ENERGY STORAGE TECHNOLOGIES: STATE OF DEVELOPMENT FOR STATIONARY AND VEHICULAR APPLICATIONS

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

OCTOBER 3, 2007

Serial No. 110–61

Printed for the use of the Committee on Science and Technology

Available via the World Wide Web: http://www.science.house.gov

U.S. GOVERNMENT PRINTING OFFICE

37–987PS WASHINGTON : 2008

For sale by the Superintendent of Documents, U.S. Government Printing Office
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ENERGY STORAGE TECHNOLOGIES: STATE OF DEVELOPMENT FOR STATIONARY AND VEHICULAR APPLICATIONS

WEDNESDAY, OCTOBER 3, 2007

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

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

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
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SUITE 2320 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6301
(202) 225–6375
TTY: (202) 226–4410
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Subcommittee on Energy and Environment

Hearing on

Energy Storage Technologies:
State of Development for Stationary and Vehicular Applications

2318 Rayburn House Office Building
Wednesday, October 3, 2007
10:00 a.m. – 12:00 p.m.

WITNESSES:

PANEL I

Ms. Patricia A. Hoffman
Deputy Director Research and Development, Acting Chief Operating Officer, Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy

Mr. Brad Roberts
Chairman, Electricity Storage Association

Mr. Larry Dickerman
Director, Distribution Engineering Services, American Electric Power

Mr. Thomas S. Key
Technical Leader, Renewables and Distributed Generation, Electric Power Research Institute

PANEL II

Ms. Lynda Ziegler
Sr. Vice President for Customer Services, Southern California Edison

Ms. Denise Gray
Director, Hybrid Energy Storage Systems, General Motors Corporation

Ms. Mary Ann Wright
Vice President and General Manager, Hybrid Systems Power Solutions, Johnson Controls, Inc.

HEARING CHARTER

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

Energy Storage Technologies: State of Development for Stationary and Vehicular Applications

WEDNESDAY, OCTOBER 3, 2007
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

PURPOSE

On Wednesday, October 3, 2007 the Subcommittee on Energy and Environment of the Committee on Science and Technology will hold a hearing to receive testimony on the state of developing competitive energy storage systems for both stationary and vehicular applications and the role for the Department of Energy's (DOE) research and development programs in supporting the development of these systems.

There are significant economic and environmental benefits for improving the Nation's energy storage capability. Broad deployment of energy storage technologies can help to improve the operational efficiency and reliability of our electricity delivery system, and allow for more diversified electricity sources and vehicle models that utilize less conventional liquid fuel, have lower emissions, and address concerns about global climate change. However, there is concern that the U.S. is falling behind in the race to develop and manufacture a wide range of energy storage technologies, and a significant effort is underway to build up a domestic energy storage industry for both stationary and vehicular applications.

The Subcommittee will hear testimony from two panels of witnesses. The first panel will focus primarily on stationary energy storage technologies, and the second panel will emphasize the state of storage technologies for applications in vehicles. The first panel will be comprised of representatives from the Department of Energy, the Electricity Storage Association, an electric utility, and the Electric Power Research Institute. The second panel will consist of representatives from the automobile and battery manufacturing industries, as well as a second electric utility witness who can speak to the potential for integrating the electricity and vehicles sectors.

WITNESSES

Panel One:

Ms. Patricia Hoffman, Deputy Director Research and Development, U.S. Department of Energy Office of Electricity Delivery and Energy Reliability. She will discuss the Department's programs to advance stationary electricity storage and how it relates to the electric grid. She will also provide information regarding the Department's activities on storage technologies for automobiles.

Mr. Brad Roberts, Chairman, Electricity Storage Association. He will discuss the state of stationary storage technologies and the various benefits of developing and commercializing storage technologies on a wider scale.

Mr. Larry Dickerman, Director Distribution Engineering Services for American Electric Power. He will speak to AEP's announcement to expand use of stationary electricity storage and the main benefits realized by storage investment.

Mr. Tom Key, Technical Leader, Renewable and Distributed Generations, Electric Power Research Institute. He will discuss the role that electric energy storage plays in the power delivery system today and in the future.

