreement and it is very difficult.

We believe that the fuel economy standards need to be nationwide. Otherwise, it puts companies in an untenable situation trying to balance——

Senator FEINSTEIN. So you would support then nationwide standards to do something similar to what California is doing?

Ms. CISCHKE. Yes. We would support nationwide standards. And, again, we need NHTSA to set the maximum fees for technologies.

When I indicated that we were meeting Canadian commitments, that is forecasting out where we believe the fuel economy will be for our fleet at that time. And it is also the greenhouse gas holes which are more than just the fuel.

Senator FEINSTEIN. Would you work with us on a bill that would take that tact?

Ms. CISCHKE. Well, we are trying to develop a national dialog to do this through NHTSA in order to achieve the maximum feasible ability, I guess, to do the fuel economy. And we believe that the CAFE reform that NHTSA is working on in truck CAFE will help along those lines as well.

Senator FEINSTEIN. As you know, this is very important to my State because 57 percent of emissions come from transportation, whereas nationally it is much less, about a third.

So having this kind of national effort across the board, do you believe it would be realistic to set the goal of reducing greenhouse gases from vehicles by 30 percent by 2016?

Ms. CISCHKE. That is a very aggressive number. We have looked at what it would take in terms of even if we produced a hundred percent hybrids, we could not make that number.

Senator FEINSTEIN. What do you believe would be realistic?

Ms. CISCHKE. That is a pretty complex answer. And I think that is why working together—and, again, we are saying it has got to be a combined solution with auto makers, with the oil industry, with the consumers because, as you know, a lot of the issues have to do with how people drive.

And the fact is we are predicting almost a 50 percent increase in vehicle miles traveled over the next 20 or 30 years. So we really do need to reduce the vehicles on the road and the consumers can do a lot in terms of driving more efficiently.

Senator FEINSTEIN. The Bush administration found that 99 percent of flexible-fuel vehicles on the road today never use a drop of E-85 ethanol. As a result, the administration found that this loophole actually increases America's oil dependence by 14 to 17 billion gallons of gasoline per year.

As I understand it, Ford uses its fuel economy credits for these flex-fuel vehicles to lower fuel economy standards for the rest of the automobiles so that we are not really doing much to increase vehicle economy.

What would you suggest we do to really increase fuel economy?

I had a bill just to bring SUVs over 10 years up to the fuel economy of the sedans which the fleet number, as you said, is 27 miles per gallon as opposed to the SUV at 20 miles per gallon. And it went down because there is really no support for that. Detroit opposes it very strongly.

What do we do that Detroit could support to really rapidly increase fuel economy standards?

Ms. CISCHKE. Well, I think we have to be very sensitive to what the consumers want to buy. Right now in the auto industry, over 30 vehicles get better than 30 miles per gallon in fuel economy, yet it accounts for less than 5 percent of our sales.

So we have a challenge in terms of putting vehicles out there that nobody wants to buy. And that is a real problem for all the auto companies.

When you mentioned the E-85 usage, this is kind of a chicken and the egg type situation. We need the fuel in order to make the vehicles run on E-85, but the fuel is not going to be there unless there is enough volume of vehicles.

And I think by introducing a very popular-selling vehicle like the F150 to run on ethanol in a lot of the corn States where farmers would also get the benefit there will help drive that market.

So I think there is a number of things that we need to do. But, again, I think we have to be sensitive to giving customers what they want and trying to do it in the most fuel efficient way.

Hybrids are a good example of that. And as you know, Ford is committed to producing 250,000 hybrids by 2010 and offering those to our customers in over half of the models that we will sell in that timeframe.

Senator FEINSTEIN. Yes. Congratulations on that program.

Ms. CISCHKE. Thank you.

Senator FEINSTEIN. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much.

Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman.

And I, too, would like my opening statements to be included in the record if I may.

The CHAIRMAN. It will be included in the record.

[The prepared statement of Senator Murkowski follows:]

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

Mr. Chairman, thank you for holding this hearing. I'll be brief. For three decades the holy grail of energy debate has centered on whether the United States can become "energy independent," which some has interpreted as meaning we should produce ALL of our energy needs domestically, while others have interpreted as meaning we should produce a sizeable amount of our energy domestically—certainly far more than the 41% of our oil needs that we supply today, while remaining less dependent on imported liquefied natural gas.

For years we've heard that energy independence is a pure pipe dream given that America—not counting ANWR—has just over 20 billion barrels of proven conventional oil reserves (1.6% of known world reserves), while the Middle East has 57% of the world's known supply of conventional oil and nearly as much gas.

But with rises in both oil and natural gas prices because of the exhaustion of much of the cheap "conventional oil and gas," because of sharp increases in demand for energy from developing nations and because of environmental fears, we may well be moving into a period when unconventional fuels and new technology, including alternative fuels, can increase our domestic energy production and dare we say permit energy "independence."

The Pentagon last year began seriously funding research efforts to promote bio and synthetic fuel development to meet military needs.

The Energy Policy Act of last summer provided research funding, tax incentives and policy changes to spur biofuels like ethanol, and hybrid vehicle sales to cut consumption; increased oil and gas recovery from heavy oil deposits and by use of carbon dioxide to produce more fuel from aging fields. We promoted oil shale and tried to speed permitting for conventional fossil fuel development on federal lands. We pushed the next generation of nuclear power, increased funding for wind, solar and geothermal energy, and increased the incentives—slightly—for more hydro power.

The Energy bill furthered research and pilot plants for combined—cycle coal gasification, so we can produce more power, fuels and other products from coal—while producing near zero air pollution and possibly releasing no carbon into the atmosphere.

And the Energy Bill encouraged energy efficiency, raising appliance and home and office heating and cooling standards.

And in the short range we have the ability to produce more gas and oil from the Outer Continental Shelf, unlock billions of barrels of oil from Alaska's Arctic coastal plain—you knew couldn't get through a statement without plugging quick action to open ANWR—and also push other additional conservation and fuel efficiency efforts.

What I hope to get from this hearing and our witnesses is an assessment of how likely all this new technology is to work within the constraints of real-world economics, and if it does, how much energy we are likely to produce, how much conventional oil and natural gas we are likely to displace, and what the environmental consequences—both good and bad—will be for us and the globe.

And if any of our witnesses have ideas we have not thought of, I would love to hear them too. Thank you.

Senator MURKOWSKI. Mr. Lovins, in looking at your testimony as well as some of the backup documentation that you have provided with it, you are arguing against producing more oil from Alaska basically from the security perspective.

And I keep reading with interest the same phrase you have used, the all-American Strait of Hormuz, as well as the reference to this world's biggest chapstick.

So I went to your Atlantic monthly article and was reading it with great interest, but I noticed that it was written back in 1983. A heck of a lot has changed since 1983. And certainly from a secu-

rity perspective, we kind of pride ourselves up in the State of Alaska on watching over this asset that we have.

We realize that it is a long silver thread running through the State providing a valuable resource to the country. We recognize that security is an issue and we work very, very hard to make sure that we do provide for that protection.

Unfortunately, you cannot prevent somebody from taking a potshot at it and inflicting some limited damage. But, overall, if you look at the track history of that pipeline for the past 30 years, it has got a pretty good record.

And I find it unfortunate that some of the phrases that I see in this 1983 article keep sticking around because I think that it does do damage to the efforts that we have been doing in terms of providing for close to 20 percent of the country's domestic oil needs for the past 20 some odd years.

Let me ask you. You are focusing on the oil perspective in your comments. We are in the process now of trying to move Alaska's natural gas from our north slope to the lower 48 States. And we would do this through a proposed natural gas pipeline.

Do you have the same issues in terms of security for a natural gas pipeline to meet that energy need for this country that you have indicated in your comments about oil?

Mr. LOVINS. Senator, I think many of the details would differ. The gas pipeline would not be hot and would not have to be above ground and, therefore, very exposed. You would not have the coal restart problem that a hot oil pipeline does. That is the source of the chapstick comment.

I would call your attention to the more recent article originally entitled "The Alaskan Threat to National Energy Security" that's cited toward the end of footnote five in my prepared testimony, and it was published just weeks before 9/11 with a title change by the editor. And the annotated version of that, which is cited, details that the security issues I described have not gone away.

The reason that Mr. Woolsey's written testimony here today refers to a potentially devastating attack on the pipeline, and I presume the reason that he testified in the House against drilling in the arctic refuge on national security grounds is exactly my reasoning.

And I find the scariest episode in the 30-year record you refer to, Senator, is not the drunk taking a potshot at the line. Rather it is the disgruntled engineer who was very fortunately caught months before blowing up three critical and very hard to fix parts of the line with 14 bombs he had already built and cold weather tested.

And he was caught only because he involved someone else in the plot who turned him in. He was not aiming to hurt the United States. He intended to make money in the oil future's market.

But as Mr. Woolsey and I wrote in the *Christian Science Monitor* in 2002, that guy was an amiable bungler compared to our al Qaeda adversaries.

Senator MURKOWSKI. Well, we disagree that there are security issues as they relate to any resource aspect, whether it is a pipeline, an oil pipeline, a refinery. We should be concerned it. Our water sources, we should be concerned about them.

But the reality is that when we have had a shutdown in the State of Alaska, the longest shutdown we have ever had was 66 hours and that was due to an earthquake that was, I think, 7.6 on the Richter Scale. It was a pretty substantial earthquake. Otherwise, essentially what we are looking at are shutdowns that really do not exceed more than 48 hours.

So, anyway, the security aspect is one that we get concerned about. We are focused on it, but we are doing a pretty darn good job with the project.

Mr. Chairman, I have other questions, but I see my time is up.

The CHAIRMAN. Thank you very much.

I am going to claim my time for just a moment Senator Bingaman, because I am probably going to have to go to a budget meeting of Members.

Let me go back to why we had this hearing and just take one at a time.

Mr. Woolsey, the purpose of this hearing is to talk about goals, discuss energy independence. First, does the idea of energy dependence make sense? I do not want a long dissertation. Is it something we should try to do?

Mr. WOOLSEY. I do not worry nearly as much about natural gas as I do about oil for the reasons I stated, Mr. Chairman, so I tend to put this more in terms of oil security because shifting trade patterns does not do any good.

In other words, if we were to buy less from the Middle East and more from Canada and Europe buys more from the Middle East and less from Canada, it does not really change anything.

So to my mind, it is conserving conventional oil, moving away from it toward a range of these possibilities that a number of people, a number of Senators have raised, and some of which I emphasized along with Amory and others. I think that is the heart of the matter, so I would tend to say it is more oil security than it is energy independence.

The CHAIRMAN. All right. And what is your view on that subject? Just the same question, same observation on your part.

Ms. CISCHKE. Yes. I think that we know that we can drive both research in the fuel as well as advanced technology vehicles by encouraging that research through tax incentives and others.

So we believe that there is an opportunity to use renewable fuels, like E-85, and eventually hydrogen if we develop the incentives to get people to invest in those.

The CHAIRMAN. Mr. Verrastro.

Mr. VERRASTRO. Senator, as I said in my statement, I think that the real crux of the issue is reducing consumption both globally and in the United States. If we reduce consumption by definition, we reduce imports.

And I do not actually see that there is a huge difference between gas and oil. If you look at the areas of the world that have hydrocarbons, while we are importing more natural gas and building LNG gas facilities, if we are really concerned about unstable sources, take your pick.

The CHAIRMAN. Mr. Lovins.

Mr. LOVINS. Mr. Chairman, I would agree with all of those comments and emphasize the importance of seeing them within the

broader context of all of the things that drive energy security. It is not only about oil. It is about many kinds of vulnerability. And it is important that we get rid of them rather than make them worse.

The CHAIRMAN. I just want to make an observation about ANWAR and your concerns about supply interruption. I cannot imagine that oil supply from Alaska to the United States is any more or less secure. Probably more secure than many sources of oil in the world today. There are far more insecure areas than it. So I do not understand the concern you have about it versus Iraq, Iran, and all the other countries that are so vulnerable.

Mr. LOVINS. Senator, it is——

The CHAIRMAN. I just made an observation, please.

Mr. LOVINS. Okay.

The CHAIRMAN. Let me ask, since you all seem to be saying to us we should do something in the area of reducing our transportation use of crude oil derivatives so that we minimize our security, let me ask again, particularly of you, Mr. Woolsey, how serious a problem is this in terms of the United States and its future?

We prepare ourselves for war. We commit ourselves totally for things like winning a war. I am not speaking of this war, but a war. How would you describe based on your experience this problem that we have with reference to oil dependency?

Mr. WOOLSEY. I agree with former Secretary Shlesinger that it is the biggest threat to American security outside the area of combat itself. And just one illustration.

Ten days ago, these al Qaeda radars attacked Abqaiq. Abqaiq has in it sulfur clearing towers through which the sulfur is removed from Saudi crude. If you take those out with, say, a hijacked aircraft, which is a scenario in one recent book, you could take some six million barrels a day off line for over a year. That would send oil to well over a hundred dollars a barrel.

My friend, Bud McFarland, who was national security advisor to President Reagan, said I am an old Marine artillery-man and he said I have been up there and seen those towers and I could take them out with a good Marine mortar squad.

So that type of crisis in the Middle East itself, quite apart from policies of governments there, is an immediate and direct threat to American security as far as I am concerned.

The CHAIRMAN. Have you seen any estimates, any of you, of what might happen to the price of oil if the oil from Iran suffered from a total boycott in the world market?

Mr. WOOLSEY. It is about four million barrels a day. I am sure it sends it up to over a hundred dollars a barrel, but I do not know how far.

The CHAIRMAN. Have you seen any numbers on that?

Mr. VERRASTRO. Senator, we have done some work on that and Jim is right. It is four million barrels day. The export market is a little over two million barrels a day depending on the amount of time if there were to be an embargo.

Increased production from other sources as well as drawing down stocks both in Europe and the United States could offset the loss of Iranian crude. The problem is that if at the same Venezuela, Ni-

geria, Saudi Arabia, Iraq, it makes it more difficult. But you could do it.

The CHAIRMAN. Well, I think what we are hearing here is that this talk about boycotting, stopping the flow of oil, doing something to Iran with reference to their economy, the truth of the matter is that is a two-edged sword. It hurts them. They cannot stand it very long, but the price of oil could go to a hundred dollars a barrel without any question.

Mr. WOOLSEY. It is very much a two-edged sword if we cutoff Iranian exports. But Iran refines almost all of its crude abroad. So if we cutoff its imports of gasoline and diesel fuel, that might be far more effective.

The CHAIRMAN. Ford Motor, let me ask, are you seeing signs in the marketplace that the price of gasoline is affecting the consumer choice of cars and are they choosing more efficient vehicles and is this trend something you are expecting and building pursuant to?

Ms. CISCHKE. Yes. We have seen some of that, especially after Katrina, that the SUV sales did go down a bit. We had prepared for that in designing cross-over vehicles and getting back into the car business at Ford. And so we are adjusting our sales mix to match with the customers' need.

But we have also noticed a slight drop in the interest in the hybrids and that is a very fuel-efficient technology. Part of it is due to the early adopters of technology that have probably purchased those already. And in order to encourage the more mainstream customers, things like tax incentives help along that line as well.

The CHAIRMAN. Okay. Last question and one for each of you.

Mr. Woolsey, we have established the fact that what we are trying to do on independence is address the issue of transportation fuel.

What two things would you recommend that we do if our goal is that and we wanted to achieve it?

Mr. WOOLSEY. Encourage biofuels and plug-in hybrids via some combination of feebates as Amory suggests and tax incentives.

The CHAIRMAN. All right.

Ms. CISCHKE. Again, tax incentives for advanced vehicle technology as well as the fuel and also education for the public in terms of how important it is to conserve energy and there is things they can do along that line as well.

The CHAIRMAN. If you got those things, would that have any bearing on whether you were interested in modifying the 1985 CAFE standards?

Ms. CISCHKE. Well, we are working with NITSA to modify those standards in order to again look at maximum feasible technology as well as different classifications to make CAFE a little bit more productive.

The CHAIRMAN. But if we did those things you recommend, you still would not support amendments to the CAFE standard to change the standards to mandate a more efficient fleet?

Ms. CISCHKE. No. I think what we are saying basically is we have to address to what our consumers are demanding and we have got to find a way to make them want to buy more fuel-efficient vehicles.

The CHAIRMAN. Thank you.

What are your two?

Mr. VERRASTRO. Increase fuel efficiency through technology, including what Amory is talking about, lighter-weight vehicles, and CAFE standards as well, and then supplemental sources of fuel.

I would just point out that I——

The CHAIRMAN. What do you mean supplemental? Just tell us what it is.

Mr. VERRASTRO. Biofuels, I think, is the most attractive right now and cellulosic ethanol. I would point out that all forms of fuel or crop raising takes energy. Plug-in hybrids, clearly that you would use them on off-peak hours, but you still need more coal and more natural gas, more nuclear to produce that extra electricity. So it all comes at a cost somewhere.

The CHAIRMAN. What would your two be?

Mr. LOVINS. If you are asking on a technical level, I would say tripled efficiency, cars, trucks, and planes, and a diverse dispersed, decentralized resilient, invulnerable electric system.

If you are asking on a policy level, I would say size and revenue-neutral feebates and encouraging the States to reward gas and electric utilities for cutting your bill, not for selling you more energy. That would free up half the gas in the country and a lot of that could be substituted back for oil.

The CHAIRMAN. Okay. With that, we are going to go through the rest of it. I think the next Senator is Senator Salazar; is that right? He was here earlier.

Senator, you were here and had to leave for something. I am going to recognize that unless——

Senator SALAZAR. I had to go to a Veterans' Affairs hearing. But if Senator Dorgan has to go, please go.

The CHAIRMAN. All right. Senator Dorgan, he wants you to go.

Senator DORGAN. Thank you, Mr. Chairman.

First of all, Mr. Lovins, I have always enjoyed your work and research and writing in these areas. And you do say, however, in your last paragraph of your statement, that the surest path to energy policy that enhances security and prosperity is free-market economics.

It is the case, however, much of what you propose will require policy changes and will not be necessarily a part of free-market choices. Isn't that the case?

Mr. LOVINS. Senator, I think the policy suggestions in winning the oil end game are very much less interventionist than anything else I know in energy policy. And by the way, such interventions as are suggested are generally in the category of getting out of the way and are typically at a State rather than Federal level.

We do not suggest in there a need for any new Federal laws, taxes, mandates, or subsidies. So it is pretty much the opposite of flavor from energy policy as we have known it.

Senator DORGAN. But the feebates themselves would be Federal policy, correct?

Mr. LOVINS. They could ultimately be Federal. I think like most suggestions, they should be piloted at a State level and they could perfectly well be adopted just at a State or regional level.

Senator DORGAN. Mr. Woolsey, following up on the question by the chairman about the goal of independence, in addition to having

a supply of oil which is actually critical to our economy and to the functioning or our economy, in addition to that, it is the case that our dependence on foreign oil at the moment is likely financing terrorism. Is that the case?

Mr. WOOLSEY. Absolutely. This is the first war the United States has fought, Senator, this War on Terrorism, I guess except for the Civil War, in which the United States pays for both sides.

By shipping a billion dollars every working day abroad in debt, $250 billion a year to pay for imported oil, we are funding things like indirectly the Madrassas, the Wahhabis running Pakistan, and the rest. And that educates in hatred and hostility to democracy, to all other religions and the rest. So I think you are exactly right.

Senator DORGAN. Go to the 9/11 Commission report for some of that information as well.

Mr. WOOLSEY. Absolutely.

Senator DORGAN. You know, I think a dispassionate observer living off of our planet and looking at this planet and seeing that we use what, 84 million barrels a day that we extract from the planet. One-fourth of that is used in this little spot called the United States. A substantial portion of the inventory exists in another part of the globe covered with sand.

And they would look at this part of the country or this part of the planet, the United States, needing a quarter of it, 60 percent of what it needs coming from off our shores, particularly from troubled parts of the world and they would say, well, how could they not have been so concerned about that that they would have taken dramatic action, because tonight or tomorrow or next Saturday or God forbid next month or whenever, a terrorist action or some other cataclysmic action could just simply throw this country's economy flat on its back. It will affect every job. It will affect everything we do.

And so when the chairman has a hearing, the chairman and Senator Bingaman have a hearing that talks about the goal of energy independence, this is not just some etherial notion about what would be nice to do. This is really an urgent priority for a country.

I mean, I guess the question is, do we have the luxury of deciding whether to try to strive for independence specifically of oil or is this an urgent requirement for this country at this point?

Mr. WOOLSEY. I think it's extremely urgent, Senator Dorgan. I think that this could collapse on us at most any time.

There was almost a coo in Saudi Arabia in 1979. And Iran could cutoff for a while for its own reasons of pursuing its nuclear program, terrorist attacks in a number of places. This is something that we need to fix and we need to fix now.

And that is the reason why I think this portfolio of moving forward with several different types of encouragement for biofuels and plug-in hybrids is, and I think Amory's lightweight materials are another, that if you work these problems together, the effect is multiple.

A hybrid that now gets 50 miles a gallon, if it becomes a plug-in hybrid, it gets about 125 miles per gallon of petroleum products. The rest is electricity from the grid.

If you make it out of lightweight materials, like Amory suggest, you're probably up to 250 to 300 miles per gallon because the lightweight materials are so good at reducing cost of fuel.