Panel Two:

Ms. Lynda Ziegler, Sr. Vice President for Customer Services, Southern California Edison. She will discuss the company's initiatives to advance electric vehicles in the marketplace.

Ms. Denise Gray, Director Hybrid Energy Storage Systems, General Motors. She will speak to the state of battery technology development for vehicles, as well as General Motors views as to how vehicle electrification fits into a portfolio of advanced vehicle technologies

Ms. Mary Ann Wright, Vice President and General Manager Hybrid Systems for Johnson Controls, Director of Advanced Power Solutions, a Johnson Controls and Saft joint venture. She will discuss the electrification of vehicles through advanced battery systems, and reducing their costs through advances in manufacturing technology, enhancing our domestic supply base, and establishing demonstration fleets.

BACKGROUND

Stationary Storage Technologies

Today, electricity is generated as it is used, with very little electricity being stored for later use. While this system has worked for decades, it is not very efficient. Demand for power varies greatly throughout the day and throughout the year as demands for lighting, heating and cooling fluctuate through the seasons. Because the capacity for generation of power matches the consumption of power, the electricity supply system must be sized to generate enough electricity to meet the maximum anticipated demand, or peak demand. This inefficiency becomes more evident when considering that it is possible that the peak electricity demand for any given year could be for a very short period—a few days or even hours. Rather than maintain massive generation systems that are designed around a short-lived peak demand, energy storage technologies would provide a means to stockpile energy for later use and essentially reduce the need to generate more power during times of peak electricity demand. Generally, energy storage systems could be charged at night during off-peak consumption hours and then discharge the energy during peak demand. Using our generation capacity at night time to store energy for use during the day is more efficient, cheaper, and helps to equalize the demand load.

The expanded use of energy storage would also help to avoid the need to upgrade transmission and distribution facilities as well as reduce the need to run certain generation plants that may have higher operating costs and/or have a poor emissions profile. Energy storage also can improve reliability by providing an alternate source of power during an outage of the primary power source.

Advances in energy storage technologies are often regarded as key to increasing the reliability and widespread use of many renewable energy technologies. Renewables such as wind and solar produce electricity only when wind speeds are high enough and sunlight is bright enough to generate power. Strategically distributed storage would permit electricity from these renewable sources to be stored and used during times of high demand or low resource availability.

Together, all of these potential benefits from broad deployment of energy storage technologies would help to improve our energy security. Because our economy relies heavily on an affordable and reliable electricity delivery system, the energy security benefits achieved from greater use of energy storage systems could be significant.

There are a number of promising energy storage technologies being developed, but they are not all at the same stage of development and certain storage systems are better suited for specific purposes. Described below are some of the more promising technologies:

Pumped Hydropower—water is pumped into a storage reservoir at high elevation during times when electricity is in low demand and relatively inexpensive. When demand is high, the water is released and used to power hydroelectric turbines. It is well-suited for applications requiring large power levels and long discharge times.

Compressed Air Energy Storage—this technology uses high efficiency compressors to force air into underground reservoirs, such as mined caverns. When demand for energy is high, the stored air is allowed to expand to atmospheric pressure through turbines connected to electric generators that provide power to the grid. In Alabama and Germany, compressed air energy storage has dispatched power to meet load demands and keep frequency and voltage stable.

Batteries—there are different types of battery systems for energy storage. With conventional batteries, chemical reactions within the battery generate electrons that travel from the negative terminal through a wire to an application, thus providing electric power, and then return to its positive terminal. A different battery system such as flow batteries store electrolytes outside the battery and circulate them through the battery cells as needed. Batteries have great potential for use in a range of energy storage applications.

Flywheels—these energy storage systems consist of a rotating cylinder on a metal shaft which stores rotational kinetic energy. Flywheels are suitable for stabilizing voltage and frequency.

Electrochemical Capacitors—electrochemical capacitors store energy in the form of two oppositely charged electrodes separated by an ionic solution. They are suitable for fast-response, short-duration applications such as backup power during brief outages.

Power Electronics—power conversion systems are not explicitly a storage device, but are a critical component of any electricity storage system as they serve as the communication device between the storage system and the electric grid.