And if it is an E-85 capable vehicle that is a flexible-fuel vehicle—and by the way, Brazil has gone in 2 years from having 5 percent to 75 percent of their new cars be flexible-fuel vehicles. So if it's a flexible-fuel vehicle that can use E-85, you're now up close to a thousand miles per gallon.

If one of those or more than one do not work out real well, you have got a portfolio in which you are moving forward and maybe some work out better than others. But if we only get up to two or three hundred miles per gallon, how bad is that?

So to me, that is the essence of it. We want to do things that are compatible with the existing infrastructure and can do quickly.

Senator DORGAN. I think my time is about up. A couple people wanted to comment.

I did want to ask you about hydrogen because I agree with the urgency of the short term and the urgency to do a lot of things in the short term, but I also believe that in the longer term, the 25- and 50-year term, that hydrogen fuel cells are a very important part of our future.

But, Mr. Chairman——

Senator THOMAS [presiding]. We have some more that want to ask questions.

Senator DORGAN. Mr. Chairman, I understand. Thank you.

Senator THOMAS. Senator Talent.

Senator TALENT. Let me ask Ms. Cischke a question and then just a question for everybody.

I know you are developing a hybrid vehicle that is capable of running on E-85——

Ms. CISCHKE. That's correct.

Senator TALENT [continuing]. To get the efficiencies associated both with hybrid and also E-85. Maybe you could discuss your plans.

And then to everybody, and Senator Dorgan just touched on this, how fast are we building out the infrastructure for E-85 and what can we do to make that go faster?

Ms. CISCHKE. Yes. Ford did announce recently a research program to take a hybrid vehicle and run it on E-85. And there are some technology challenges in terms of evaporative emissions and other things.

But we believe there is a lot of promise there because you are marrying two fuel-saving technologies, the hybrid, which helps more in the city driving, and then the E-85, which would be on the road.

I just wanted to comment a bit on the plug-in hybrids as well because more research has to be done on that. But there are changes in the vehicle system. We need more batteries, a little bit heavier. We are concerned with battery life. So we do have to figure out how we balance that.

But if the electricity we get from the grid is not a clean source as it is in Japan and others, then I am not sure we are making a good tradeoff in terms of the energy.

So there is a lot of work that needs to be done in these advanced technologies. And we do believe that there is not one clean solution. It has got to be a number of different clean diesel, hybrids, fuel cells, a number of things that we are working on.

Senator TALENT. Thank you.

Do you all have any comments on building out the infrastructure for E-85 which in layman's terms, I think, means in large part having pumps available to the average consumer that E-85 is available to.

Ms. CISCHKE. In fact, Ford has entered into a program with Verisun to try and increase the number of fueling stations. I know other manufacturers have as well. But I think we do need to get more stations available so that we can have E-85 used in all the vehicles that are out there today.

Senator TALENT. Because we are building the plants and I think in the Midwest in particular, that process, that cat is out of the bag and that is going to happen. We have just got to get it to consumers.

Mr. Verrastro, do you have a comment?

Mr. VERRASTRO. Yes. Two things. The first point is that the flexible-fuel vehicles run on about 10 to 15 percent alcohol or ethanol rather than 85 percent. An E-85 is a totally different bird. There are evaporative emissions issues in terms of the environment. There is also massive transportation and distribution issues. You cannot put it in a pipeline.

In our country on the coast, we have the greatest demand for fuels. If you grow corn or use cellulosic ethanol and then transport it to the coast and you cannot put it in pipelines, you have to find a different distribution system.

Clearly in Europe, the oil companies have taken to incorporate biodiesel and biomass and other fuels at their retail stations. It is the cost of a tank and a pump.

But this transition to move to E-85, I am not sure that that is the answer. Brazil, as Jim Woolsey just said, is kind of the poster child for ethanol. And over the weekend, they reduced the content of the ethanol in their fuel from 25 percent to 20 percent because they cannot produce enough of it.

So to think that we are going to grow our way crop-wise into an energy solution, I think is far reaching.

Mr. WOOLSEY. Senator, Brazil is using sugarcane which has to be cultivated. Grass grows pretty much everywhere. And with cellulosic ethanol, the National Energy Policy Commission found you do not need more land available than is already in the soil bank and is already on farmers' land with grass to be mowed. And it is 30 million acres. You do not need more land than that to replace half the gasoline in the country. So I do not agree that we have a land scarcity problem with respect to that.

Senator TALENT. And I agree with your statement, too, Mr. Woolsey. I mean, it cautions against viewing technology in a snapshot and making policy.

The top of page 9 where you say the developments that are currently going on with regard to ethanol, biodiesel, genetically engineered plants basically, are comparable in importance to the invention of thermal and catalytic cracking of petroleum.

In other words, there was a time when you could have made all the arguments against petroleum and said, well, gee, it is never going to be available, we are not going to be able to get enough of it, and the rest of it.

Mr. WOOLSEY. Absolutely. A century ago, before thermal cracking was invented, you could use about 1 percent of petroleum to produce gasoline. And you can use less than 1 percent of what grows to produce ethanol now.

But the genetically modified biocatalysts, and you do not have to change the plants themselves—it is just the enzymes and the yeasts that operate the process—those have now been invented and it is being used in Belgium and Canada with Shell backing to produce cellulosic ethanol.

Senator TALENT. The more that we do, the more options we are going to have for the future. And the more this technology matures, the more the infrastructure builds out, the more options we are going to discover for the future.

Mr. WOOLSEY. Absolutely.

Senator TALENT. If I have time, Mr. Lovins can comment, but I do not want to take more than my time, Mr. Chairman.

Senator THOMAS. Go ahead. Try and hold it down a little bit.

Mr. LOVINS. Senator, I would call the Commission's attention to the Bio Alcohol Fuel Foundation, baff.info in Sweden. There is a majority bill pending in the Swedish Parliament to require the top half of the filling stations to provide E-85 in the next few years.

And both Volvo and Saab have said that they could by then be making as in Brazil total flex vehicles which take anything from pure ethanol to pure gasoline, any blend.

That is one of the reasons for the success of the Brazilian program. There are no captive customers, so biofuels really have to compete just on price and they do without subsidy.

Senator THOMAS. I would like to go ahead, if we don't mind, with Senator Salazar.

Senator SALAZAR. Thank you very much, Senator Thomas and Senator Bingaman.

I just wanted to followup on a comment from Senator Talent and the responses with respect to where we can go with renewable fuels.

It seems to me that given what the President has said on our addiction to foreign oil and what the National Renewable Energy Lab is telling us and the energy experts is that we really do not have a lot of limitations. They tell us that within 6 years from now, we are going to be at a point where we can be in the commercial production of cellulosic ethanol, which I think is going to open a whole new door.

So I think we ought never to look at the current snapshot of technology as being a limitation that we currently have as we seek energy independence, oil security, or whatever it is that you might want to call it.

Here is my question for all four of you. There are a number of us, Senator Luger, Senator Coleman, and there are six Republicans, six Democrats on the bill, S. 2025. It essentially sets out a target of getting us to reduce oil demand in this country by some ten million barrels by the year 2031. That is the target.

And the tools to get us there essentially are twofold. One is major investments in renewable energies, including ethanol and other kinds of renewable energy sources, and, second, incentives and programs for advanced technologies, including flex-fuel vehicles and hybrid plug-ins and the like.

My question to all of you—and I know, Mr. Woolsey, you have been involved in this for some time—if you would comment on that and in this context.

The President told us at the White House the other day, he said I want to be bold. I do not want to be foolishly bold. And if we are in the face of this national security crisis which I believe we are in with respect to our over-dependence on foreign oil, how bold can we be and is 2025 the right direction for us to go?

Mr. WOOLSEY. Senator Salazar, I very much support that bill. I think that the President's objective is about three times in 2025 what ANWAR would have delivered. It is about maybe 8 percent of our oil and ANWAR was about three.

Your objective in the bill is about three times the President's objective, about 25 percent replaced by these other fuels and by economies.

Senator SALAZAR. Is that a foolish target?

Mr. WOOLSEY. I do not think it is a foolish target at all. I think it is a very reasonable target.

Senator SALAZAR. Reasonable?

Mr. WOOLSEY. And I think that especially if one approaches as the bill does with these several approaches at once as noted, one may work out a bit slower or a bit better. Another may work out a bit faster or a bit worse. We do not know.

But if one moves with the efficiency and things like plug-in hybrids and with the biofuels and encourages them all now, I think year 2025 goal is extremely reasonable.

Senator SALAZAR. Ms. Cischke, could you respond to that as well?

Ms. CISCHKE. Yes. I think that we are prepared to put out more vehicles capable of running on E-85. And whether we get it right now in the short term from corn or later as—I agree with what our other panel members have said about cellulosic ethanol and there is great research that is happening today that will increase the production.

So, again, we can produce vehicles that give us that flexibility. It is just that we need to start now to develop that infrastructure and ramp it up very quickly. And at the same time, we are looking at hydrogen as well as hybrids to help along that line for vehicle technology. But it has to be a system of vehicles, fuel, and then consumer behavior as well.

Senator SALAZAR. Has Ford taken a position on S. 2025?

Ms. CISCHKE. I do not think so. I am not familiar with that, no.

Senator SALAZAR. Would you get some information to me on your review and analysis of the bill, please?

Ms. CISCHKE. Yes, I will.

Senator SALAZAR. And, Mr. Verrastro, same question.

Mr. VERRASTRO. Senator Salazar, I think it is a great stretch target. I think it is overly ambitious. I would argue that American consumers want affordable, available, reliable, secure, and environ-

mentally benign fuels. And depending on which one of those priorities you take, your approach is slightly different.

And I would add the competitive factor. We cannot produce something or move the industry to something that is not competitive where the rest of the world is using a lesser expensive fuel without putting our industries at risk. That is the only caveat I would add.

Senator SALAZAR. Mr. Lovins.

Mr. LOVINS. Senator, I think by 2025, oil use and imports in this country could be at 1970 levels and both heading down all led by business for profit.

Let me just remind us all that from 1977 to 1985, the last time we paid attention to oil in this country, in those 8 years, GDP grew 27 percent. Oil use fell 17 percent. Oil imports fell 50 percent. Oil imports from the Persian Gulf fell 87 percent, and it would have been gone in one more year if we had kept that up.

This broke OPEC's pricing power for a decade because we could save oil faster than they could conveniently sell less oil. We are the Saudi Arabia of nega barrels and we can rerun that old play all over again.

Senator SALAZAR. Thank you for your participation here today.

Senator THOMAS. Thank you very much.

We have a vote going on, so we will have to—I want to thank you. I think this has been very interesting and useful in terms of the topic here, which is independence.

I just have to say from my own standpoint that we have to also look a little closer. We are going to have to use coal in the interim as you accomplish these things that you all see far out. We are going to have to see new ways of recovering oil here.

We have more resources than you act like we have if we can find new ways of doing it. Nuclear is going to be part of our system, I think, and I do not think there is any question about that. And conservation is something we can do rather quickly if we move to do it.

So you had got great ideas. We look forward to working with you in the future. And thank you so much for being here.

[Whereupon, at 11:17 a.m., the hearing was adjourned.]

[Subsequent to the hearing the following statement was received for the record:]

STATEMENT OF THE AMERICAN PETROLEUM INSTITUTE

API is a national trade association representing more than 400 companies involved in all aspects of the oil and natural gas industry, including exploration and production, refining, marketing and transportation, as well as the service companies that support our industry. Its mission is to advocate public policy in support of a strong, viable U.S. oil and natural gas industry essential to meet the energy needs of consumers in an efficient and environmentally responsible manner. API advocacy on public policy issues is based on the consensus of its members.

We live in an energy interdependent world, and complete energy independence is probably unachievable and certainly undesirable. Even if it were achievable or nearly achievable, the costs to consumers and our economy for pursuing this goal would in all probability be enormous. Nevertheless, there is much we can and should do to strengthen our energy security. These measures, which will require changes in energy policy, must focus on increasing energy supplies, oil and natural gas and other conventional as well as alternative energy; reducing demand; and expanding and diversifying our energy infrastructure. By taking these steps we are likely to produce more of our own energy and reduce volatility in energy markets. For Con-

gress to repeat the mistakes of the past by imposing new controls, new or expanded mandates, allocation schemes, new taxes on industry, or other obstacles would be counterproductive.

U.S. ENERGY SITUATION IN A GLOBAL MARKET

World oil demand reached unprecedented levels in 2005 and continues to be strong despite higher prices last year. Strong economic growth, particularly in China and the United States, has fueled a surge in oil demand.

At the same time, the world's oil production was not able to keep up with the strong growth in demand. World oil spare production capacity—crude that can be brought online quickly during a supply emergency or during surges in demand—is at its lowest level in 30 years. Current spare capacity is equal to only about 1 percent of world demand.

The delicate supply/demand balance in the global crude oil market makes this market extremely sensitive to political and economic uncertainty, unusual weather conditions, and other factors. Over the past several years, we have seen how the market has reacted to such diverse developments as dollar depreciation, cold winters, the post-war insurgency in Iraq, hurricanes in the Gulf of Mexico, the Venezuelan oil workers' strike in 2002-2003, uncertainty in the Russian oil patch, ongoing ethnic and civil strife in Nigeria's key oil producing region, and decisions by OPEC.

We currently import more than 60 percent of the crude oil and petroleum products we consume. American refiners pay the world price for crude and distributors pay the world price for imported petroleum products. U.S. oil companies don't set crude oil prices. The world market does. Whether a barrel is produced in Texas or Saudi Arabia, it is sold on the world market, which is comprised of hundreds of thousands of buyers and sellers of crude oil from around the world.

Complicating the overall U.S. fuel supply/demand situation are numerous contributing factors. Passage of the new Energy Policy Act has led to a new renewable fuels standard, the elimination of the reformulated gasoline oxygen requirement in May, and the expected rapid phase out of MTBE use in gasoline. In addition, ultra-low sulfur diesel will be introduced starting June 1. The industry is working hard to meet these new requirements, but they are major transitions and will present a challenge.

MEETING U.S. ENERGY CHALLENGES

The Energy Policy Act of 2005 signals a first step in a much-needed effort to enhance energy security and ensure the reliable delivery of affordable energy to consumers. Nevertheless, much remains to be done.

We can no longer afford to place off limits vast areas of the Eastern Gulf of Mexico, off the Atlantic and Pacific coasts, and offshore Alaska. Similarly, we cannot afford to deny Americans consumers the benefits that will come from opening the Arctic National Wildlife Refuge and from improving and expediting approval processes for developing the substantial resources on federal, multi-use lands in the West.

In fact, we do have an abundance of competitive domestic oil and gas resources in the U.S. According to the latest published estimates, there are more than 131 billion barrels of oil and more than 1000 TCF of natural gas remaining to be discovered in the United States.

Much of these oil and gas resources—78 percent of the remaining to be discovered oil and 62 percent of the gas—are expected to be found beneath federal lands and coastal waters. The amount here is enough oil to power 55 million cars for 30 years and heat 24 million homes for 30 years. And there is enough natural gas to heat 60 million homes that use natural gas for 120 years.

Federal restrictions on leasing put significant volumes of these resources off limits, while post-lease restrictions on operations effectively preclude development of both federal and non-federal resources. Addressing these restrictions is critical.

And, while we must focus on producing more energy here at home, we do not have the luxury of ignoring the global energy situation. In the world of energy, the U.S. operates in a global marketplace. What others do in that market matters greatly.

For this country to secure energy for our economy, government policies must create a level playing field for U.S. companies to ensure international supply competitiveness. With the net effect of current U.S. policy serving to decrease U.S. oil and gas production and to increase our reliance on imports, this international competitiveness point is vital. In fact, it is a matter of national security.

An important, related issue is natural gas, which fuels our economy—not only heating and cooling homes and businesses but also generating electricity. It is used by a wide array of industries—fertilizer and agriculture; food packaging; pulp and

paper; rubber; cement; glass; aluminum, iron and steel; and chemicals and plastics. And, natural gas is an essential feedstock for many of the products used in our daily lives—clothing, carpets, sports equipment, pharmaceuticals and medical equipment, computers, and auto parts.

Only four to five years ago, natural gas prices were in the $2 to $3 per million Btu (MMBtu) range. Recently, prices have settled in the $6-7 per MMBtu range, after reaching record levels in December 2005 of $14-15 per MMBtu. Higher natural gas prices have taken their toll—more than 2.8 million U.S. manufacturing jobs have been lost since 2000, and chemical companies closed 70 facilities in the year 2004 alone and have tagged at least 40 more for shutdown.

Unlike oil, natural gas imports in the form of liquefied natural gas (LNG) are limited by the lack of import terminals. There are only five operating in the United States. A number of additional terminals have been proposed but many have run into not-in-my-backyard opponents and complex permitting requirements. While natural gas imports from Canada have been important, Canada's own needs are growing. Expanding our ability to tap into global natural gas supplies is essential.

The National Petroleum Council (NPC) study, "Balancing Natural Gas Policy: Fueling the Demands of A Growing Economy" (2003), highlighted the significant costs associated with current policies—such as access restrictions on the Outer Continental Shelf and process impediments to development in the West—that impede the development of America's abundant natural gas resources. The NPC estimated that continuing on our current policy path could result in $300 billion more in consumer costs over 20 years.

Beyond easing the way for greater development of oil and natural gas, we must also address those public policies that inhibit refinery capacity expansion. The U.S. refining industry has been expanding a little more than 1 percent per year over the past decade—the equivalent of a mid-size refinery being built each year. In order to create the opportunity for increasing the growth of U.S. refining capacity, government policies are needed to create a climate more conducive to investments in the refining industry.

In addition, many of the steps the federal government could take to help the refinery capacity situation are covered in the December 2004 National Petroleum Council (NPC) study, *Observations on Petroleum Product Supply—A Supplement to the NPC Reports "U.S. Petroleum Product Supply—Inventory Dynamics, 1998" and "U.S. Petroleum Refining—Assuring the Adequacy and Affordability of Cleaner Fuels, 2000."*

The NPC study suggested that the federal government should take steps to streamline the permitting process to ensure the timely review of federal, state and local permits to expand capacity at existing refineries.

For example, new-source review (NSR) requirements of the Clean Air Act need to be reformed to clarify what triggers these reviews. Some refineries may be able to increase capacity with relatively minor adjustments, but are unsure if the entire facility's permit review would be triggered—a burdensome and time-consuming process.

In addition to the administrative issues deterring new refining capacity investments, there are financial constraints as well. Attracting capital for new refining capacity has been difficult with refining rates of return historically averaging well below the average for S&P Industrials. Over the 10-year 1995-2004 period, the return on investment for the refining and marketing sector was 7.7 percent or less than half as much as the 13.9 percent for S&P Industrials. In only two years between 1977 and 2004 did the average return of refiners exceed the average for the S&P Industrials.

While taking these factors into account, it is important to remember that the oil and natural gas industry operates in a global marketplace. Many oil and gas companies are global companies, whose U.S. investment decisions compete not only with decisions as to how to allocate capital investments in the U.S. among various sectors of the industry, but also with competing demands and investment needs overseas. In a global marketplace, companies will make the best economic investment decisions in order to bring affordable petroleum products to consumers. Imports may be the more economical option than new U.S. refineries, but that is a decision to be left to the global marketplace. Government policies must encourage, not interfere with, the global marketplace.

ALTERNATIVE ENERGY

Alternative energy has much potential, but it is not likely to become a substantial let alone dominant part of the market for many decades. While the U.S. EIA forecasts a 50-percent increase in renewable energy consumption between 2004 and

2025, it also forecasts that the renewable energy share of total U.S. energy consumption will rise from 6 percent to only 7 percent during that period.

There is a misperception by some about the time and costs involved in any transition to the next generation of fuels. Consider what would be involved in replacing the dominant role of oil with a substitute like hydrogen or solar power. Most experts agree that such a transition would require dramatic advances in technology and massive capital investments—and take several decades to accomplish, if at all.

The United States—and the world—cannot afford to leave the Age of Oil before realistic alternatives are fully in place. It is important to remember that man left the Stone Age not because he ran out of stones. And, when we someday leave the Age of Oil, it will not be because we will have run out of oil. Rather, oil will be replaced by alternatives that are proven more reliable, more versatile, and more cost-competitive than oil.

This does not mean that our industry is narrowly focused on oil and natural gas alone. In fact, our companies have long been pioneers in developing alternative sources of energy. Permit me to cite several examples:

- BP is one of the world's largest producers of photovoltaic solar cells;
- Chevron is the world's largest developer of geothermal energy;
- Our industry is the largest producer and user of hydrogen;
- ExxonMobil, BP, Chevron, Shell and ConocoPhillips are key players in government/industry hydrogen fuel and vehicle partnerships, such as the DOE FreedomCar and Fuel Partnership and the California Fuel Cell Partnership; and
- Shell is one of the top players in the worldwide wind industry.

Our companies intend to meet the energy needs of industrial and retail consumers well into the future, and they compete fiercely with one another and others for the opportunity to do so. The companies' research and development efforts are continuing in the search for the most competitive, efficient, and economical energy technologies.

Indeed, thanks to our industry's technology and refiner flexibility and investment, an array of alternative fuels is already included in our companies' product slates. For example, we in the United States now consume as much ethanol as Brazil, the world's long-time champion producer of ethanol. Very soon, we will overtake them. However, we need to keep in mind that no energy alternative is a panacea. Each has its plusses and minuses, but they can each play an important role.

For example, based on various studies, the energy savings from corn-based ethanol are moderate—3 to 20 percent—because production from corn requires significant energy input. And, judging from this past year, ethanol is higher-priced than gasoline and, measured on a BTU basis, considerably more expensive. In addition, some have estimated that the total amount of ethanol that could be produced by converting the entire 2005 U.S. corn crop into ethanol would be about 31.1 billion gallons—an amount equal to just 22.2 percent of U.S. gasoline consumption last year.

API's member companies feel there is a very bright future for a full range of alternatives. But, we do not want to be a party to any "over-promise and under-perform" commitment. We have to be realistic, including the need to exercise full due diligence and appropriate risk management methodologies. We need only look at the auto industry and consumer experience with diesels in the 1970s to see that wishful thinking, absent merit, can end up hurting everyone.

THE CHIMERA OF ENERGY INDEPENDENCE

While oil is essential to fuel economic growth, its supply is volatile, subject to short-term interruptions as well as longer-term variation in the rate of supply development. As a consequence, any imbalances carry with them substantial economic costs and give rise to concern over "oil security." In the past, these prospects led to government attempts to preserve U.S. "energy independence" via a number of policies designed to insulate the U.S. from world markets. Some are now calling for a repeat of this experience. However, such past efforts were abysmal failures, which aggravated rather than solved these problems, before being quickly abandoned. Today a return to such policies would be even more futile. Most experts agree that sustaining even modest economic growth worldwide for the next several decades will require massive new investments in oil and gas. The world energy markets are inherently global, and no single country can exempt itself from the interdependencies of that market. Geographical differences in the location of supply and demand will continue to expand trade. Differences in resource ownership and access to capital and technology will require increasing cooperation between private international oil

companies (IOCs) and the state owned national companies (NOCs). The consuming and producing countries share a mutual interest in this expansion, and in avoiding volatility. In fact, these interdependencies generate a web of mutual interests between producers and consumers, which can provide a basis for reducing the security problem. While there is no assurance that cooperation in expanding supplies over the next several decades will succeed, it is certain that the cost of failing to do so will be enormous.

What is the oil security problem? Given the key role of oil to economic growth, and the heavy concentration of oil supply in the Persian Gulf region, the oil security problem came to be articulated in the 50s and 60s as the vulnerability of Western economic growth to events that might interrupt such supply. These fears actually materialized in 1973 as a group of oil exporting countries attempted to influence U.S. foreign policy via an oil embargo, and a transfer of control over the oil assets in those countries from the major international oil companies (IOCs) to a group of state owned national oil companies (NOCs). While the actual reduction in supply was small and temporary, the reduction in the rate of supply growth was of longer-term significance. Prices rose sharply in 1973, triggering a recession and a reduction in economic growth throughout the remainder of the 70s. This damage was repeated in 1979 when the Iranian revolution triggered another supply disruption, followed by another recession. The episode clearly illustrated Western vulnerability to economic damage from supply inadequacy, and the potential for such damage to compromise the independence of U.S. foreign policy, which remains the essence of the oil security problem.

The initial U.S. response to the events of the 70s was a futile attempt to insulate itself from the global oil market. Price controls, product allocation schemes, and subsidies to alternative fuels were attempted in the name of protecting U.S. "energy independence." In rapid succession, each of these interventions failed to reduce dependence and, in some cases increased vulnerability.[1] By 1980, all were abandoned in favor of reliance on markets and prices to guide the patterns of oil use and volume of oil traded. Today, in response to recent increases in world oil prices, some are again calling for government intervention to promote energy independence. But such a pursuit today would be even more futile than it was in the 70s, for several reasons. First is the fact that the U.S. resource base (consisting of 3% of world reserves) will not support it. The U.S. Department of Energy estimates that sustaining modest economic growth will require about a 20% expansion of U.S. oil supplies by 2020, even allowing for improvements in energy efficiency and significant growth in alternatives. With domestic production declining, imports must rise, reaching 68% of consumption by 2020. Even if reversal of these trends were feasible, it would be futile to pursue such independence in a global market, since all participants face the same price, regardless of their level of imports. Consequently, a change in U.S. import dependence or a shift in bilateral trade relationships with a particular area may do nothing to change either the price or composition of global supply, thus leaving both U.S. and global vulnerability unchanged. Given that energy independence has proven neither feasible nor desirable, our only options involve managing the risks faced by participation in this market.

We have learned to manage vulnerability to short-term interruptions. We have made progress in this area. While U.S. import dependence has generally increased since 1980, vulnerability to short-term interruptions has not. The world has weathered several major interruptions since 1980, such as the invasion of Kuwait in 1990 and the invasion of Iraq in 2003, neither of which produced economic damage of either the magnitude or the duration of those in the 70s. In part, this is attributable to measures adopted to manage such risks, by the building of strategic stocks, the promotion of free trade and investment, and the development of traditional diplomatic and military instruments to secure that trade. In part, it is attributable to favorable market or political trends, such as the decline in the share of oil in GDP and the increased access to potentially productive lands as a result of the breakup of the Soviet Union. But primarily it was due to the fact that OPEC since 1980 has had available a large volume of excess capacity, which it has generally used to offset any such shortfalls.

There are new challenges ahead. First is the sheer magnitude of the prospective growth in supply likely to be required to sustain modest global economic growth. A variety of recent forecasts by the International Energy Agency, the U.S. Department of Energy, and the OPEC Secretariat estimate that sustaining a 3% rate of annual growth in the global economy over the period to 2020 will require an expansion of between 24 and 28 mmbd in global oil supplies. (The projection also assumes

[1] For instance, by holding prices at below world market levels, U.S. policy actually encouraged a level of oil use higher than that which would have occurred without such controls.

improvements in energy efficiency and greater use of alternative energy sources.) Satisfying this demand will require an enormous development effort on the part of both OPEC and non-OPEC suppliers.

Interdependence is a fundamental characteristic of the emerging market environment. The first interdependence is that of trade, stemming from the geographical dispersion of supply and demand. Consumption growth will become increasingly concentrated in the developing countries over time, primarily in Asia, while supply will become increasingly concentrated in the Middle East, West Africa and Russia. The second form of interdependence arises between resource owners and producing companies. This interdependence arises from the separation that occurred in the 70s between the resource owners (host governments) and the producers (IOCs). As a result of this separation, currently only about 6% of the world's reserves are actually fully accessible to equity participation by the IOC's. About another 12% is accessible under terms negotiated with the NOC's, leaving 77% under exclusive control of the NOCs. At first glance, both dependencies may be viewed as favoring the producing country or company, but such an interpretation does not withstand scrutiny. That is, a trading relationship is clearly a mutual dependence, with both parties hoping to gain from the transaction. The consumer faces risks of uncertain supply; the producer faces risks of uncertain demand. There may be an appearance of greater risk to consumers, since their costs are realized in the short run. Generally, the oil exporting country faces the risk of demand erosion that may occur more gradually, but ultimately poses larger risks. For instance, oil export revenues comprise 38% of Saudi Arabia's GDP, while oil import costs comprise 1.5% of U.S. GDP. Likewise, a cooperative arrangement between NOCs and IOCs is built on voluntary agreements premised on mutual acceptance of risk for mutual gain. The IOC's have the capital and technology to develop the resource, but have few of their own. The NOCs have the resource, but often are hard pressed for the capital or the technology to develop it.[2]

While the producer and consumer countries, as well as the NOCs and IOCs, face fundamental differences of interest with their trading or operating partners, they also face a mutual interest in the orderly development of a market within which they can achieve their mutual goals. It is a fundamental error to characterize the security problem as the exclusive province of the consumer countries resulting from repeated hostile actions by producing countries. Only the 1973 embargo can be so characterized. Ironically, each of the other interruptions was attributable either to conflicts among producer countries or embargoes imposed by consuming countries. Moreover, in dealing with the short run supply interruptions since 1980, it has been producer actions, rather than the use of strategic stocks or other emergency measures by the consuming countries, that have played the greatest role in limiting the economic damage associated with each disruption. Perhaps the greatest challenge to future security is presented by the disappearance of excess capacity within OPEC. Its use provided both a source of surge capacity that reduced the impact of short run interruptions and a source of new supply to accommodate demand growth over time for nearly two decades. From the standpoint of the dual security problem—replacing supply lost to short-term interruptions and providing for long-term capacity growth, it provided the bulk of the world's protection. In a very real sense, however, world supply has reached a crossroads. In this setting, additional reliance may be placed on other protective measures such as strategic stocks to replace supply lost to short-term disruption, and to free trade and investment to develop the interdependence to assure adequate long run growth. While it is by no means certain that adequate investment and new supplies will be forthcoming, it is inevitable that failure to do so will have costs. The IMF estimates that a $5 per barrel increase in price could reduce world GDP as much as $100 billion annually. The magnitude of these potential losses suggests the enormous value of finding a basis for cooperation in such expansion.

CONCLUSION

We hope that people will better understand that, in today's global energy marketplace, U.S. "energy independence" is impossible. We hope they come to see that, instead, "energy interdependence" is essential. We hope consumers will come to recognize that their interests are best served when we can source fuels from multiple providers located both in the U.S. and throughout the world. Sourcing flexibility is one of our most powerful energy security tools. We also want others to understand that we can operate only where governments permit us to do so. If we are prevented

[2] A 2003 study by Wood Mackenzie found that the only OPEC country that has been able to develop significant new capacity without direct IOC participation has been Saudi Arabia.

from exploring for and producing oil and natural gas here at home in the United States, we must look elsewhere in the world to get the energy the nation needs.

If the government elects to keep us from attractive oil and natural gas production opportunities in the U.S., and burdens us from competing fairly abroad, our foreign competitors—national oil companies, heavily supported and, at times, subsidized by their governments—could move more aggressively into energy markets here in the U.S.

Clearly, the nation needs to work together—industrial and retail consumers, energy companies and government—to address the energy challenges we all face. In looking at these challenges, it's easy to see the glass as half empty, when, in fact, it is half full. America's oil and natural gas producers and suppliers have the technology, the efficiency, the infrastructure savvy, and the desire to compete anywhere on a level playing field with their competitors. We need commonsense energy policies that provide access to conventional energy supplies, encourage energy efficiency, and promote continued development of new energy technologies.

APPENDIX

RESPONSES TO ADDITIONAL QUESTIONS

ROCKY MOUNTAIN INSTITUTE,
Snowmass, CO, April 6, 2006.

Senator PETE V. DOMENICI,
Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR SENATOR DOMENICI: I appreciate the opportunity to have testified before you and your Committee colleagues on 7 March 2006 on the goal of energy independence. While some of my ideas may have been unfamiliar, I hope that they were stimulating and will be taken in the independent and constructive spirit in which they were meant. The degree of consensus within the panel of witnesses was certainly encouraging.

Since I was abroad for two weeks when your 13 March letter with questions for the record arrived, your staff kindly gave me leave to reply a week later than your suggested 27 March date. My response is attached.

I'm sorry that in September 2004, when we were launching Winning the Oil Endgame at NDU, RFF, CSIS, CFR, and other Washington venues, your schedule reportedly did not permit you to take the proffered brief (although Senator Bingaman and some staff were able to do so, and I also did a prebrief for staff from both sides of both Houses). It typically takes about an hour to explain our study's main findings to a knowledgeable audience, so its depth can't be conveyed in two minutes, as I attempted in the 7 March hearing. But should you and your colleagues wish a fuller exposition, I'd be glad to try to oblige on a future trip to Washington. My work with DoD typically brings me to town every few months. Alternatively, it's easy to schedule a brief and discussion at a mutually convenient time via our near-broadcast-quality Internet videoconference apparatus.

If my colleagues and I can be of further service to the Committee, please don't hesitate to let me know.

Cordially,

AMORY B. LOVINS, *CEO.*

RESPONSES OF AMORY LOVINS TO QUESTIONS FROM SENATOR DOMENICI

Question 1. In your written testimony you state that the elimination of all oil (including domestic) in our economy by the 2040's is an attainable and worthy goal. You state that this will revitalize the economy and is welcomed by business and military leaders.

In your view what is the government's role in reaching this goal? Won't the market dictate this result fit is economically possible and profitable?

Answer. *Winning the Oil Endgame* synthesized a national oil solution explicitly built around competitive-strategy business cases for the car, truck, plane, and oil industries and around military requirements. The business and military logics are so compelling that I believe they will *ultimately* prevail, and that the Nation's transition beyond oil will be led by business for profit. But if public policy supported rather than distorted the business logic, oil use would be eliminated *faster and with higher confidence.* Thus I believe government should steer, not row, and that it's vital to steer in the right direction. Regrettably, current Federal policy has only limited relevance to eliminating oil dependence, and much of its content that is relevant is unhelpful. Most of the public policy initiatives that are both relevant and helpful are coming from the States. Basing Federal policy on sound market principles and "best buys first" would be a propitious change from recent tendencies. So would a clear focus on oil, rather than confusing oil with electricity (please see my response below to Senator Bunning's question #1).

Question 2. How do you respond to those, like me, who say that an economy run entirely without oil by the 2040's is quite difficult to believe?

Answer. First, I would respectfully invite you to examine the analysis we presented on 20 September 2004 in *Winning the Oil Endgame* and its Technical Annexes, all posted free at www.oilendgame.com. More than 150,000 copies have been downloaded and our findings have been intensively scrutinized within industry, but my knowledge, no material flaw in its facts, logic, or conclusions has been found. Indeed, many technology analysts in the energy industries and their leading consultancies have reached similar conclusions.

Next, I would remind you that on a similar timescale of decades, our Nation has made such major energy transitions before—for example, away from directly burned coal, town gas, and coal oil. Economic history is full of such technology-led, market-driven substitutions. Particularly striking is the market response to what Phil Gramm called America's first "major energy crisis" ("The Energy Crisis in Perspective," *Wall St. J,* 30 Nov. 1973, p. 8) when the almost universal illuminant—whale oil—became too costly. *Winning the Oil Endgame* documents how, in the nine years before Drake struck oil in Pennsylvania in 1859, over five-sixths of that illuminant market went to competitors, chiefly coal gas and town gas, to which the whalers hadn't paid attention: they were astounded to run out of customers before they ran out of whales. Around 1850, whaling was the fifth biggest American industry; a few decades later it was nearly gone, reduced to begging for Federal subsidies on national-security grounds: its real revenues fell by tenfold in a half-century. (See Davis, Gallman, & Gleiter, *In Pursuit of Leviathan,* U. of Chicago Press, 1997.) Oil feels rather like this today: a mighty industry that hasn't paid enough attention to fast-moving competitors. America has spent decades quietly accumulating a huge backlog of powerful ways to save or replace oil, but until RMI's 2004 study, nobody had added them up. When we did, we found that that saving or displacing all the oil the U.S. uses would cost about one-fourth as much as buying it at today's price. I think that as you have a chance to read our study, you'll find it less surprising and more compelling—as its Foreward authors (Secretary George Shultz and Sir Mark Moody-Stuart) and the authors of the comments on its back cover, such as Bud McFarlane and Bill Martin, have done.

Third, the transitional speeds suggested or assumed in our analysis are firmly rooted in historical experience, both in aggregate and in specific sectors, such as the decades-long automotive transition summarized on pp. 180ff. Our analysis assumed the vehicle-fleet stocks and sales through 2025 used in EIA's January 2004 Reference Case, adopted higher efficiencies based on detailed technical and economic analysis, and for the crucial light-vehicle sector, applied a consumer choice model that matches the DOE/ORNL model within a few percent. Our suggested policy tweaks would speed up by a few years the "takeoff point" in the logistic S-curves found throughout the literature on technological succession. Our industrial and building oil and gas savings are consistent in size, cost, and speed with those in the Five Labs study (which, based on our extensive consulting experience, we consider very conservative). Our adoption scenarios for biofuels and natural-gas savings are consistent with NAS/NRC and other standard sources. I think you'll find no surprises in these analytic components; their sum may seem startling only because it hadn't previously been coherently synthesized.

As a reality check, our analysis assumed that oil will be saved about two-fifths slower than occurred in 1977-85, when America last paid attention to oil. In those eight years, U.S. oil intensity—barrels consumed per dollar of real GDP—fell at an average rate of 5.2%/y. At that rate, it'd fall by 88% in 40 years. However, our scenario achieves half its oil displacement by substituting saved natural gas and advanced biofuels for oil—a greater ratio of supply substitution to end-use efficiency gains than occurred historically. And it's not important whether every last bit of oil use is wrung out; the point is to make oil unimportant, hence no longer a security threat nor a major cause of conflict.

Other helpful analogies might be the 59% reduction in U.S. water intensity during 1950-2000, or the >50% reduction in oil intensity since 1975. Hardly anyone noticed. The more diverse the means of such savings or substitutions, the more market actors can adopt them (more like buying cellphones than like building cathedrals), the shorter their technical lead times, and the more desirable they are, the faster the transition can be.

Fourth, I respect free enterprise's dynamism and American industry's ability to innovate. In the 1920s, U.S. automakers took six years to switch from wood to steel autobodies. At the start of World War II, it took six *months* to switch from making four million cars a year to making zero cars, but much of the materiel—tanks, jeeps, planes, munitions—that won the war. Of course, that was via a real mobilization, which I'm not calling for (though perhaps I should be). But the U.S. auto industry's parlous state cries out for rapid and dramatic technical innovation just to ensure that the business survives; incrementalism won't beat Toyota. Many industry lead-

ers are starting to understand this. In aerospace, I believe Boeing already has. Similarly rapid change is underway in heavy trucks, where Wal-Mart, based on our analysis, has set a goal of improving its new trucks' fuel efficiency by 25% next year and by 100% within nine years.

America no longer maintains a strategic stockpile of gutta percha—though she did until, as I recall, the 1990s. I believe that under the inexorable pressure of technological change and market competition, the younger people in your hearing room will live to see the day when the Strategic Petroleum Reserve is abolished as a similarly quaint anachronism.

Question 3. You say that your goals are attainable if government would simply provide the financial incentives.

How do [you] respond to those who point out the vast financial investment that government has made and is still making in energy technology, when you say that not enough is being done?

Answer. My testimony did not call for "financial incentives" nor even for increased Federal energy R&D, and would cost the Treasury zero. But if asked, first I'd say that most R&D has been and still is misallocated to favored technologies that are already mature or show no hope of becoming competitive. The money seems to be allocated more by porkbarrel politics than by risk-adjusted public return. Second, total federal energy R&D is far too small for its actual and rhetorical priority. Prof. Dan Kammen at UC Berkeley reckons (*Issues in Sci. & Tech.,* Fall 2005, pp. 84-88) that private-sector U.S. energy R&D totals less than the R&D budget of a single large biotech company like Amgen or Genentech, and that inadequate and uneven Federal funding is driving private investors away too.

I'd add that the Federal government is doing far too much to distort private markets, deliberately causing huge misallocations of private capital. I'd love to see a thorough, transparent, and defensible compilation of Federal energy subsidies—unlike EIA's partial ones (http://earthtrack.net/earthtrack/index.asp?page__id=201&catid=73). My Institute did the first thorough analysis of Federal energy subsidies, summarized in "Hiding the True Costs of Energy Sources," *Wall St. J.,* 17 Sept. 1985, p. 28. A partial list 17 kinds of tax breaks, net program outlays from 21 agencies' budgets, and cheaper capital from eight agencies' loans and guarantees—exceeded $46 billion in FY84, varying by more than 200x per unit of energy saved or supplied by the different technologies. For example, 65% of the subsidies went to electricity, which was 13% of delivered energy, reducing its apparent price by about a fifth: that's >11x the subsidy per BTU of direct fossil fuels, and at least 48x the subsidy per BTU that energy efficiency got. Nuclear power in FY84 got 34% of the subsidies (excluding Price-Anderson) but delivered 1.9% of the energy; each of its subsidy dollars delivered 1/80th as much as a dollar of subsidies to renewables and efficiency. The latest analyses by the top contemporary independent scholar in this field, Doug Koplow (www.earthtrack.net), confirm that Federal energy subsidies are still large and probably even more distortive. There is little point developing new technologies if such massive market interventions favoring rivals continue to suppress their adoption.

Responses of Amory Lovins to Questions From Senator Murkowski

Question 1. Coming from a state that has the lion's share of gas hydrate potential, what is the likelihood of gas hydrate production both on shore and under the seafloor coming into its own within the next two decades? It is said that America has a 1,000 year energy supply of hydrates out there waiting to be tapped. Should we be focusing more on developing that resource?

Answer. No. Alaska's onshore methane hydrates may bubble out of the thawing tundra on their own, causing a global climate disaster. I haven't seen a convincing argument that onshore or offshore methane hydrates can be extracted without a substantial risk of major uncontrolled releases of methane. Lacking such grounds for confidence that the operation could avoid making our planet more like Venus, I hope the hydrates stay right where they are. And we don't need them if, more cheaply, we use energy in a way that saves money.

Question 2. DOE last year issued a report that indicated we should be able to coax up to 40 billion barrels of additional conventional oil from aging oil fields by injecting carbon dioxide into the fields to squeeze out more oil. How important is more widespread use of CO_2 likely to prove to be to aid shorter-term energy production, especially since the same technology CO_2 injection—results in sequestering carbon from the environment, cutting greenhouse gas emissions?

Answer. CO_2 injection is an important and mature means of enhanced oil recovery, which I welcome. Whether the CO_2 then remains in the reservoir depends on many geological and operational details. The industry is intensively examining this

and other enhanced-recovery techniques for its whole production portfolio, but most details are proprietary. Though I've consulted for oil majors for 33 years, I'm not aware of an independent assessment, using public data, that would support a meaningful response to your request .

Question 3. We all know that America is the Saudi Arabia of coal. My state alone has about 15% of the planet's coal reserves, 160 billion short tons. I am really interested in pushing coal gasification to produce coal without emissions and to help sequester carbon. What can we do on top of what we did in last years Energy Bill, to further clean coal technology and production economics?

Answer. Coal gasification is a feasible but costly way to produce gas or liquids. It is quite carbon-intensive as normally conceived. However, researchers like Prof. Robert H. Williams at Princeton, and many in industry worldwide, are exploring possible methods that include carbon sequestration. Williams claims, not implausibly, sequestration costs ~1¢/kWh or less, which would seem usefully cheap. I would hope that proposals like his, which uses solid membranes for the H_2 separation, would receive due attention. However, all carbon-sequestered "clean coal" innovations are in my view a fourth-best approach, after energy efficiency, renewables, and combined-heat-and-power (co-, tri-, and polygeneration), so I'd give it a lower overall priority in energy R&D than it currently has. Having a lot of coal is in my view a less important reason to use it than whether it can provide energy services at least cost. R&D should be driven by cost-effectiveness, not resource bases.

Question 4. If we do everything that we think we can do in terms of fuel efficiency, stimulating production of conventional fuels and alternative fuels from wind, geothermal, biomass, solar and ocean current energy and also further nuclear, do we have the ability to be truly energy independent by 2025?

Answer. Winning the Oil Endgame provided a detailed roadmap for reducing 2025 U.S. oil use from EIA's Jan. 2004 Reference Case forecast of 28.1 Mbbl/d to 20.4 Mbbl/d by capturing 55% of the efficiency potential whose average cost is $12/bbl (2000 $), then substituting 5.7 Mbbl/d of biofuels/biomaterials/biolubricants and 1.6 Mbbl/d of price-independent saved natural gas. That cuts net demand 54%, to 13.0 Mbbl/d. EIA's 2025 domestic production of 7.8 Mbbl/d leaves 5.2 Mbbl/d to come from any combination of:

- continued imports of oil from Canada and/or Mexico, ethanol from Brazil, etc.
- more efficiency (at one-fifth of today's oil price, maybe we should buy more—or faster, since 7.0 Mbbl/d of efficiency wouldn't yet be captured by 2025)
- substituting the rest of the saved natural gas for the 5.2-Mbbl/d "balance" term
- optionally turning that saved gas into hydrogen, whose more efficient end-use would permit it to displace that "balance" term plus the 7.8 Mbbl/d of forecast domestic oil output (with efficient light vehicles and an integrated deployment strategy, per pp. 227-242 of our study, this would be the most profitable use of the saved gas, competing robustly with our 2025 benchmark of $26/bbl RAC in 2000 $; but even without H2, our approach saves $70b/y vs. $26/bbl oil);
- optionally supplementing or supplanting that hydrogen source with others; e.g., just Dakotas windpower could competitively produce ~50 million tonnes of hydrogen per year—enough to run cost-effectively, at our levels of vehicle efficiency, every highway vehicle in the United States. Note that our least-cost off oil strategy doesn't need most of the energy resources you're positing, and your nuclear suggestion is uneconomic (n. 10 of my testimony).

By law, EIA's Jan. 2004 forecast of 7.8 Mbbl/d of domestic oil output in 2025 excludes ANWR as not yet permitted. (I also believe the oil majors will continue in their opinion that its risk/reward ratio makes it one of the least attractive prospects in their global port-folios; neither higher oil prices nor new E&P technologies favor ANWR drilling unless they advantage ANWR against the rest of the portfolio, and I see no evidence they do or can.) As you'll have gathered from my testimony, however, I share Mr. Woolsey's view, expressed in our written testimonies on 7 March 2006, that this is the correct national-security outcome because of what he rightly called the "devastating" potential for attack on TAPS or the facilities at either end of it. Kindly see note 5 in my written testimony, especially the detailed documentation cited just before note 6, for details of why Mr. Woolsey and I both consider this longstanding vulnerability inherent, unfixable, and a show-stopper for the whole ANWR venture. I appreciate your understandable concern for Alaska's revenues, but based on my work long ago for the State of Alaska, I think this internal budgetary problem can be addressed without endangering national security.

RESPONSES OF AMORY LOVINS TO QUESTIONS FROM SENATOR BUNNING

Question 1. Many of you focus on biodiesel and transportation fuels. But coal is our most abundant domestic fossil fuel and it accounts for half of our electricity generation. The Energy Information Administration predicts coal will continue to be the centerpiece of our energy production for the next 25 years. Do you think we could lessen our dependence on imports by using clean coal power and nuclear energy to replace the natural gas and oil that currently goes to the electricity production?

Answer. No, coal and nuclear generation of electricity have virtually nothing to do with displacing oil, which is the nub of the Nation's energy security problem. Less than 3% of U.S. electricity is made from oil (over 90% of which is gooey bottom-of-the-barrel residual oil, not distillate), and less than 2% of U.S. oil (again nearly all resid) makes electricity. Both these quantities are declining. (worldwide they're only 7% and falling.) The only importantly oil-dependent U.S. electricity systems are in Hawai'i, whose Republican Governor Lingle and main utility are solving this problem at least cost via a least-cost mix of efficiency and renewables. The U.S. and most other countries *already* substituted coal and nuclear power for oil-fired electricity generation in the 1970s and 1980s, and they can't do so again. Even the enormous coal-and-nuclear push in that era caused only 27% of U.S. savings of resid, or 18% of total oil savings, during 1977-85. Since transportation currently uses ~70% of U.S. oil, we must look there for most of the oil savings. This is even truer for the future, since in EIA's 2004 forecast, 55% of the projected growth in U.S. oil use was just for SUVs and other light trucks.

It's easier to imagine expanded coal or nuclear power generation replacing the natural gas that still produces one-sixth of America's electricity. But this is uneconomic and impractical, because nuclear and most coal plants, being capital-intensive, are run rather steadily (as nuclear plants must be anyway for technical reasons), whereas most gas-fired plants run rather infrequently. And there's a far cheaper way to save natural gas: pp. 112-122 of *Winning the Oil Endgame* explains how efficient use of gas and gas-fired electricity can save half of U.S. natural gas at an average cost of $0.88 per million BTU (2000 $). The main obstacle is that 48 states penalize utilities for cutting customers' bills, and reward them only for selling more energy. These findings, summarized in n. 12 of my testimony, are now being expanded by further study at RMI. I expect this deeper examination to reinforce our initial findings that efficient use of natural gas, both directly and (especially) by saving gas-fired electricity, is a hugely important gap in the Federal energy agenda.

Question 2. I have been impressed with new Coal-to-Liquids technology that can turn coal into a synthetic liquid fuel. Other parts of the world, like South Africa, have been using this technology for decades. I know there are several pilot facilities here in America, but what do we need to do to push this industry into full commercial-scale operations?

Answer. I'm familiar with the technology, having recently helped redesign a $5b Fischer-Tropsch plant. It's inherently costly, ~$50,000-70,000 per daily barrel—even more so with additional measures to reduce its high CO_2 releases. As noted in my response to Chairman Domenici's question #3, I think the Federal government is already doing more than is sensible to help this expensive option get to market, but much less than is sensible to level the playing-field for the far cheaper competitors—now fighting against far bigger subsidies given to their uneconomic rivals—suggested in our least-cost analysis in *Winning the Oil Endgame.* Many of these cheaper competitors are, like coal, a Kentucky resource whose exploitation could bring great benefits to your State. For example, North Carolina is aggressively exploring a half dozen crops that look promising for producing cellulosic ethanol; many of them would make good tobacco replacements.

Question 3. In some parts of the world—and a few places in Western Kentucky—people drive their cars and trucks on a blend of fuel that is 85% ethanol. That means only of the fuel is based on oil. Some of you on the panel have mentioned that the best case scenario for biodiesel is that it will only replace 10% of gasoline used for transportation. What are the limiting factors? Can the government help address problems like infrastructure and efficiency?

Answer. Biodiesel doesn't displace gasoline; it displaces diesel fuel, which chiefly runs heavy trucks. Ethanol displaces mainly gasoline, used by almost all U.S. cars (though diesels may become popular, as in Europe, if they can pass ever-tighter fine-particulates standards). Biodiesel also looks a lot costlier than ethanol, which is why it accounts for only 1% of the advanced biofuels in our *Winning the Oil Endgame* scenario; the rest is ethanol, mainly from woody, weedy plants like switchgrass, poplar, and crop/forestry wastes.

Like most analysts, I think the potential for cellulosic ethanol—not corn ethanol, which may be what you have in mind—to replace gasoline is far higher than you

mention. Our analysis, consistent with most others including the Administration's, found that nearly 4 million bbl/d of oil-equivalent ethanol can be produced as advanced biofuels, without needing cropland, at short-run marginal costs below $26/bbl (EIA's Jan. 2004 forecast of world oil price in 2025; the current forecast is much higher). And since *Winning the Oil Endgame* showed how to triple the efficiency of cars, trucks, and planes—without compromised attributes, not-yet-invented technology, taxes, subsidies, mandates, or new Federal laws, but with direct economic paybacks of 1-2 years—that biofuel would then support three times more vehicle-miles. In all, the cost-effective biofuels could displace one-fifth of total forecast oil use, efficient use one-half, and saved natural gas the rest.

Question 4. In your testimony before this Committee you state that: Both energy independence and its purpose, energy security, rest on three pillars:

1. Making domestic energy infrastructure, notably electric and gas grids, resilient.
2. Phasing out, not expanding, vulnerable facilities and unreliable fuel source[s]
3. Ultimately eliminating reliance on oil from any source.

Do you have any suggestions about specific legislation that could be adopted by Congress to at least begin the process of implementing any of your recommendations?

Answer. Yes. As explained above in my response to Chairman Domenici's question #1, the strategy described in *Winning the Oil Endgame* doesn't require any new Federal laws; the transition would be driven by business logic; and the changes in public policy that would help support that business logic could all be administrative or at a State level. Pages 169-226 of our study describe numerous State and Federal actions that would help accelerate this business-led transition beyond oil. For example, our analysis suggests size- and revenue-neutral feebates (pp. 186-190), low-income scrap-and-replace car financing (which could greatly help poor rural areas while creating a new million-car-a-year market for Detroit: pp. 191-197), smart government fleet procurement (pp. 197-198), "Golden Carrots" and technology procurement (pp. 199-200), "Platinum Carrot" innovation incentives (pp. 201-203), support for automotive retooling and retraining at no net cost to Treasury (pp. 203-204), military and civilian science and technology initiatives (pp. 204-206), further reforms of light-vehicle efficiency regulation (pp. 206-207—happily, NHTSA has since adopted our key recommendation to base future light-truck efficiency standards on size, not weight), a DARPA fly-off of the ~10 competing cellulosic-ethanol conversion processes to cut a decade off their commercial scaleup (p. 208), reforming and redirecting agricultural subsidies (p. 208), encouraging biofuels and other bioproducts, especially by reforming USDA rules (p. 209), requiring or encouraging fuel-flexible and total-flex vehicles and their infrastructure (pp. 209-210), modernizing and harmonizing heavy-truck standards and policies (p. 211), leveling the playing-field between aviation and surface transportation fuels and for hub-and-spokes vs. point-to-point aviation business models (p. 212), reforming transportation policy and system integration (pp. 212-214), encouraging more efficient buildings (p. 215), and rewarding utilities for cutting our bills rather than for selling us more energy (p. 215). Corresponding suggestions are on pp. 216-220 for State policy (most of the suggested Federal actions should be piloted first in State-level of regional experiments), p. 220 for non-biofuel renewables, and pp. 221 for military energy efficiency. (DoD is emerging as the most forward-leaning Federal agency in helping to lead the Nation off oil—which is as it should be, given oil's centrality to national security.) And on pp. 265ff, our analysis suggests that the Federal actions we propose would reduce, not raise, the budget deficit.

Since we wrote that study in 2004, I've added a few more suggestions: requiring agencies like GSA and DESC to write *long*-term contracts for biofuel blends like E85 (e.g., up to 30% of GSA's fuel requirements), since a major impediment to financing advanced-biofuels plants is the lack of such contracts; expanding the § 1511 renewable-fuel loan guarantee in the 2005 Energy Policy Act to allow more than 50 projects rather than just 4; lengthening biofuels' credits to at least a decade to fit financing for their production scaleup; and encouraging automakers to make Brazilian- (and soon Swedish-) style total-flex vehicles that can use any fuel on the fly, from 100% ethanol to 100% gasoline, thus eliminating captive customers and exerting more price discipline on all producers.

Responses of Amory Lovins to Questions From Senator Bingaman

Question 1. Your study winning the Oil Game analyzes how to eliminate U.S. oil use by 2040. What policies do you recommend we adopt that could reduce the

amount of oil we use in the transportation sector within the next 5 to 10 years? What concrete steps can you suggest?

Answer. Please see my response to Sen. Bunning's question #3. By far the most important actions would be size- and revenue-neutral automotive feebates (pp. 186-190 of our study), heavy-truck regulatory reform (p. 210), the DARPA cellulosic-ethanol process flyoff (p. 208), and, at a State level with Federal encouragement, utility decoupling and shared savings (p. 215) as the key to saving natural gas, directly and indirectly, so we can substitute it for oil. If it's possible to stop mandating and subsidizing sprawl, or otherwise to advance the smart-growth agenda, that too would bear huge longer-term dividends by reducing vehicle-miles travelled, although land-use was bounded out of our study.

Question 2. In your (oral) testimony you noted that there did not need to be any change to federal law or regulation; however in your written testimony (in footnote 7) you say that "FERC doesn't let resilient options compete. " Do changes need to be made to FERC regulations in order for renewable generation, distributed generation and new transmission technologies to be competitive? Such rules as energy imbalance penalties, interconnection rules for small generators, etc., appear to prevent these technologies from being competitive. Are there other rules that inhibit development and if so how should they be changed?

Answer. Yes, yes, and yes. Thank you for noting this important point. Although, as noted in my response to Sen. Bunning's question #1, electricity reforms can save almost no oil, they are extremely important to creating a resilient national energy system—including the ability to get power to filling stations so customers can pump gas! (The industry has stupidly redesigned its pumpheads without the old handcrank socket; as in Florida recently, a prolonged power outage therefore grounds the surface transportation system too.)

FERC is the last bastion of central planning in the Federal Government, and last year gained new authority to site supply-side resources, or override state and local objections to them, without having to consider cheaper alternatives, ranging from end-use efficiency and demand response to micropower. This will probably result in further construction of vulnerable, terrorist-magnet, and uneconomic LNG terminals, with potentially catastrophic consequences for nearby communities and increased financial risks for investors. It also has such perverse effects as I saw recently in Vermont: a northern transmission project in the Burlington area is considered a "reliability resource" by the regional power pool, so its costs are spread over all of New England, but a ~10x cheaper demand-side or distributed-generation solution isn't considered a "reliability resource"—even though it has the same or better reliability outcomes—so Vermonters would have to bear its whole cost themselves. I'm particularly concerned that FERC is making America's power system more prone to regional blackouts by continuing to push larger, longer bulk power flows through more and bigger transmission lines, rather than allowing or, preferably, requiring fair competition (whether market or administrative) by demand-side and distributed options so as to achieve a least-cost system solution. It's not clear that FERC's Commissioners or Staff adequately understand the reliability, resilience, national-security, and economic value of these alternatives, although the proposed addition of the very knowledgeable Commissioner Jon Wellinghoff of Nevada is encouraging.

FERC should better integrate its electricity and gas policies. For example, the approaches our study suggests for saving peak electricity, thereby freeing up a great deal of cheap gas from very inefficient simple-cycle peakers, would also displace much of the generating and transmission capacity FERC is licensing, as well as costly local distribution capacity.

Another desirable focus for FERC's attention would be ensuring that as utilities automate distribution systems, their topology should be made bidirectional, so that distribution shifts from a tree structure (distributing centrally generated electrons to dispersed customers) to a web structure (gracefully handling power flows any which way). This is largely a State regulatory matter, but Federal standards would probably help, and State attention to this issue could be encouraged in many ways.

Still another area for FERC reform would remove the transmission roadblock facing wind developers, especially in and near the Dakotas. In essence, the incumbent lignite operators in that region aren't allowing fair transmission access, and FERC has not yet intervened to promote it, so a cheap, climate-safe, domestic resource exceeding 300 GWe just on tribal lands in the Dakotas remains virtually unexploited.

Broadly, I think State Commissions should follow Texas's example (under then PUCT Chairman Pat Woods' and Governor Bush's leadership) of allowing distributed generators to "plug and play" freely: if the inverter meets IEEE 1547, UL, and local building code requirements, no other approval or procedure should be required. Federal policy should encourage this outcome uniformly, and should encourage State

Commissions to remove artificial constraints as to feed-in generators' unit size, the symmetry of TOU vs. flat-rate payments vs. charges, and other accounting arrangements to ensure a level playing-field for distributed resources. Federal policy should give no preference to big over small or to supply-side over demand-side resources; all should compete fairly as a central principle of Federal energy policy.

A detailed agenda for both Federal and State electricity reforms is at pp. 310-347 in my 2002 Economist book of the year *Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size* (available from www.smallisprofitable.org). Many of the same recommendations apply to retail natural gas systems.

Question 3. Your testimony lists as a high priority making domestic energy infrastructure, notably electric and gas grids, resilient. Your suggestions for making the electric grid more resilient include depending less on central station power plants and long distance transmission by depending more on distributed generation. Would this not, to the extent that micro-turbines are fueled by natural gas, put more demand on the gas infrastructure?

Answer. It would often reduce the required gas flows to the distal ends of the distribution system to run distributed generators, because their cogeneration design (together with the greater building and factory efficiencies that should meanwhile be installed anyhow) would tend to reduce gas consumption by furnaces, boilers, and central gas-fired generators. For the same reason, total gas consumption would generally go down, not up. For example, some years ago my team designed a 92%-efficient gas-fired microturbine polygeneration system for a large Midwestern office-and-laboratory complex. This would obviously use less gas than the boilers and power plants it replaced.

Of course, efficiency and renewables also have a major role. And LBNL has found a U.S. potential approaching 100 GWe for cogeneration based on waste heat currently being discarded because of needless institutional barriers. Such a project with a less-than-one-year payback can remain unbuilt because the incumbent monopsonist refuses to let the intending developer sell electricity across the street or over the fence to a willing buyer.

Question 4. What can we learn from your green building project with TI that can be applied to our quest for better energy security?

Answer. The basic lesson is that integrative design has kept a thousand high-tech jobs in Texas that would otherwise have gone to Asia, just by redesigning a new Texas Instruments microchip fabrication plant (chip fab) that costs 30% less to build while saving a fifth of its energy and a third of its water. The plant is expected to open in April 2006 and has attracted wide attention, partly via Tom Friedman's 18 Jan. 2006 *New York Times* column on the TI/RMI collaboration that produced this result. As TI's designers adopt further proposed innovations that weren't thoroughly tested in time for this project, I'd expect that their next chip fab could well save over half its energy and cost even less to build. Those innovations include onsite power production that could keep the plant running even if the grid went down, and could probably even export power to the rest of the community at need. Not only can many of the efficiency techniques from this project inform others, both new and retrofit (including the big fab in Albuquerque); they, and the whole-system thinking they embody, can also be applied to a wide range of other industries. In 22 sectors so far, my team has found energy savings typically around 30-60% in retrofits paying back in a few years, and ~40-90% in new facilities typically with *reduced* capital cost. It's not rocket science just good whole-system engineering.

These empirical savings far exceed the size and undercut the cost of efficiency projections in government studies. That gap represents a risk to supply-side investors, who may build for demand that turns out not to exist just as the U.S. recently did with ~200 GWe of combined-cycle gas plants. Indeed, all the policy and investment errors that caused the painful energy-markets crash of the mid-1980s are now being repeated, so in a few years, we may see that very bad movie all over again.

Responses of Amory Lovins to Questions From Senator Wyden

Question 1. The Administration's FY2007 budget request seeks $942-million for the Advanced Energy Initiative, $1.18-billion for energy efficiency and renewables and about ten times that amount for various nuclear energy programs. Is any of this going to do much of anything to address what President Bush calls our "national oil addiction" anytime soon?

Answer. While I applaud the President's use of this phrase, and broadly agree that "the best way to break this addiction is through technology," I'm sorry to say that the answer to your question is no. U.S. oil use, and market expectations of it, will remain high, creating upward pressure on oil prices, until there is fundamental

improvement in oil-using efficiency, chiefly in the vehicles that use 70% of the oil, and until we get serious about rapid scaleup of alternative mobility fuels, chiefly cellulosic ethanol.

I have studied the White House Fact Sheet on the Advanced Energy Initiative with some puzzlement. The stated purpose is "to help break America's dependence on foreign source of energy." This can only mean oil: the U.S. does not import coal, uranium is in surplus, and natural gas imports are small (although Administration policy is to increase them by severalfold, creating a new dependence). However, the section on "diversifying energy sources" is all about electricity, which, as explained in my response above to Senator Bunning's question #1, has almost nothing to do with oil. This confusion between oil and electricity, conflating them both into "energy," bemuses energy experts the world over who assume that the responsible U.S. officials must understand these fundamentals; yet such jumbled formulations persist. Perhaps the White House also doesn't know that nuclear expansion would worsen climate change by buying less solution per dollar (nn. 10-11 in my written testimony).

Some of the Advanced Energy Initiative is reasonable; for example, restoring U.S. leadership in large-format advanced lithium batteries would be a good idea, and there is some promising technological basis for hoping it could happen. Hybrid and fuelcell cars are worthy, and plug-in hybrids may be (please see my response below to Senator Feinstein's question #4), but they'd all work better and cost less if combined with an apparently missing element advanced materials that eliminate half the car's weight and fuel use, improve its safety, and don't raise its production cost. When the Freedom Car initiative was announced in 2002, I told a senior DOE official that a small firm I chair had already developed in 2000, with two European Tier Ones, a complete virtual design—production-costed and manufacturable—for the car that his program meant to spend the next decade developing [please see n. 16 of my written testimony]. He replied: "Well, then we'd better not try to help you, because we'd just slow you down." That might be true, but the capital market for such ventures collapsed just as we came to it in 2000, so the car remains unbuilt. Had it been built timely, Detroit would now have a lot more strategic options than it does, including a path to cut many years off the deployment of fuel-cell cars: whichever automaker goes ultralight first also wins the fuel-cell race, a strategic prize.

The renewable-electricity parts of the Advanced Energy Initiative, like increased photovoltaics R&D, are desirable but unrelated to oil. Also, better PV materials, though useful, are less important than better application of existing PVs, and helping the market recognize "distributed benefits" (www.smallisprofitable.org). For example, the Fact Sheet refers to a future possibility of "zero energy" homes (I've lived in one since 1984), and seems not to recognize that this year or next year, the world will install PV capacity exceeding nuclear construction starts in the same year. A decade ago, the U.S. had nearly half the global PV market, but now has just ~8%, because Federal policies drove activity overseas, from whence we must now buy our hardware. Japan now has over 50% market share, thanks to coherent and farsighted policy consistently pursued. Japan is now eliminating its PV subsidies because their pump-priming task is done, years earlier than expected.

The $5M increase in wind R&D could slightly increase windpower's ability to displace natural gas fungible for oil, and low-speed-optimized machines are important for many parts of the U.S. Yet the main windpower issues are in deployment: e.g., past (and possibly future) Congressional stop-go policies that have repeatedly bankrupted the domestic wind industry, Federal and state policies that don't allow windpower fair access to existing transmission lines, misguided opposition to wind offshore Nantucket, and Federal encouragement of short-term commodity markets to the detriment of the long-term fixed-price contracts that could let wind and other renewables capture their ≥2¢/kWh value premium for avoiding fuel-price volatility.

In contrast, the President's increase in cellulosic-ethanol funding is both relevant and welcome, as is the higher priority implied by his 6-year development goal. However, I haven't dug into the budgetary details. Sometimes such initiatives only repackage and shuffle existing budgets, taking money from other good efforts to fund the new one. And I hope the Congress will note that much of the recent troubles at NREL—not a place one should be trying to divert or demoralize during an energy crisis—arose from ~15% of its budget's being, in effect, hijacked by Congressional earmarks. If NREL is to do its job and retain its excellent people, such raids must cease.

As leading venture capitalist Vinod Khosla notes, the main constraint today to scaling up cellulosic ethanol production is capital: entrepreneurs with competing processes must each convince venture capitalists to finance their own projects in the face of uncertainty about whether another one might be better. That's why *Winning*

the Oil Endgame suggested a DARPA fly-off of the best ~10 processes: just spend ~$1billion to build one of each kind of plant and publish the results, cutting perhaps a decade off the commercialization cycle and freeing up the entrepreneurs to do their best.

Question. How much do we need to spend to make a difference? Is there anything that can be implemented in the next few years to start changing course?

Answer. I don't think we need to spend more (although more *well-targeted* energy R&D would certainly be valuable), but we definitely need to spend smarter. The lion's share of both current and new energy R&D funding is going, as usual, to the least promising but most politically powerful technologies—coal and nuclear—that can by their nature contribute virtually nothing to getting America off oil. This and the ill-conceived subsidies in last year's Energy Policy Act don't simply divert Federal funds from best buys; they also leverage untold sums of private capital into nonsolutions. These mistaken Federal energy priorities in the 1980s, in practical effect, *created* today's oil crisis because of what they didn't do and what they dissuaded private investors from doing. Today's repetition of this policy error is setting the stage for another, longer, worse oil crisis.

As to near-term implementation: Senator Snowe asked my colleague Mr. Odd-Even Bustnes to prepare a memo on this very question. That memo of 30 September 2005 showed how to save ~5-9% of U.S. oil use within *one year* without significant cost or disruption. It has been sent to Senators Domenici and Bingaman, and my office would be glad to share it more widely if desired.

Now that the President has raised the notion of "oil addiction," I hope he'll clarify why for drug addiction, he recommends cutting off the supply, while for oil addiction, he favors increasing the supply. In both cases, demand-side understanding and emphasis seem more promising.

Question 2. The Japanese have been on a steady course to conserve energy and reduce their dependence on imported energy while their GDP continues to grow. They're turning down their thermostats and shutting off their idling car and truck engines to save energy. Opinion polls show that more than 75% of Japan's citizens view energy conservation as a personal responsibility. Many are willing to shell out extra cash for efficient appliances and office equipment. Do you think that Americans can gain energy independence without feeling a little pain? Are American consumers willing to accept some financial pain for energy independence gain?

Answer. Yes and yes (though they prefer profits, which are equally available). I think most Americans hunger for leaders who engage their patriotic personal involvement in a great national project to shed our oil burden. *Winning the Oil Endgame* showed how to do this through entrepreneurship and innovation rather than through cost, pain, or sacrifice. But those interested—and there are many—in changing careless habits should be welcomed too, because markets work better when they're mindful. Just please don't confuse efficiency (which is widely called "conservation" in the Pacific Northwest but nowhere else in the country) with curtailment (which is what many Americans from other regions think "conservation" means): they should be discussed separately and in unambiguous language, not interchangeably.

Having spent six weeks of the past year in Japan, I've been struck by that society's resurgence of *technical,* not just behavioral, energy savings. For example, Toyota has cut CO_2 emissions per car produced by 15% during 2002-05; Honda has cut its CO_2 emissions in Japan by 24% below the 1990 level and targets 30% by 2010 while raising average fuel economy 31% during 1995-2005; Nissan expects by 2007 to emit 10% less CO_2 than it did in 2000; Kirin, to emit at last 25% less CO_2 in 2007 than in 1990; Ricoh, to emit 12% less CO_2 in 2010 than in 1990; and many more. New national standards aim to cut electricity use 30% from ~1997 levels for refrigerators (the best Matsushita 2005 model uses 160 kWh/y, about three-fifths less than the U.S. 2001 Federal standard), 16% for TVs, 83% for PCs, 14% for air conditioners, etc., and all these can go much lower still. But while these innovations, executed with customary Japanese speed and quality, will undoubtedly hone Japan's competitive edge in world markets, there's far more to do, because Japanese cars are becoming nearly as inefficient as ours (inefficient SUVs are rapidly proliferating) and Japanese buildings are generally quite inefficient. The President of Tokyo University, one of Japan's top engineers, recently told me that he believes Japan can profitably *triple* her existing aggregate energy efficiency. I'm sure he's right and that gives American businesses the greater challenge of hitting a moving target.

Responses of Amory Lovins to Questions From Senator Feinstein

Question 1. In your opinion, what is the most important step that the United States could take today to help reduce our dependence on oil?

Answer. Triple the efficiency of cars, trucks, and planes—with better safety, uncompromised comfort and performance, and 1-2-year paybacks—by properly applying today's best technologies for ultralight materials, ultralow aerodynamic drag (and, for highway vehicles, rolling resistance), and advanced propulsion. The most important single policy to encourage this leapfrog in cars and light trucks would be State, regional, or ultimately Federal feebates that, within each size class, broaden the price spread between less and more efficient models by charging a fee on the former and using the proceeds to pay rebates on the latter. *Winning the Oil Endgame* described a fuller agenda for both the technical and the policy elements of these breakthroughs for cars, trucks, and planes—and how those industries' competitive imperatives demand such dramatic developments.

Question 2. What are some ways that you believe we can make oil play a less critical role in the American economy?

Answer. America now uses half as much oil as in 1975 to produce a dollar of GDP. This doubled oil productivity has proven enormously profitable. So will redoubling it, at an average cost of only $12—one-fifth what we now pay for a barrel of oil. Natural gas, which can then be directly or indirectly substituted for oil, can be saved even faster and with enormous financial benefit: saving half the gas will cost roughly 1/15th of its recent price, and the peak electrical savings that are the most important gas-saver are typically better than free (because they're more than paid for by their capacity value).

Question 3. What do you believe are the largest barriers to the entry of new vehicle technology into the market?

Answer. These barriers are chiefly cultural (within the auto industry) rather than technical or economic. They include:

- the incorrect assumption that more efficient cars must be less affordable, roomy, peppy, stylish, safe, or otherwise desirable than inefficient cars—*i.e.,* that engineers are slaves to a theoretical economic assumption about diminishing returns (an assumption daily violated by engineers designing computer electronics, and easily falsifiable for cars too);
- the industry's tendency to base strategic decisions on accounting, not economic, principles—on treating obsolete manufacturing capacity as unamortized assets rather than as sunk costs;
- the industry's habit of thinking of costs per *pound* or per *part* rather than per *car;*
- a stovepiped, dis-integrated, and highly risk-averse design process; and
- the peculiar labor, distribution, management, and other rigidities of this extraordinarily ponderous and complex industry.

It's not easy to fix any of these problems, but they must and will all ultimately be fixed, because U.S. automakers are about to be deluged in a tsunami of Schumpeterian destruction. Relentless competition will change either the managers' minds or the managers, whichever happens first.

Similar but less daunting barriers apply to basic innovation in aviation and in trucking—both already well ahead of automaking. The heavy-truck efficiency revolution being led by Wal-Mart is especially encouraging, as are certain aspects of Boeing's 787 program. (Isn't it odd that this platform has a higher mass fraction of advanced polymer composites than does the Joint Strike Fighter?) And I'm gratified by the Pentagon's increasing focus on radically reducing fuel-logistics footprint in theater: if seriously implemented, this could create the industrial base that can lead the civilian vehicle industries off oil, just as DoD research transformed the civilian economy by inventing for military purposes the Internet, GPS, and the jet-engine and chipmaking industries—all foundations of America's and especially California's economy.

Question 4. Would it make sense to focus the nation's technological energy on rapidly developing and commercializing plug-in hybrids that could both take energy from the electric grid at night, when electricity is practically free, and then hopefully give energy back to the grid during the day when electricity use is the greatest? If so, what could the Federal government do to help promote plug-in hybrids?

Answer. Rocky Mountain Institute is currently conducting the first independent assessment of this technology. It would be premature for me to comment until that work is done, probably this summer. Then we'll know whether it's a good idea, and if so, under what conditions. And regardless of propulsion, ultralighting is the most important automotive innovation.

Question 5. If we move in the direction of cellulosic ethanol/biofuels, how possible will it be to replicate that in the developing world?

Answer. Very possible, but it's vital that in all countries, this be done in an environmentally and socially sustainable way—unlike some recent destruction of trop-

ical forests to make way for palm-oil plantations to produce biodiesel. Even more important is to share and greatly accelerate developing countries' adoption of advanced end-use efficiency in all sectors.

Question 6. What is your view of the effectiveness of the Strategic Petroleum Reserve (SPR) as an energy security tool in its current form? In your opinion, are there changes that could be made to the SPR to make it a more beneficial tool for the United States?

Answer. SPR is useful, though I've heard disturbing recent reports about its ability to sustain maximum output, and I remain concerned about the vulnerability of its centralized facilities to disruption by hurricanes or terrorism. I'd prefer greater emphasis on distributed stockpiles of refined products rather than crude oil, rotated as needed to guard against deterioration. The oil system used to have much larger product stockpiles close to its customers than it does today, because beancounters have wrung out inventory as mere carrying-cost overhead, sapping its societal value for private gain. Europe is generally ahead in this regard; many governments require market actors, both suppliers and major customers, to carry refined-product stocks that are already in the form and at the place where they'd be needed by final customers. With so many simultaneous disruptions in the world oil system, and strong incentive to cause more, I think the case for such distributed product stocks (duly protected against attack) is now unassailable. So is the even more powerful case for efficient use of oil. This gives the most bounce per buck by stretching existing *stocks* and buying more *time* to mend what's broken or improvise substitutes.

I made this case in our Pentagon study *Brittle Power: Energy Strategy for National Security* in 1981 (n. 4 of my written testimony), to which Mr. Woolsey and Admiral Tom Moorer wrote the Foreword. The case is far stronger today. Indeed, that *Brittle Power's* findings remain so virtually unchanged since 1981 particularly the facility-vulnerability findings to which Senator Murkowski referred in her opening question at the hearing—seems to me a devastating indictment of the policy process. The grave security problems I identified 27 years ago in our Nation's energy infrastructure should have been fixed, but instead, most of them have been worsened. These self-inflicted vulnerabilities are an attractive nuisance for Al Qa'eda, and we should at least stop multiplying them.

Current Federal energy policy perpetuates American's expanding oil dependence, because it ranges from modest support (advanced biofuels) to inaction (natural-gas and electric efficiency) to opposition (seriously improving light-vehicle efficiency). The resulting oil dependence funds both sides of the war, impugns U.S. moral standing, has bailed out the nearly empty Iranian and Saudi treasuries, has created (in effect) such leaders as Ahmadinejad, Chavez, El-Bashir, and Putin, systematically distorts foreign policy and postures, poisons foreign attitudes, weakens competitiveness, and enhances vulnerability and fragility. Meanwhile, Federal policy strongly favors overcentralized system architecture, as seen in Katrina's damage and in bigger, more frequent regional blackouts. It creates terrorist targets, from LNG and nuclear facilities to Iraqi infrastructure. Its centerpiece, ANWR drilling, would create an all-American Strait of Hormuz in a world that already has one such chokepoint too many. It lavishly supports expansion of nuclear power and reverses the Ford-Cheney reprocessing moratorium, thus worsening proliferation. On top of that, it sacrifices what's left of the nonproliferation regime, painfully built over a half century, to support the nuclear bureaucracy that makes 3% of India's electricity, while ignoring the vastly greater and cheaper potential to improve the peaceful 97%. (India, by the way, has more windpower capacity than nuclear capacity, and in 2004 was the world's #3 installer of windpower.) These seem to me undesirable outcomes for a government committed to enhancing national security. Such policies and outcomes are also, in general, contrary to free-market principles, and often inimical to the principles of federalism, States' rights, and human rights. In short, the most comprehensive threat to national energy security today is national energy policy. This Committee should reexamine its approach, and stop energy policy from undercutting DoD's mission.

RESPONSES OF AMORY LOVINS TO QUESTIONS FROM SENATOR MENENDEZ

Question 1. Could the panel comment on what technologies are available now that could be used to improve the fuel economy of passenger cars, light trucks, and SUVs?

Answer. About 27% of projected light-vehicle fuel in 2025 can be saved (most of it much sooner) by putting in all cars a long list of well-proven, on-the-market technologies that are now used in some cars. Our analysis, following the 2001 NAS/NRC report, found that such incremental improvements would repay its cost in a year at a retail gasoline price of $1.43/gallon (2000 $), or nearer a half year at today's

fuel price. Such independent analysts as DeCicco, Ross, and Argonne National Laboratory's Feng An have been meticulously documenting this potential for more than a decade. There is no excuse for inaction. Indeed, all such cost-effective potential is mandated by Federal law to be reflected in CAFE standards, yet only a small fraction of it actually is. (I'd prefer to make CAFE standards irrelevant via feebates that improve efficiency far more than standards require; but the current policy of ignoring the law seems to me bad public policy.)

However, these traditional assessments seriously understate the modem efficiency potential. Sixty-nine percent of the gasoline that EIA projects to be used by light vehicles in 2025 could be saved with a three-year payback at $1.43/gal, or two years at today's fuel price, by the ultralight, ultra-low-drag-and-rolling-resistance, hybrid-electric combination described on pp. 44-73 of *Winning the Oil Endgame.* (The NAS/NRC panel refused to be briefed on this approach, and assumed that hybrid-electric propulsion, which had entered the market four years earlier, was too far off to matter over its 10-year study horizon. They were wrong. If all 2025 light vehicles were only as efficient as the best hybrids now in dealers' showrooms, they'd save twice as much oil as the U.S. now imports from the Persian Gulf.) Advanced composites, using new cost-effective manufacturing methods mentioned in my testimony, are one route to ultralighting, but if they proved unready for prime time, then ultralight steel autobodies could achieve about four-fifths of the same fuel saving with nearly as good economics. The market will choose which materials win. If aggressively pursued, automakers could start ramping up production of ultralight, doubled-efficiency cars (tripled-efficiency if hybrids) as early as MY2011.

The policy framework can strongly influence how quickly these technologies, whether incremental or leapfrog, are marketed and bought. A comprehensive portfolio of innovative Federal and State policy initiatives is presented at pp. 178-219 of *Winning the Oil Endgame.* In addition, our memo last September for Senator Snowe (please see my response to Senator Wyden's question #1) suggests some short-term measures that together could save at least 5-9% of U.S. oil consumption:

Roughly 4-8% of U.S. gasoline or 2-4% of crude oil could be quickly saved by:

- reducing speed limits for all non-Class 8 vehicles to 60 mph in zones now above this limit under Federal (and if possible State) jurisdiction
- changing EPA rules so that HOV lanes and preferential parking now available only to Alternative Fuel Vehicles are also available to hybrid and all-electric vehicles (EPA's inaction on this is frustrating many States that wish to make this change)
- giving so-called double-tax-credit to State and local nonprofit vehicle buyers such as public safety agencies for adopting high-efficiency hybrids
- authorizing all citizens to deduct mass transit costs on IRS Schedule A
- providing for universal approval of "parking cash-out" (as long practiced in Southern California) and perhaps requiring it for large employers
- for a few years, extending the Federal tax credit for AFVs, hybrids, and all-electric vehicles to far more than the current 60,000 per manufacturer
- eliminating continuing loopholes in CAFE rules
- clarifying that NHTSA does have authority to extend to cars its 23 August 2005 proposed decision to base future light-truck CAFE rules on size, not weight

Roughly 12-18% of diesel fuel could be rapidly saved by heavy-truck reforms proposed in *Winning the Oil Endgame* and in our memo for Senator Snowe (please see my response above to Senator Wyden's question #1).

Roughly 4-6% of gasoline and diesel fuel could be promptly saved by:

- immediately switching all Federal civilian (and nontactical military) road vehicle procurement to the top 5%, or at worst 10%, of efficiency in their subclass
- saving ~3% through proper tire inflation, including rental and commercial fleets as well as individual owners
- exerting Federal pressure to improve traffic-light timing on major urban streets and to speed adoption of electronic tolling (with careful controls to protect personal privacy) and of "urban box" congestion charges
- encouraging proper engine tuning and air-filter replacement, as well as EPA's other gas mileage tips
- having NHTSA clarify that manufacturers and sellers of hybrid cars are allowed to advise buyers how to drive them for optimal efficiency (thus reversing the false impression, spread chiefly by *Consumer's Reports,* that hybrids are inherently much less efficient than they actually are if properly driven)

Finally, DoD initiatives to make military-platform (and -facility) energy efficiency a high priority—in doctrine, requirements-writing, acquisition, design pedagogy and practice, operations, and reward systems—should be strongly encouraged. This is in-

directly very relevant to your question about civilian light vehicles, because, as mentioned above in my response to Senator Feinstein's question #3, targeted military science and technology investments in ultralight materials and their low-cost manufacturing could create the advanced-materials industrial cluster that is the most important single manufacturing innovation for getting off oil. Emerging DoD leadership on this issue is commendable and is vital to national security.

RESPONSES OF SUSAN CISCHKE TO QUESTIONS FROM SENATOR DOMENICI

Question 1. You mention that there are presently only about 600 fueling stations in the U.S. capable of dispensing E85. How would you suggest that the lack of ethanol capable fueling venues be expanded?

Answer. To promote energy security initiatives, priority must be focused on addressing infrastructure deficiencies for alternative fuels. For today's most promising and readily available alternative fuel, E85, a key near-term goal is to increase the number of E85 retail stations from 600 to at least 10% of existing gasoline retail stations in Midwest markets. Because there are approximately 170,000 retail gasoline stations in the U.S., participation by independent fuel providers, as well as major fuel providers will be required. The following federal legislative initiatives can help grow the ethanol infrastructure needed to greatly expand the use of the fuel.

FEDERAL OPPORTUNITIES FOR INFRASTRUCTURE GROWTH:

a) Dramatically increase incentives for retail fuel providers to promote E85 by expanding the current alternative fuel infrastructure tax credit from 30% to 100% for two years. Increasing the tax credit from 30% to 100% for a limited period of time (e.g. two years) would provide an immediate incentive for fuel providers to accelerate their plans to install fuel pumps capable of using E85. A simple conversion of an existing pump/tank can be done for as little as $3,000.

b) Provide a multiplier and early-compliance credits for fuel providers under the federal Renewable Fuel Standard (Energy Policy Act of 2005) to incentivize E85 fuel sales (for example, 2.5 gallons RFS credit should be given for each gallon of E85 sold).

c) Initiate a feasibility study on the costs and roadblocks to ensure that 10% of all U.S. retail gasoline stations provide E85 or other renewable fuels (such as biodiesel / hydrogen) available to consumers by 2010. Potential exceptions for small retailers could be included.

d) Pursue appropriation funding (annual budget bills / Farm Bill) for infrastructure corridor funding, expanded Clean Cities grants, customer awareness campaigns (including notices to existing FFV customers and fuel cap labels):

i. Increase Clean Cities appropriation funding for infrastructure support—currently only $1 million/year 1

ii. Add infrastructure funding provisions to the 2007 Farm Bill—$50 million/year for 5 years (equivalent to 1,500 new pumps/tanks or 10,000 pump conversions per year)

Question 2. You suggest an "integrated approach" to foster advances in fuels as well as vehicle technology. Can you please elaborate on this?

Answer. We need to view vehicles and fuels as a single system: vehicle + fuel + driver. By integrated approach, we mean a partnership of all of the corresponding stakeholders which includes the automotive industry, the fuel industry, government and consumers. The combined efforts of such an approach are the most economically efficient means of achieving our common goal of reducing our energy dependence.

We at Ford are excited about the potential role of renewable fuels. However, the fact is that without the whole-hearted involvement of the fuel industry, we cannot move forward far enough or fast enough. We obviously need key partners like the oil industry to invest in developing and marketing renewable fuels like E85—and we need it to do so now and rapidly. We fully support government incentives to encourage the industry or others to accelerate this investment.

There is a great deal that policy makers can do at all levels as well. We would like to see more R&D support for vehicle technologies and renewable fuels. Government incentives for advanced technology vehicles and E85 infrastructure can accelerate the introduction of these vehicles and fuels into the marketplace. Government must play a critical role to promote U.S. innovation and can do so by expanding and focusing R&D tax credits for a broad range of energy efficient technologies. We would also like to see greater investment in improved road traffic management infrastructure in order to reduce congestion and save fuel.

Question 3. What examples from Ford's experience in Europe might be translated into domestic policies?

Answer. In December 2005, the European Commission issued a report on a competitive automotive regulatory system for the 21st century (CARS 21). Ford and the other member companies of the European Automobile Manufacturers Association (ACEA) support the analysis and conclusions of CARS 21. For example, to maximize the potential for road transport CO_2 emissions reduction, CARS21 strongly endorses applying an integrated approach involving vehicle manufacturers, oil/fuel suppliers, repairers, customers/drivers and public authorities. The integrated approach aims at producing clear and quantifiable reductions in CO_2 through a range. of options (e.g. vehicle technology, alternative fuels, taxation, eco-driving, gear shift indicators, consumer information and labeling, consumer behavior and congestion avoidance).

Question 4. Why was the idea of improving the miles per gallon of sports utility vehicles by 25% by 2005 abandoned by Ford Motors?

Answer. We acknowledged in 2003 that we would not meet our goal of improving SUV fuel economy by 25 percent by 2005 for a variety of market-demand, technology, and investment reasons. Ford is committed to improving the fuel economy of all of our vehicles. We've broadened our passenger car offerings to include models that provide greater fuel economy. We've launched the industry's first full hybrid SUV, and announced plans to increase annual production capacity of hybrid vehicles moving toward 250,000 annually by 2010. We've introduced technologies such as six-speed transmissions that deliver fuel efficiency benefits. In addition, we are pursuing commercial applications across a range of advanced technologies, including hybrids, clean diesels, hydrogen internal combustion engines and fuel cells. Clearly, there's more work to be done, but as these developments illustrate, Ford remains focused on innovating in these areas so we can deliver to consumers the fuel economy they demand.

Question 5. In your testimony, you state that, "Even further down the road, hydrogen powered fuel cells appear to be another promising technology for delivering sustainable transportation." Please explain—how far down the road do you mean?

Answer. We expect commercially viable FCVs to begin arriving in the market no earlier than the middle of the next decade—most likely even later. Hydrogen fuel cell vehicles are seen by Ford and the industry as a long-term alternative transportation solution. They are clean and efficient, with zero tailpipe emissions, and use a renewable fuel source. Although FCVs are in development today, much work remains to meet the functionality, durability, and affordability demands of automotive consumers. In 2005, Ford delivered customer-ready Focus FCVs for use in demonstration fleets in Canada, the United States, and Germany. We expect to get data and feedback from these demonstration fleets that will help us develop commercially viable FCVs for the future.

Question 6. How do you respond to the growing chorus of people who believe that raising CAFE standards will reduce our dependence on foreign sources of oil and should be a policy advanced by our government?

Answer. Automobile fuel economy has been mandated via the CAFE program for about 30 years. Most industry and government experts agree that the program has not been an effective way to reduce petroleum consumption, and that it has had dramatic competitive and economic impacts. For one thing, it takes a long time for the vehicle fleet to turn over. New CAFE standards take time to implement, and their effects take even more time to make their way through the vehicle fleet. Another problem is that higher fuel economy simply makes it cheaper for people to drive more. Vehicle miles traveled have increased substantially over the life of the CAFE program and tend to overwhelm improvements in fuel economy. Addressing our dependence on foreign oil must include taking steps to reduce vehicle miles traveled.

We support working with the technical and safety experts at NHTSA to set standards at maximum feasible levels and to reform the CAFE system. We also support market-driven incentives for advanced technology vehicles to increase their presence in the marketplace and the greater use of low-carbon, renewable fuels as a way to decrease the use of fossil fuels. Automakers are already producing more than 100 models that achieve 30 mpg or more on the highway; however, the consumer demand for these vehicle models is low.

Responses of Susan Cischke to Questions From Senator Murkowski

Question 1. DOE last year issued a report that indicated we should be able to coax up to 40 billion barrels of additional conventional oil from aging oil fields by injecting carbon dioxide into the fields to squeeze out more oil. How important is more widespread use of CO_2 likely to prove to be to aid shorter-term energy production, especially since the same technology—CO_2 injection—results in sequestering carbon from the environment, cutting greenhouse gas emissions?

Answer. Ford does not claim special expertise with respect to CO_2 injection and other oil recovery technologies. This is an excellent question for the oil industry.

Question 2. Coal Gasification: We all know that America is the Saudi Arabia of coal. My state alone has about 15% of the planet's coal reserves, 160 billion short tons. I am really interested in pushing coal gasification to produce coal without emissions and to help sequester carbon. What can we do on top of what we did in last year's Energy Bill, to further clean coal technology and production economics?

Answer. Coal gasification, followed by synthesis to liquids that are suitable for transportation fuels, is a known technology. These are large plants with substantial investment, and their long-term commercial operation must be certain. A related technology, recovery of remote natural gas with synthesis to liquid fuels (Gas-to-Liquids, GTL) is now considered economical in select cases, and several large GTL plants are now planned for Qatar, with diesel fuel to be supplied to Europe, where diesel demand now exceeds supply. Gasification of coal (Coal-to-Liquids, CTL) adds a substantial processing step compared with natural gas as the resource. So the overall efficiency of CTL will be less than GTL, with a corresponding increase in CO_2 as a byproduct. The GTL path will be an issue for total CO_2 emissions unless carbon capture and sequestration is implemented with the GTL plant. Carbon capture and sequestration trial projects are proceeding with good success.

The three key steps needed to proceed with commercial operation of GTL and CTL are:

1. Economic projections that these processes will be competitive with petroleum fuels during the lifespan of the plant and will support the investment required.
2. Determine how carbon capture and sequestration should be implemented on a necessary scale and with reasonable economics, so that these processes have a neutral to positive impact on Greenhouse Gasses.
3. Economic studies of CTL coupled with sequestration to ascertain the cost and potential market incentives to assure the economic viability of the approach.

Question 3. If we do everything that we think we can do in terms of fuel efficiency, stimulating production of conventional fuels and alternative fuels from wind, geothermal, biomass, solar and ocean current energy and also further nuclear, do we have the ability to be truly energy independent by 2025?

Answer. Becoming "more" energy independent depends on whether economic and financial policies and technology advances make alternative forms of energy more economically viable. For example, the U.S. Department of Energy (DOE) and the U.S. Department of Agriculture (USDA) conducted a study that concluded that there is sufficient U.S. biomass feedstock to displace 30 percent of the country's present petroleum consumption by 2030. Whether or not this is a viable scenario depends on the economic practicability of a large-scale biorefinery industry. Becoming "truly" energy independent by 2025 may be a difficult goal.

Responses of Susan Cischke to Questions From Senator Bunning

Question 1. Many of you focus on biodiesel and transportation fuels. But coal is our most abundant domestic fossil fuel and it accounts for half of our electricity generation. The Energy Information Administration predicts coal will continue to be the centerpiece of our energy production for the next 25 years. Do you think we could lessen our dependence on imports by using clean coal power and nuclear energy to replace the natural gas and oil that currently goes to the electricity production?

Answer. Yes. See also our response to question #2 (below).

Question 2. I have been impressed with new Coal-to-Liquids technology that can turn coal into a synthetic liquid fuel. Other parts of the world, like South Africa, have been using this technology for decades. I know there are several pilot facilities here in America, but what do we need to do to push this industry into full commercial-scale operations?

Answer. Coal gasification, followed by synthesis to liquids that are suitable for transportation fuels, is a known technology. These are large plants with substantial investment, and their long-term commercial operation must be certain. A related technology, recovery of remote natural gas with synthesis to liquid fuels (Gas-to-Liquids, GTL) is now considered economical in select cases, and several large GTL plants are now planned for Qatar, with diesel fuel to be supplied to Europe, where diesel demand now exceeds supply. Gasification of coal (Coal-to-Liquids, CTL) adds a substantial processing step compared with natural gas as the resource. So the overall efficiency of CTL will be less than GTL, with a corresponding increase in CO_2 as a byproduct. The GTL path will be an issue for total CO_2 emissions unless

carbon capture and sequestration is implemented with the GTL plant. Carbon capture and sequestration trial projects are proceeding with good success.

The three key steps needed to proceed with commercial operation of GTL and CTL are:

1. Economic projections that these processes will be competitive with petroleum fuels during the lifespan of the plant and will support the investment required.
2. Determine how carbon capture and sequestration should be implemented on a necessary scale and with reasonable economics, so that these processes have a neutral to positive impact on Greenhouse Gasses.
3. Economic studies of CTL coupled with sequestration to ascertain the cost and potential market incentives to assure the economic viability of the approach.

Question 3. In some parts of the world—and a few places in Western Kentucky—people drive their cars and trucks on a blend of fuel that is 85% ethanol. That means only 15% of the fuel is based on oil. Some of you on the panel have mentioned that the best case scenario for biodiesel is that it will only replace 10% of gasoline used for transportation. What are the limiting factors? Can the government help address problems like infrastructure and efficiency?

Answer. To be clear, the 10% replacement scenario is with respect to biofuels, not biodiesel. Like ethanol, biodiesel is one example of a biofuel. Ethanol can replace gasoline in both low levels in gasoline as E10 (ten percent ethanol in gasoline) which can be used in all gasoline vehicles or in higher levels of E85 (70 to 85% ethanol, as required for vehicle operation in cold temperatures) for use in flexible fuel vehicles.

The 2005 Energy Policy Act has already made progress toward increasing replacement fuels by setting goals for ethanol and biodiesel in the Renewable Fuels Standard and promoting the development of production of ethanol from cellulose with research funds and incentives. These cellulosic sources for ethanol include corn stover (the stalks and residue left over after harvest), grain straw, switchgrass, quick-growing tree varieties, or municipal waste.

Although the Energy Policy Act is an excellent start, more can and must be done to grow E85 infrastructure at an accelerated pace to take advantage of the nearly 6 million FFVs on road today as well as those of the future. We have a number of specific suggestions on how government can accelerate the growth of fueling infrastructure. Please see our response to the next question below.

Question 4. Do you have any suggestions about specific legislation that could be adopted by Congress to at least begin the process of implementing any of your recommendations?

Answer. To promote energy security initiatives, priority must be focused on addressing infrastructure deficiencies for alternative fuels. For today's most promising and readily available alternative fuel, E85, a key near-term goal is to increase the number of E85 retail stations from 600 to at least 10% of existing gasoline retail stations in Midwest markets. Because there are approximately 170,000 retail gasoline stations in the U.S., participation by independent fuel providers, as well as major fuel providers will be required. The following federal legislative initiatives can help grow the ethanol infrastructure needed to greatly expand the use of the fuel.

FEDERAL OPPORTUNITIES FOR INFRASTRUCTURE GROWTH:

a) Dramatically increase incentives for retail fuel providers to promote E85 by expanding the current alternative fuel infrastructure tax credit from 30% to 100% for two years. Increasing the tax credit from 30% to 100% for a limited period of time (e.g. two years) would provide an immediate incentive for fuel providers to accelerate their plans to install fuel pumps capable of using E85. A simple conversion of an existing pump/tank can be done for as little as $3,000.

b) Provide a multiplier and early-compliance credits for fuel providers under the federal Renewable Fuel Standard (Energy Policy Act of 2005) to incentivize E85 fuel sales (for example, 2.5 gallons RFS credit should be given for each gallon of E85 sold).

c) Initiate a feasibility study on the costs and roadblocks to ensure that 10% of all U.S. retail gasoline stations provide E85 or other renewable fuels (such as biodiesel / hydrogen) available to consumers by 2010. Potential exceptions for small retailers could be included.

d) Pursue appropriation funding (annual budget bills / Farm Bill) for infrastructure corridor funding, expanded Clean Cities grants, customer awareness campaigns (including notices to existing FFV customers and fuel cap labels):

i. Increase Clean Cities appropriation funding for infrastructure support—currently only $1 million/year.

ii. Add infrastructure funding provisions to the 2007 Farm Bill—$50 million/year for 5 years (equivalent to 1,500 new pumps/tanks or 10,000 pump conversions per year).

ADDITIONAL OPPORTUNITIES:

a) Expand existing consumer-based tax credits for advanced vehicle technologies to include $250 per vehicle for E85 flexible fuel vehicles.

Question 5. In your testimony you discuss the need for an Integrated Approach to the energy problems facing our nation. You state that there is a "great deal that policymakers can do" to help address the energy crisis. You suggest additional governmental incentives for advanced technology vehicles and E85 infrastructure and "expanding and focusing R&D tax credits for a broad range of energy efficient technologies."

Answer. That is correct. There is an enormous amount that we can achieve if we act together in an integrated manner. A good example of the need for more integrated action would be the case of flexible fuel vehicles. Congress wanted to increase the use of alternative fuels in motor vehicles, but there is always the chicken-and-egg problem of what comes first—the vehicles or the fuels. Congress addressed the first part of the chicken-and-egg problem by building incentives into the CAFE law for the production of dual-fueled vehicles. Thanks to this provision, manufacturers have produced nearly 6 million FFVs capable of running on ethanol over the last decade. However, the second part of the chicken-and-egg problem has not been adequately addressed—the issue of infrastructure for ethanol fuel. Too many owners of duel-fueled vehicles have no E85 refueling station in their vicinity. If the duel-fueled vehicle program had been followed by legislation incentivizing or encouraging the development of E85 infrastructure, we could already have made some headway in reducing our dependence on foreign oil.

RESPONSES OF SUSAN CISCHKE TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. Your testimony indicates that Europe is moving forward in using an Integrated Approach involving all stakeholders to address energy challenges in the transportation sector, including the fuel industry. Have the Europeans come up with any ideas that should be applied in the U.S.? Is climate change mitigation part of Europe's integrated approach?

Answer. In December 2005, the European Commission issued a report on a competitive automotive regulatory system for the 21st century (CARS 21). Ford and the other member companies of the European Automobile Manufacturers Association (ACEA) support the analysis and conclusions of CARS 21. For example, to maximize the potential for road transport CO_2 emissions reduction, CARS21 strongly endorses applying an integrated approach involving vehicle manufacturers, oil/fuel suppliers, repairers, customers/drivers and public authorities. The integrated approach aims at producing clear and quantifiable reductions in CO_2 through a range of options (e.g. vehicle technology, alternative fuels, taxation, eco-driving, gear shift indicators, consumer information and labeling, consumer behavior and congestion avoidance). CARS 21. also calls for the creation by the Commission of a stakeholder "working group on the integrated approach to reduce CO_2 emissions from light-duty vehicles" under the European Climate Change Programme.

Question 2. How many hybrid vehicles did Ford produce in 2005? What percentage does this represent of the overall fleet? How many hybrids will Ford produce in 2010? What percentage is this forecast to be of the overall fleet?

Answer. Ford's U.S. HEV volume for 2005 model year was 10,715 units at 0.6% of the light truck fleet. In 2006, the volume of HEVs has almost doubled.

Ford has already announced plans to expand our global capacity to build hybrid electric vehicles to 250,000 units per year by 2010. This represents almost 4% of Ford's current global volume, depending on consumer demand.

Question 3. How many flex-fueled (E85 capable) vehicles did Ford produce in 2005? What percentage does this represent of the overall fleet? How many flex-fueled will Ford produce in 2010? What percentage is this forecast to be of the overall fleet?

Answer. Ford's U.S. E85 FFV volume for the 2005 model year was 201,028 units for the combined car and truck fleet or 7% of the fleet. The annual volume of FFVs for the last five years is about 250,000 units a year or around 9% of our light duty vehicle volume.

Question 4. How long would it take to double Ford's production of flexible fueled vehicles (assuming demand was there)?

Answer. By the end of this year, Ford will have already put nearly 2,000,000 Flexible Fuel Vehicles on the nation's roads. However, applying technologies too broadly, too fast, and too soon (even those already on other vehicle lines in the fleet) can result in poor performance and ultimately customer rejection of promising technologies. Ford's typical engineering practices require that new technologies be phased into production over several years such that there is a cycle of manufacturing and customer service experience in the field. In the case of E85 FFVs, this experience has been limited due to the lack of fuel availability.

Moreover, because ethanol is a unique fuel with unique properties, these vehicles require unique hardware and engineering. For example, fuel tanks with low permeation characteristics are required. It also requires a special fuel pump and fuel lines to deliver the fuel to the engine. Unique injectors introduce the fuel into the engine where special calibrations programmed into the on-board computer determine how much ethanol is in the fuel and how best to set spark timing and fuel flow to ensure the engine operates properly and meets emission standards on all ethanol and gasoline mixtures. Because there is more than one fuel calibration within an FFV, costly development and certification testing is doubled. Many of the FFV parts and processes are patented by Ford and are the result of innovative ideas by our best engineers, and we're proud of them. The bottom line . . . making an FFV is a significant investment for auto manufacturers.

Question 5. How long would it take to double Ford's production of hybrid vehicles (assuming demand was there)?

Answer. Ford has already announced plans to expand our capacity ten fold to build hybrid electric vehicles to 250,000 units per year by 2010, based on consumer demand. In 2008, Ford plans to introduce the Ford Fusion and the Mercury Milan with a hybrid powertrain. Ford plans to offer hybrid versions of the Ford Five Hundred and Mercury Montego full-size sedans, and the Ford Edge and Lincoln MKX crossovers by the end of the decade. As in the previous answer, applying technologies too broadly, too fast, and too soon (even those already on other vehicle lines in the fleet) can result in poor performance and ultimately customer rejection of promising technologies. Ford's typical engineering practices require that new technologies be phased into production over several years such that there is a cycle of manufacturing and customer service experience in the field.

Question 6. Is Ford planning to produce plug-in hybrids for the U.S. market? What is the projected forecast (timeframe) for this?

Answer. Ford does not currently produce plug-in hybrids. While we do not disclose future product plans, we continue to investigate a range of advanced technologies, including hybrids, clean diesels, hydrogen internal combustion engines and fuel cells. In the case of plug-in hybrids, there are benefits and disadvantages to be considered.

Question 7. Mr. Lovins and Mr. Woolsey mentioned the efficiency benefits of constructing vehicles with light-weight carbon composites. Do you agree? When does Ford think this technology will be ready for the market?

Answer. Ford is already using light-weight materials in its products. One example is the aluminium-intensive 2004 Jaguar XJ. The XJ's all-aluminum body is 40 percent lighter yet 60 percent stiffer than its predecessor, translating into overall weight savings of 200 kilograms. As a result, the XJ is delivering segment-leading fuel economy and lower emissions.

Mr. Woolsey testified that light weight materials also use a different manufacturing process to achieve comparable costs. This requires significant capital investment, development, and design—it is not simply a substitution of parts. Even if possible, these new materials and processes would take decades to phase in.

Responses of Susan Cischke to Questions From Senator Wyden

Question 1. I understand that EPA is in the process of recalculating the fuel economy ratings that they assign to different makes and models of cars and trucks, and these new ratings will show vehicles are getting about 10 percent fewer miles per gallon on the road than advertised. Yet the Corporate Average Fuel Economy (CAFE) standards that auto manufacturers have to meet won't be changed. Don't you think that this sets up a double standard? The new EPA ratings will tell consumers one thing about their car's fuel economy, while car manufacturers will continue to say something different to the government when they report on their compliance with CAFE standards.

Answer. No. This really is two different issues. First of all, CAFE standards are changing. NHTSA just finished its current CAFE rulemaking covering 2008-2011 model year light trucks that increases the CAFE requirements for light trucks for seven consecutive years—from 20.7 mpg in 2004 to over 24 mpg by 2011. In addi-

tion, vans and SUVs up to 10,000 lbs. GVW are now included for the first time ever. This represents the most aggressive increase in the CAFE standards for these vehicles in the history of the program. For 2008-11 alone, NHTSA estimates that over 10.7 billion gallons of gasoline will be saved over the useful life of the vehicles produced in these model years.

Second, when Congress enacted the CAFE law in the 1970s, the standards were based on a certain set of test procedures and calculations. Congress realized that changes to the test procedures and calculations could affect the stringency of the standards just as much as changes to the standards themselves. For that reason, Congress provided that if the methodology for measuring fuel economy was changed, adjustment factors must also be incorporated to ensure that the new methodology was equivalent in stringency to the original methodology. This was necessary to ensure an even playing field from year to year, and it prevents "hidden" changes to the standards.

With respect to the CAFE data, the federal government recently noted that ". . . these values are not intended to be used by the public for consumer information, as the government's best estimate of the fuel economy the public will actually achieve. Instead, the manufacturer fleet fuel economy values are used to determine compliance with the applicable average fuel economy standards." [1]

Question 2. Don't you think that auto manufacturers should be required to meet new CAFE standards using the new EPA testing and rating methods? If not, how do you justify allowing auto companies to have one standard for what they tell consumers is their cars' fuel economy and another, inaccurate standard they use to meet CAFE requirements?

Answer. See response to question #1 above. The EPA ratings give consumers a reference to compare vehicle A to vehicle B under the exact same conditions which simulate one type of driving cycle. Consumers' driving styles are unique and variable, so their real world fuel economy may differ from the EPA values.

Question 3. [For Panel] The Administration's FY 2007 budget request seeks $942-million for the Advanced Energy Initiative, $1.18-billion for energy efficiency and renewables and about ten times that amount for various nuclear energy programs. Is any of this going to do much of anything to address what President Bush calls our "national oil addiction" anytime soon?

How much do we need to spend to make a difference? Is there anything that can be implemented in the next few years to start changing course?

Answer. We believe that our nation must establish long-term energy policies and the resolve to remain committed to those policies to successfully reduce our energy dependence. Both near and long-term policies are needed to effect the transition. In the near term, energy sources like renewable fuels offer us a clear pathway to immediate reductions in fossil fuel use. Ethanol is in the market now as both El0 and E85, and growth of that market, while currently ramping up, will be heavily dependent on the government's commitment to support expanding the infrastructure for this alternative to imported oil. In the longer-term, advanced renewable fuels, including cellulosic ethanol and biodiesel, hold promise of even greater energy efficiencies, but government support by way of incentivization of research and development will be crucial to bring those fuels to fruition. On the far horizon, super advanced technologies like hydrogen powered fuel cells may offer a better solution, but these technologies and fuels will be extremely expensive to develop and will be successful only with the government's support along with public/private partnerships that will lead to their successful implementation.

Question 4. The Japanese have been on a steady course to conserve energy and reduce their dependence on imported energy while their GDP continues to grow. They're turning down their thermostats and shutting off their idling car and truck engines to save energy. Opinion polls show that more than 75% of Japan's citizens view energy conservation as a personal responsibility. Many are willing to shell out extra cash for efficient appliances and office equipment. Do you think that Americans can gain energy independence without feeling a little pain? Are American consumers willing to accept some financial pain for energy independence gain?

Answer. Yes, we believe consumers *will* have to make some adjustments. Events over the past year, including Hurricane Katrina, the war in Iraq, and threats to overseas refinery operations have combined to sensitize U.S. consumers to the increasing costs of energy. Energy price increases affect consumers' lives daily through escalating transportation and home heating costs, and eventually in the price of all goods. Still, gasoline prices in the U.S. are not aligned with the rest of the world. Europe and Japan, for example, have much stronger price signals as well as the cultural differences that drive behavior to conserve.

---

[1] Federal Register/Vol. 68, No. 198/October 14, 2003/page 59234.

American consumers have a certain "rugged individualism" about them that demands no compromises when it comes to their lifestyle. This differs from the European and Japanese cultures. We tend to believe that we can "have it all" through technology without lifestyle adjustment—a belief that will not be easy to change. Therefore, we need to consider ways to incentivize consumers to create a "pull" or shift toward increasing energy conservation.

That being said, consumers in the U.S. are beginning to respond to higher transportation costs by altering their daily driving habits, and are reassessing non-essential trips such as vacations. This will lead to a reduction in vehicle miles traveled—a critical factor in conserving fuel. Consumers are also increasingly interested in advanced, fuel efficient technologies including hybrid electric vehicles, flexible fuel vehicles, and diesels which are available today. Whether these will be "permanent" changes depends on how the energy markets respond going forward.

RESPONSES OF SUSAN CISCHKE TO QUESTIONS FROM SENATOR JOHNSON

Question 1. How many FFVs is Ford scheduled to produce over the next 5 years? What are your immediate plans for 2006 and 2007?

Answer. U.S. E85 FFV volume for the 2005 model year was 201,028 units for the combined car and truck fleet or 7% of the fleet. The volume of FFVs for the last five years is about 250,000 units a year or about 9% of our light duty vehicle volume. We continue to produce FFVs (E-85) on a high volume basis on select models. The F-150, Crown Victoria, Mercury Grand Marquis and Lincoln Town Car are new for 2006. We will have the capacity to produce approximately 250,000 ethanol vehicles in 2006.

Question 2. What would it take for Ford to convert substantially all new vehicles to FFVs and when could this begin?

Answer. Applying technologies too fast, too soon (even those already on other vehicle lines in the fleet) can result in poor performance and ultimately customer rejection of promising technologies. Ford's typical engineering practices require that new technologies be phased into production over several years such that there is a cycle of manufacturing and customer service experience in the field. In the case of E85 FFVs, this experience has been limited due to the lack of fuel availability. With the recent rise in gasoline prices, coupled with new federal incentives to increase the use of ethanol, it is more attractive than ever for fueling providers to invest in E85 infrastructure.

Moreover, because ethanol is a unique fuel with unique properties, these vehicles require unique hardware and engineering. For example, fuel tanks with low permeation characteristics are required. It also requires a special fuel pump and fuel lines to deliver the fuel to the engine. Unique injectors introduce the fuel into the engine where special calibrations programmed into the on-board computer determine how much ethanol is in the fuel and how best to set spark timing and fuel flow to ensure the engine operates properly and meets emission standards on all ethanol and gasoline mixtures. Because there is more than one fuel calibration within an FFV, costly development and certification testing is doubled. Many of the FFV parts and processes are patented by Ford and are the result of innovative ideas by our best engineers, and we're proud of them. The bottom line . . . making an FFV is a significant investment for auto manufacturers.

Question 3. Ethanol contains fewer BTUs than gasoline. In a traditional FFV, this results in approximately 20% loss in MPG when the vehicle is running on E85 as compared to gasoline. Given the high price of gas, it is still cheaper to run an FFV on E85 than regular gasoline. I understand, however, that the technology exists to increase miles per gallon when run on E85. We know that the SAAB 9-5 is able to get equal or better mileage when using E85 as compared to gasoline. I understand that this is done through the use of a turbo charger. As I understand it, a turbo charger is able to increase the compression of the engine to transfer E85's higher octane (105 compared to 89 in regular gasoline) to better full efficiency. As you are aware, the current FFV CAFE program is under fire by some because of its negative impact on CAFE standards. It would appear to me that introducing this technology into more FFVs would make sense. Is Ford looking to introduce the turbo charger technology or any other technology into any new vehicles to increase mileage for FFVs running on E85 as compared to gasoline? What is the incremental cost of adding turbo changes to vehicles? What could be done to help you introduce this technology into more vehicles?

Answer. It is certainly true that use of higher octane fuel would allow an increase in compression ratio, which will increase engine efficiency. So a *dedicated* E85 vehicle could be designed to have higher efficiency than our current FFVs with somewhat higher fuel economy. However, the point of the Flexible Fuel Vehicle is its

flexibility to use both gasoline and E85. Under these conditions, when the fuel being used can change from tankful to tankful, the engine must be able to operate properly and without damage on either fuel. If the vehicle can be dedicated to use E85 only, then we can take these steps. For example, our ethanol vehicles in Brazil can be dedicated to operate only on ethanol and use higher compression ratios, but we do not have the extensive ethanol distribution in the U.S. that would enable such a specialty vehicle.

Even with a dedicated E85 vehicle, the fuel economy improvement would only offset a portion of the energy content difference in the fuels, so full equivalence in miles per gallon would require other differences in the vehicles being compared. Reducing the engine size and adding the turbocharger to recover performance is another approach that can take advantage of the high octane of ethanol, but as suggested, the turbocharger is expensive and is generally used on specialty performance vehicles. The same issue, however, remains: that necessary use of gasoline some of the time prevents full optimum design for dedicated E85.

Therefore, while a portion of the fuel economy can be recovered with such engine changes, this is only possible in situations where the vehicle will operate exclusively on E85. Until E85 is available at most U.S. retail fueling stations, FFVs must be designed to operate on ethanol and gasoline, and will incorporate engine designs to handle both fuels.

Question 4. You introduced your Escape FFV Hybrid concept car at the Washington Auto Show in January. I commend you for this initiative. When can we expect to see this vehicle available to the public? What roadblocks do you have in front of you in order to make this a reality and what can we do to help?

Answer. The Escape Hybrid E85 is a research vehicle that holds the potential to further expand the appeal of ethanol-capable vehicles. But even though the volume of ethanol-capable vehicles continues to grow rapidly, there are less than 600 E85 fueling stations in the U.S.—and that's out of over 170,000 retail gasoline fueling stations nationwide. For ethanol to compete as a motor fuel in the transport sector, we need strong, long-term focus on policies that increase U.S. ethanol production and accelerate E85 infrastructure development.

Question 5. You announced a partnership with VeraSun Energy, the nation's second largest ethanol producer located in my home state of South Dakota. (Might consider having the Washington Post ad where Bill Ford is recognizing their partnership.) I commend you for reaching out to the ethanol industry. Can you tell me how this relationship is developing and what you look to achieve?

Answer. We announced our partnership with VeraSun last November and are pleased to report that we are making important progress. In December 2005, VeraSun opened a new 110,000,000 gallon ethanol plant in Ft. Dodge, Iowa. In conjunction with the plant opening, Ford and VeraSun also announced four new E85 retail sites in the area; which began offering E85 this January. The bigger news is the recent announcement that Ford and VeraSun will be working together to create the nation's first "Ethanol Corridor" across Missouri and Illinois. Station sites are now being selected in locations that will allow a FFV driver to travel from Kansas City, MO to Chicago, IL using only E85. We are very excited about this project and our efforts to make E85 more readily available to FFV owners who choose to fill their vehicles with a fuel that enables the U.S. to reduce its dependence on imported oil.

Responses of Susan Cischke to Questions From Senator Feinstein

Question 1. In your opinion, what is the most important step that the United States could take today to help reduce our dependence on oil?

Answer. There is no single step that is most important. Our nation's energy challenges must be addressed with an integrated approach—a partnership of all stakeholders that includes the automotive and fuel industries, government, and end users. We must all accept that the long-term challenges needed to move us closer to energy independence can be solved only through the collaborative efforts of all stakeholders.

Consistent implementation of an integrated approach will allow us to achieve much more in a shorter timeframe and at a significantly lower cost than if each stakeholder were to unilaterally pursue its own agenda. There is an enormous amount we can achieve if we act in harmony towards the same common goals.

We are clearly excited about the potential role of renewable fuels. However, the fact is that without the whole-hearted involvement of the fuel industry, we cannot move forward far enough or fast enough. We need key partners like the oil industry to invest in developing and marketing renewable fuels like E85. We support government incentives to encourage the industry or others to accelerate this investment.

There is a great deal that policy makers can do at all levels as well. We would like to see more R&D support for vehicle technologies and renewable fuels. Government incentives for advanced technology vehicles and E85 infrastructure can accelerate the introduction of these vehicles and fuels into the marketplace. Government must play a critical role to promote U.S. innovation and can do so by expanding and focusing R&D tax credits for a broad range of energy efficient technologies. We would also like to see greater investment in improved road traffic management infrastructure in order to reduce congestion and save fuel.

Government can also educate the public on how to drive in an energy efficient manner. In the end, it will ultimately be the size of the car fleet, and consumers' choices of vehicles, the number of miles they drive, and how they drive that will determine how much motor fuel we consume. A person who drives in an energy-conscious way—by avoiding excessive idling, unnecessary bursts of acceleration and anticipating braking—can enjoy much better fuel consumption, today. Government can play a key role to raise public awareness.

Question 2. What are some ways that you believe we can make oil play a less critical role in the American economy?

Answer. We believe there are many opportunities for the U.S. to reduce the amount of oil we use in transportation today. Advanced alternative technologies including flexible fuel vehicles, hybrid electric vehicles, fuel cell vehicles, advanced diesel vehicles, and others can all play a part in reducing the amount of petroleum used in the U.S. by either displacing petroleum or by achieving breakthrough improvements in fuel efficiency. These technologies either exist or are under development by the auto industry.

Renewable fuels such as biodiesel and ethanol blends of El0 and E85 directly displace petroleum and should be considered an essential part of transportation fueling going forward.

Drivers can also reduce the amount of petroleum they use by adopting driving styles that are more fuel efficient. "Eco-driving"—operating a vehicle in a more environmentally responsible manner—can achieve up to a 25% improvement in fuel economy.

Question 3. What do you believe are the largest barriers to the entry of new vehicle technology into the market?

Answer. We are working to accelerate the commercial application of all areas of advanced vehicle technologies, including hybrids, flexible fuel vehicles, advanced clean diesels, hydrogen-powered internal combustion engines and fuel cell vehicles. As you can imagine, the R&D investment that goes with all of this work is a very big number—certainly in the billions, not the millions—and it will only grow in the future. Government has a role to play in overcoming cost barriers to new technology implementation. See answer to Question # 1 above.

Question 4. Would it make sense to focus the nation's technological energy on rapidly developing and commercializing plug-in hybrids that could both take energy from the electric grid at night, when electricity is practically free, and then hopefully give energy back to the grid during the day when electricity use is the greatest? If so, what could the Federal government do to help promote plug-in hybrids?

Answer. We believe that a portfolio approach is the best way to offer consumers a range of products that meet their specific needs and circumstances. That is why at Ford, we are moving ahead with a range of technological solutions simultaneously. We know that when customers consider purchasing a vehicle, they are concerned with numerous attributes including price, quality, safety, performance, comfort and utility. There is simply no single solution or "silver bullet." As we have said, government incentives for advanced technology vehicles and fueling infrastructure development can accelerate the introduction of these vehicles and fuels into the marketplace. Government must play a critical role to promote U.S. innovation and can do so by expanding and focusing R&D tax credits for a broad range of energy efficient technologies. It is possible that plug-in hybrids could play a future role, although there is much more research and development to be done to determine if these vehicles can in fact provide the benefits that supporters widely claim. The environmental and energy factors for the source of electricity used to charge plug-in hybrids will have to be considered very carefully before any conclusion can be drawn about the benefits of this technology.

Question 5. What percentage of the total Ford fleet will the 250,000 hybrids represent?

Answer. Ford's commitment to increase global hybrid production capacity ten-fold, to approximately 250,000 units annually by 2010, could represent almost 4% of Ford's current global volume (based on consumer demand).

Question 6. How many flex-fueled vehicles does Ford sell in Brazil?

Answer. Ford began selling vehicles that operate on alcohol ("E93") in 1979 as Brazil's ethanol program was implemented. In 1985, Brazil began to produce an "E22" ethanol/gasoline blend. Ford has produced vehicles capable of running on either of those two blends using dedicated engine designs. In 2004 Ford began to market flexible fuel vehicles in Brazil that can operate on either blend or mixes of the two (over 40,000 units to date). In total, since the start of these programs, Ford has produced nearly 3,000,000 units with the ability to operate on ethanol.

RESPONSES OF SUSAN CISCHKE TO QUESTIONS FROM SENATOR MENENDEZ

Question 1. Could you comment on what technologies are available now that could be used to improve the fuel economy of passenger cars, light trucks, and SUVs?

Answer. Globally, Ford is incorporating fuel-efficient technologies such as five- and six-speed transmissions, electronic power-assisted steering, variable cam timing, greater use of light-weight materials and improvements in aerodynamics. We introduced our first hybrid vehicle, the Escape Hybrid, in 2004. We are also investing in new vehicle segments as a strategy to improve fuel efficiency. We continue to expand our offerings of cars and "crossovers" in North America—vehicles that combine the features of cars and SUVs while generally achieving better fuel economy than traditional SUVs. Continued implementation of actions such as these will be necessary to comply with NHTSA's newly-promulgated light truck standards, which represent a significant challenge for Ford.

The fact that a given technology is available on a particular product does not mean that it can be instantly applied to all products. Some technologies, such as hybrid electric powertrains, require an enormous investment of financial and engineering resources, as well as considerable development time to integrate into a new vehicle platform. It is not possible to deploy such technologies across a wide range of vehicles in a short period of time. Moreover, applying technologies too fast, too soon throughout the vehicle fleet can result in poor performance and ultimately customer rejection of promising technologies. Ford's typical engineering practices require that new technologies be phased into production gradually in order to gain experience with consumer acceptance and customer service issues before expanding the availability of the technology.

Question 2. Could you tell me how much more it costs, on average, to produce a flexible-fueled vehicle over an equivalent one that is not an FFV?

Answer. It is estimated that Ford and the industry have invested over a billion dollars to produce the more than five million flexible-fueled vehicles that are on the road today. Currently, FFV capability on Ford vehicles costs between $100 and $200 depending on the model, but this has been an option offered at no additional cost to Ford customers.

The added cost is driven by many factors. First of all, because ethanol is a unique fuel with unique properties, these vehicles require unique hardware and engineering. For example, fuel tanks with low permeation characteristics are required. It also requires a special fuel pump and fuel lines to deliver the fuel to the engine. Unique injectors introduce the fuel into the engine where special calibrations programmed into the on-board computer determine how much ethanol is in the fuel and how best to set spark timing and fuel flow to ensure the engine operates properly and meets emission standards on all ethanol and gasoline mixtures. Because there is more than one fuel calibration within an FFV, costly development and certification testing is doubled. Many of the FFV parts and processes are patented by Ford and are the result of innovative ideas by our best engineers, and we're proud of them. The bottom line . . . making an FFV is a significant investment for auto manufacturers.

In order to continue to make FFVs a value proposition for consumers, we fully support government incentives to further accelerate investment in developing and marketing an E85 infrastructure.

Question 3. Would Ford support replacing the current CAFE credit for producing dual-fuel vehicles with a system that provided credits based on the actual amount of ethanol used?

Answer. No. First of all, it would be impractical to incorporate a fuel usage approach into the CAFE program, because manufacturers must plan for CAFE compliance years in advance, and they cannot plan to a moving target. Second, and even more importantly, the purpose of the dual-fuel incentives is to create a market that will accelerate the development of alternative fuel sources. Ford and other automakers have responded by producing more than five million alternative fuel vehicles and have absorbed significant costs to provide FFVs, most at no additional cost to consumers. And we see customer interest growing. The focus now needs to turn to increasing the availability of ethanol through infrastructure development.

RESPONSES OF R. JAMES WOOLSEY TO QUESTIONS FROM SENATOR DOMENICI

Question 1. You have spoken on a number of occasions about the security threats with respect to potential disruptions to foreign energy infrastructure and thus to our own energy security. As you look out on the areas from which we import, where are the potential threats located and what are the resulting potential price spikes?

Answer. I believe the most dangerous are in the Middle East, due to the high (appx. 2/3) share of the world's proven reserves of oil being located there, the processing infrastructure, and the ease of access for terrorist groups. I would put Saudi Arabia's processing facilities in Northeastern Saudi Arabia front and center. A successful attack there could send oil well over $100/bbl for months.

Question 2. What are your views on the possibilities of oil shale and other unconventional resources replacing much of our foreign dependence? What kind of timetable would you put on that?

Answer. Oil shale is especially promising because of the large volume of oil contained therein in the Western U.S. (several Saudi Arabias-worth). I have no good estimate of the time required to develop, but although development could begin relatively soon it would probably take a number of years to reach substantial volume.

Question 3. Is energy self-sufficiency a positive goal worth pursuing? Do you think some recent improvements have been made in shifting our reliance to allies such as Canada, for example?

Answer. I believe that, for the U.S., the issue is not so much energy self-sufficiency as our overall dependence on oil. Most of our natural gas comes from Canada and, given the diversity of sources, moving toward importing some LNG from elsewhere does not seem to me to raise the kinds of issues for us that oil does. This is especially so given the promise of IGCC coal together with CO_2 sequestration, quite possibly in deep saline aquifers. There is basically one world-wide market for oil so we do little by shifting the locus of our purchases—the objective should be to move to replace conventional oil with relatively inexpensive fuels from widely-available and inexpensive feedstocks and to require as little change in the infrastructure as possible. I would thus emphasize replacing oil with off-peak electricity (plug-in hybrids), ethanol (increasingly cellulosic), methanol, and diesel derived from agricultural and other wastes.

Question 4. In your view, what are the most immediate steps we can take to reduce oil prices?

Answer. Little will work in the very short run. We should instead focus on the steps set out in answer to Q3, supra, and even consider a floor for oil around $35/bbl or so so that the Saudis cannot increase production from their reserves, drop the price below the cost of alternatives, and undercut the alternatives' development—as occurred in 1985 and again in the late 90's. In order to have alternatives to oil we probably need to ensure that the price cannot be temporarily dropped too far.

Question 5. What are the most immediate steps we can take to reduce our reliance on foreign sources of oil?

Answer. See answer to Q3, supra: move toward plug-in hybrids, ethanol (esp. cellulosic), methanol, and diesel from agricultural and other waste.

Question 6. In the State of the Union speech, President Bush set the goal of cutting reliance on Middle East oil 75% by 2025. Is this a worthy goal? An attainable goal? And, if so, what is the most effective way to achieve this goal?

Answer. I believe a somewhat more ambitious goal is reasonable: by a combination of fuel efficiency and alternative fuel development and commercialization, I believe producing 25% of our transportation fuel from alternative fuels by 2025 is plausible, perhaps more.

Question 7. Do you think that conservation is a significant component to energy policy? What is the most effective way to convince the public that it is?

Answer. Yes, but the most attractive form of conservation is one that will let people continue to use the size cars they need for the purposes they require. One excellent idea is to move quickly toward producing vehicles from the same type of carbon composites that are now used for Formula 1 racers. Since these are more than ten times as crash-resistant as steel and weigh half as much or less, one can separate safety from size and have safe small vehicles that are extremely fuel efficient, or, for those who need large vehicles these can be much lighter and thus much more fuel efficient as well.

Question 8. Please comment on your views on raising CAFE standards.

Answer. I believe that such is reasonable, but would be willing to replace them with incentives for plug-in hybrids, carbon-composite vehicles, and alternative fuels.

Question 9. What additional steps need to be taken to develop fuel cell technology?

Answer. We are spending far too much today on this far-out technology. The National Energy Policy Commission found in 2004 that there would be no substantial effect on oil use from automotive hydrogen fuel cells for 20 years. This is in part because of the expense of fuel cells and in part because of the massive changes to the energy infrastructure that their use would entail. The vast majority of the funds now devoted to automotive hydrogen fuel cells should be transferred to uses for which there will be a much earlier benefit.

Question 10. Do you view increasing our domestic supply of oil and gas as a necessary part of achieving what you have called, "energy security"?

Answer. See answer to Q3, supra.

Question 11. Please comment specifically on the impact that the biofuels provisions in the recently passed Energy Policy Act will have on reducing reliance on foreign oil and strengthening energy security.

Answer. I believe that substantially greater encouragement for commercialization is needed in order for the impact to be timely, along the lines of the legislation introduced by Senators Lieberman, Brownback, and others (S. 2025).

RESPONSES OF R. JAMES WOOLSEY TO QUESTIONS FROM SENATOR MURKOWSKI

Question 1. Coming from a state that has the lion's share of gas hydrate potential, what is the likelihood of gas hydrate production both on shore and under the seafloor coming into its own within the next two decades? It is said that America has a 1,000 year energy supply of hydrates out there waiting to be tapped. Should we be focusing more on developing that resource?

Answer. I have read only a bit on this interesting issue—the current estimates are on the order of 21,000 trillion cubic meters, or about 100 times our current proven gas reserves. My understanding is that very large R&D investments will be necessary before these can be regarded as an affordable source, however. I would classify these as a fascinating and potentially important but distant energy source.

Question 2. DOE last year issued a report that indicated we should be able to coax up to 40 billion barrels of additional conventional oil from aging oil fields by injecting carbon dioxide into the fields to squeeze out more oil. How important is more widespread use of CO_2 likely to prove to be to aid shorter-term energy production, especially since the same technology—CO_2 injection—results in sequestering carbon from the environment, cutting greenhouse gas emissions?

Answer. This is certainly not a negligible total—it is about 25% more than the world's annual oil production today. If CO_2 sequestration is shown to be successful for the long term when it is injected into wells, this could be a very valuable step. Over the long run I believe CO_2 sequestration will require its being inserted into deep saline aquifers, however.

Question 3. Coal Gasification: We all know that America is the Saudi Arabia of coal. My state alone has about 15% of the planet's coal reserves, 160 billion short tons. I am really interested in pushing coal gasification to produce coal without emissions and to help sequester carbon. What can we do on top of what we did in last year's Energy Bill, to further clean coal technology and production economics?

Answer. The key problem, as I understand it, is that IGCC coal with carbon sequestration is still more expensive by perhaps 25% or more than just burning coal with pollution abatement but not CO_2 capture and sequestration. In my view once the technology of sequestration is sufficiently proven we should move, through federal financial incentives, to remove this difference. A mandatory carbon cap-and-trade system would be a good method to provide the needed incentives to move us in this direction.

Question 4. If we do everything that we think we can do in terms of fuel efficiency, stimulating production of conventional fuels and alternative fuels from wind, geothermal, biomass, solar and ocean current energy and also further nuclear, do we have the ability to be truly energy independent by 2025?

Answer. Although in the 1970's some 20 per cent of our electricity was produced from oil, today only 2-3% is. Thus our methods of producing electricity, while important for a number of reasons, are largely unrelated to our dependence on oil, about 2/3 of which is used for transportation and the rest for industrial and heating uses. Wind, geothermal, solar, ocean current, and nuclear energy all have the major advantage (with hydro) of not contributing to global warming gas emissions. As noted above, since our principal foreign source of electricity-producing feedstocks is natural gas from Canada, I do not believe that the decisions about electricity production should be driven by the question of foreign sources. Oil, however, is a different matter—still, the key issue (since there is basically one world-wide market for oil) is how can we reduce our reliance on conventional oil overall. The best near-term options here, I believe, are to move toward: plug-in hybrids so that inexpensive off-

peak electricity can be used for transportation; ethanol (especially cellulosic); methanol; diesel from agricultural and other wastes; and construction of vehicles out of carbon composites, supra. Such steps could, I believe, move us toward producing 25% or more of our transportation fuels from alternative sources by 2025. Together with our domestic oil production and other fuel efficiency steps we could conceivably come close to importing no oil around 2025 or a few years later.

RESPONSES OF R. JAMES WOOLSEY TO QUESTIONS FROM SENATOR BUNNING

Question 1. Many of you focus on biodiesel and transportation fuels. But coal is our most abundant domestic fossil fuel and it accounts for half of our electricity generation. The Energy Information Administration predicts coal will continue to be the centerpiece of our energy production for the next 25 years. Do you think we could lessen our dependence on imports by using clean coal power and nuclear energy to replace the natural gas and oil that currently goes to the electricity production?

Answer. IGCC coal with carbon sequestration is especially promising and nuclear energy has an important role as well in future electricity production. But only 2-3% of our electricity is now produced from oil so moving further in these directions for electricity production will have only a minimal effect on oil use or imports (until there are tens of millions of plug-in hybrid vehicles on the road). Most of our natural gas imports now come from Canada, which does not present a substantial risk in my view.

Question 2. I have been impressed with new Coal-to-Liquids technology that can turn coal into a synthetic liquid fuel. Other parts of the world, like South Africa, have been using this technology for decades. I know there are several pilot facilities here in America, but what do we need to do to push this industry into full commercial-scale operations?

Answer. My understanding is that environmental concerns and cost, in comparison with alternatives, are major hurdles to overcome, but as you suggest this technology has been improved in recent years and it deserves fair consideration.

Question 3. In some parts of the world—and a few places in Western Kentucky—people drive their cars and trucks on a blend of fuel that is 85% ethanol. That means only 15% of the fuel is based on oil. Some of you on the panel have mentioned that the best case scenario for biodiesel is that it will only replace 10% of gasoline used for transportation. What are the limiting factors? Can the government help address problems like infrastructure and efficiency?

Answer. Some types of biodiesel can be used only in mixtures of 10-20% with ordinary diesel fuel. Other types of alternative diesel (called "renewable diesel" as distinct from "biodiesel" in the statutes) have no such problem, according to the report in late 2004 of the National Energy Policy Commission. Consultation with the Commission staff (www.energycommission.org) would provide a more complete answer.

Question 4. In your testimony before this Committee you summarize your overall recommendations by stating that:

> government policies in the United States and other oil-importing countries should: (1) encourage a shift to substantially more fuel-efficient vehicles within the existing transportation infrastructure, including promoting both battery development and a market for existing battery types for plug-in hybrid vehicles; and (2) encourage biofuels and other alternative and renewable fuels that can be produced from inexpensive and widely-available feedstocks—wherever possible from waste products.

Do you have any suggestions about specific legislation that could be adopted by Congress to at least begin the process of implementing any of your recommendations?

Answer. S. 2025, introduced by Senators Lieberman and Brownback and a number of co-sponsors implements most of these suggestions.

RESPONSES OF R. JAMES WOOLSEY TO QUESTIONS FROM SENATOR WYDEN

Question 1. Your testimony makes a compelling case why energy security should be a top national security priority. What do you suggest we do to make the case for the billion-dollar funding levels that we need for energy independence and security at a time when national priorities are focused on the war on terror?

Answer. In my view reducing our dependence on conventional oil is an integral part of the war on terror. I believe we will be in this war for decades, much like the Cold War, and that one key to winning it is to cease funding the ideology of hatred that our enemies feed upon. We borrow $250 billion/year to import oil—an increasing share it will come from the Middle East as the years go on. The Saudis then, to take one example, provide around $4 billion/year to the Wahhabis who then

use much of it to run, e.g., madrassas in Pakistan and elsewhere that teach this hatred. Indeed one could say that, other than the Civil War, this is the only war the U.S. has fought in which we pay for both sides.

Question 2. In your written testimony, you say that estimates of the amount spent by the Saudis in the last 30 years spreading Wahhabi beliefs throughout the world vary from $70 billion to $100 billion and that some oil-rich families of the Greater Middle East fund terrorist groups directly. How can we persuade the Administration and Congress that this backdoor funding of terrorist with oil revenues, what I call the "terror tax" we pay on Middle East oil, is helping to fund terrorism and that cutting off this funding source should be part of the war on terror?

Answer. To avoid these funds going to the Wahhabis and to avoid them and oil-rich families funding this ideological aspect of terrorism I believe we must move away from the use of conventional oil, and do so quickly and decisively. Our resolution, if clear and decisive, can have an effect on the psychology of this conflict even before our reduction in oil use is large.

Question 3. Do you think that we should have an account in the DOD budget for energy security?

Answer. DOD can play a major role in reducing its own use of conventional oil through the design of its platforms and the logistical arrangements at its facilities. It can also help move the civilian economy in useful directions by its purchases of conventional vehicles that are fuel-efficient (e.g. plug-in hybrids) and alternative fuels. I don't know whether a separate account is the best way to increase this emphasis or not.

Question 4. The Administration's FY 2007 budget request seeks $942-million for the Advanced Energy Initiative, $1.18-billion for energy efficiency and renewables and about ten times that amount for various nuclear energy programs. Is any of this going to do much of anything to address what President Bush calls our "national oil, addiction" anytime soon?

Answer. Nuclear energy may be one good way to produce electricity, especially because it does not emit global warming gases. But it is largely irrelevant to the question oil addiction because only 2-3% of our electricity comes from oil.

Question 5. How much do we need to spend to make a difference? Is there anything that can be implemented in the next few years to start changing course?

Answer. Yes, I believe that S. 2025, introduced by Senators Lieberman and Brownback and co-sponsored by a number of Senators would help move us promptly in the direction of efficient vehicles and alternative transportation fuels.

Question 6. The Japanese have been on a steady course to conserve energy and reduce their dependence on imported energy while their GDP continues to grow. They're turning down their thermostats and shutting off their idling car and truck engines to save energy. Opinion polls show that more than 75% of Japan's citizens view energy conservation as a personal responsibility. Many are willing to shell out extra cash for efficient appliances and office equipment. Do you think that Americans can gain energy independence without feeling a little pain? Are American consumers willing to accept some financial pain for energy independence gain?

Answer. I would hope so, but one interesting aspect of moving away from oil addiction is that many of the steps we need to take are relatively painless. We can have high-performance and even large vehicles, e.g., for those who need them—if they are plug-in hybrids and run on cheap off-peak electricity, as well as being Flexible Fuel Vehicles that carry E-85, methanol, or diesel made from waste in their tanks, and are constructed from carbon composites it is possible to have sports cars or SUVs that get many hundreds of miles per gallon (of conventional oil products).

RESPONSES OF R. JAMES WOOLSEY TO QUESTIONS FROM SENATOR FEINSTEIN

Question 1. In your opinion, what is the most important step that the United States could take today to help reduce our dependence on oil?

Answer. Provide incentives to move into commercial use quickly of transportation fuels that are either cheap and environmentally attractive today (i.e. off-peak electricity via plug-in hybrids) or that are predictably cheap and environmentally attractive (cellulosic ethanol and diesel from waste products). The less need for infrastructure change the better, but where necessary incentives for change (e.g. tax credits for E-85 pumps) should be part of the package.

Question 2. What are some ways that you believe we can make oil play a less critical role in the American economy?

Answer. In addition to the answer to Question 1, supra, encourage with loan guarantees or tax credits the saving of oil in other sectors—heavy trucking, heating, and industrial uses—and the substitution of other fuels, such as IGCC coal with carbon sequestration, biomass-derived products for industrial uses, etc.

Question 3. What do you believe are the largest barriers to the entry of new vehicle technology into the market?

Answer. Investment cost and uncertainty in the market. The latter may be mitigated by encouraging orders for new types of vehicles (e.g. plug-in hybrids) by fleet purchasers.

Question 4. Would it make sense to focus the nation's technological energy on rapidly developing and commercializing plug-in hybrids that could both take energy from the electric grid at night, when electricity is practically free, and then hopefully give energy back to the grid during the day when electricity use is the greatest? If so, what could the Federal government do to help promote plug-in hybrids?

Answer. Most definitely. The vehicle-to-grid possibility can help reduce the need for new generating capacity for peak power and "regulation". Federal regulatory encouragement of such steps could substantially hasten the adoption of plug-ins.

RESPONSE OF R. JAMES WOOLSEY TO QUESTION FROM SENATOR MENENDEZ

Question 1. Could you comment on what technologies are available now that could be used to improve the fuel economy of passenger cars, light trucks, and SUVs?

Answer. The most dramatic, I believe, would be the increased utilization of carbon composites for vehicle construction. Since these (now used in Formula 1 racing cars) are ten times more crash-resistant than steel they can provide substantial safety even for small vehicles. Since the weight is half or less that of steel vehicles, they would improve fuel efficiency by 100% or more. More such ideas are included in the excellent 2004 report by the Rocky Mountain Institute, "*Winning the Oil End-game.*" (www.rmi.org).

[Responses to the following questions were not received at the time this hearing went to press:]

QUESTIONS FOR FRANK VERRASTRO FROM SENATOR DOMENICI

Question 1. In your written testimony you state that the rise in oil import levels over the next twenty years carries important infrastructure implications. Please explain what you mean by this.

What in your view is the best way to address these potential problems?

Question 2. Please comment on the effects of the 7.5 billion gallon ethanol mandate in the energy bill combined with the possibility of a moderate increase in CAFE standards and the opening of areas like 181 and ANWR. Would the combination of all of these policies significantly strengthen our energy security? Would they substantially reduce our dependence on foreign sources?

Question 3. Please tell us your views on what a windfall profits tax would do to oil prices as well as its impact on our reliance on foreign sources.

Question 4. In your written testimony you say that, "the Stone Age did not end because we ran out of rocks—something better came along. The Oil Age will similarly be overtaken when a better solution of a series of solutions emerge."

What do you think the most reasonable policies are to strengthen our energy security until the Oil Age is overtaken? In other words, where should our focuses lie and what have we been concentrating too much on?

Question 5. At what price levels for oil do you think we will start to see a significant decrease in consumption?

QUESTIONS FOR FRANK VERRASTRO FROM SENATOR MURKOWSKI

Question 1. Coming from a state that has the lion's share of gas hydrate potential, what is the likelihood of gas hydrate production both on shore and under the seafloor coming into its own within the next two decades? It is said that America has a 1,000 year energy supply of hydrates out there waiting to be tapped. Should we be focusing more on developing that resource?

Question 2. DOE last year issued a report that indicated we should be able to coax up to 40 billion barrels of additional conventional oil from aging oil fields by injecting carbon dioxide into the fields to squeeze out more oil. How important is more widespread use of CO_2 likely to prove to be to aid shorter-term energy production, especially since the same technology—CO_2 injection—results in sequestering carbon from the environment, cutting greenhouse gas emissions?

Question 3. Coal Gasification: We all know that America is the Saudi Arabia of coal. My state alone has about 15% of the planet's coal reserves, 160 billion short tons. I am really interested in pushing coal gasification to produce coal without

emissions and to help sequester carbon. What can we do on top of what we did in last year's Energy Bill, to further clean coal technology and production economics?

Question 4. If we do everything that we think we can do in terms of fuel efficiency, stimulating production of conventional fuels and alternative fuels from wind, geothermal, biomass, solar and ocean current energy and also further nuclear, do we have the ability to be truly energy independent by 2025?

QUESTIONS FOR FRANK VERRASTRO FROM SENATOR BUNNING

Question 1. Many of you focus on biodiesel and transportation fuels. But coal is our most abundant domestic fossil fuel and it accounts for half of our electricity generation. The Energy Information Administration predicts coal will continue to be the centerpiece of our energy production for the next 25 years. Do you think we could lessen our dependence on imports by using clean coal power and nuclear energy to replace the natural gas and oil that currently goes to the electricity production?

Question 2. I have been impressed with new Coal-to-Liquids technology that can turn coal into a synthetic liquid fuel. Other parts of the world, like South Africa, have been using this technology for decades. I know there are several pilot facilities here in America, but what do we need to do to push this industry into full commercial-scale operations?

Question 3. In some parts of the world—and a few places in Western Kentucky—people drive their cars and trucks on a blend of fuel that is 85% ethanol. That means only 15% of the fuel is based on oil. Some of you on the panel have mentioned that the best case scenario for biodiesel is that it will only replace 10% of gasoline used for transportation. What are the limiting factors? Can the government help address problems like infrastructure and efficiency?

Question 4. On page 1 of your testimony before this Committee you list a variety of issues our nation must consider if it is to begin addressing the energy challenges we face. These include: i) stimulating additional supplies of conventional and traditionally non-conventional fuel sources, including renewables and alternatives; ii) improving energy efficiency and conservation efforts; iii) promoting research and development and deployment of useful technologies; iv) addressing infrastructure needs to facilitate the development of fuel choices and; v) pursuing the development of a more comprehensive energy development strategy.

Question 5. Do you have any suggestions about specific legislation that could be adopted by Congress to at least begin the process of implementing any of your recommendations?

QUESTIONS FOR FRANK VERRASTRO FROM SENATOR BINGAMAN

Question 1. Your testimony notes that the deployment of proven technologies in the auto fleet can over time make a substantial contribution to reducing transportation demand. Can you give us a few examples of what these "existing technologies" are that you are referring to?

Question 2. What policies do you recommend we adopt that could help use existing technologies to reduce the amount of oil that we use in the transportation sector within the next 5 to 10 years? What concrete steps can you suggest?

Question 3. Is there anything that we should do to encourage more multilateral cooperation in the international oil trading and investment market places to try to lessen governments' pursuits of specific narrow interests?

QUESTIONS FOR FRANK VERRASTRO FROM SENATOR WYDEN

Question 1. As a recognized expert in international energy markets, and given your view that expanding domestic oil production alone won't get us very far down the road towards energy independence, are there other countries that could be models for our national efforts?

Question 2. I agree with your call to accelerate new energy technology deployment, especially those that cut transportation fuel demand. Critics complain that this puts the government in the business of picking winners and losers. In my view, we're already dependent on the losers. How do you suggest that we do this so that we can be successful?

Question 3. The Administration's FY 2007 budget request seeks $942-million for the Advanced Energy Initiative, $1.18-billion for energy efficiency and renewables and about ten times that amount for various nuclear energy programs. Is any of this going to do much of anything to address what President Bush calls our "national oil addiction" anytime soon?

How much do we need to spend to make a difference? Is there anything that can be implemented in the next few years to start changing course?

Question 4. The Japanese have been on a steady course to conserve energy and reduce their dependence on imported energy while their GDP continues to grow. They're turning down their thermostats and shutting off their idling car and truck engines to save energy. Opinion polls show that more than 75% of Japan's citizens view energy conservation as a personal responsibility. Many are willing to shell out extra cash for efficient appliances and office equipment. Do you think that Americans can gain energy independence without feeling a little pain? Are American consumers willing to accept some financial pain for energy independence gain?

QUESTIONS FOR FRANK VERRASTRO FROM SENATOR FEINSTEIN

Question 1. In your opinion, what is the most important step that the United States could take today to help reduce our dependence on oil?

Question 2. What are some ways that you believe we can make oil play a less critical role in the American economy?

Question 3. What do you believe are the largest barriers to the entry of new vehicle technology into the market?

Question 4. Would it make sense to focus the nation's technological energy on rapidly developing and commercializing plug-in hybrids that could both take energy from the electric grid at night, when electricity is practically free, and then hopefully give energy back to the grid during the day when electricity use is the greatest? If so, what could the Federal government do to help promote plug-in hybrids?

QUESTION FOR FRANK VERRASTRO FROM SENATOR DOMENICI

Question 1. Could you comment on what technologies are available now that could be used to improve the fuel economy of passenger cars, light trucks, and SUVs?

○