Smaller energy storage systems may also be deployed in stationary applications, such as a residence or in a neighborhood, in order to supply back-up energy and level the load on the electric grid. Advances in smaller energy storage systems, specifically batteries, may also allow for entirely new vehicles such as plug-in hybrid vehicle technologies to enter the mass market.

Energy Storage Technologies for Vehicles

Concerns about energy independence and climate change have caused a renewed interest in enhancing the role of electricity in the transportation sector. The benefits of this have been seen to some degree in the rise in popularity of Hybrid Electric Vehicles (HEV) because of their high fuel efficiency and lower emissions. Switching vehicles' primary energy source from petroleum-based fuels to electric batteries reduces overall consumption of conventional liquid fuels. Additionally, several recent studies[1] have shown that, regardless of its source, electricity used as a vehicle fuel reduces greenhouse gas emissions. However, greater electrification of the vehicles sector is constrained by the technological limits of energy storage technologies used in conventional hybrids, specifically the Nickel Metal Hydride (NiMH) batteries.

Plug-In Hybrid Electric Vehicles (PHEV's) are seen by some as the next logical step towards greater electrification of the transportation sector, and the eventual move towards market acceptance of all-electric drive vehicles. PHEV's allow for electricity to be used as an additional or even primary source of power for a vehicle, with a secondary role for the gasoline engine as a back-up power system. Advocates claim that 100 miles per gallon would be reasonable for PHEV's, approximately twice the gasoline mileage of today's hybrids. However, current NiMH batteries for conventional hybrids are not optimal for this application.

While significant technological advances are still likely in NiMH, and even the ubiquitous Lead Acid batteries, many in the industry believe the future of PHEV's depends on breakthroughs in new battery technologies, such as the lithium ion (Li-Ion) batteries. To expand the use of electricity in the vehicles sector batteries must be smaller, lighter, more powerful, higher energy and cheaper—all of which require considerable research and development. Achieving these needed breakthroughs will require meaningful federal support and public-private partnerships with a range of stakeholders.

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[1] Pacific Northwest National Lab—*Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids, http://www.pnl.gov/energy/eed/etd/pdfs/phev_feasibility_analysis_combined.pdf*

Electric Power Research Institute and Natural Resources Defense Council—*Environmental Assessment of Plug-in Hybrid Vehicles, http://www.epri-reports.org*

Chairman LAMPSON. This hearing will now come to order, and I want to wish you a good morning, and welcome to our subcommittee's hearing on one of the oldest and most important energy technologies available, advanced batteries and other storage devices.

As long as people have been gathering energy or generating energy, we have had an interest in storing it, because so often the rate at which we produce energy doesn't match the rate at which we use it. Also, there are times when we need portable power. We would not be able to converse on cellular telephones, work remotely on laptop computers or shine a flashlight where we needed it without batteries.

As our distinguished panel of witnesses will discuss today, batteries are not only the technology for energy storage. There are others that are not as commonplace, but have the potential to help us achieve a better match between energy production and energy consumption.

Why is this important? Because renewable energy, like wind and solar, do not produce energy on a continuous basis. These sources will become more viable if we can store the excess energy produced during times of peak wind and sun and release it as needed.

Better energy storage technologies will also enable us to operate electric utilities in a more flexible and efficient manner. Energy storage can also help us respond to power outages more efficiently, providing greater electricity reliability. This could be vital for maintaining operations at critical facilities, such as hospitals, during a natural disaster.

We are all aware of the high costs and delicate negotiations involved when building new electric generating capacity or transmission lines, especially when plants must be built to meet the power requirements of peak demand. With better energy storage options, we can expand our options for new electricity generation and transmission.

Energy efficiency is the key to progress on three important goals: economic growth, energy independence, and a cleaner, healthier environment. New hybrid engines for vehicles have demonstrated how greater use of battery power can reduce fuel consumption and emissions.

We can gain further fuel efficiencies and emission reductions, but this requires advances in better technology and manufacturing far beyond what we see today, even in conventional hybrids. This would also allow for more advanced vehicles, such as Plug-in Hybrid Electric Vehicles to enter the market and finally bridge the gap between the electricity and transportation sector.

With both stationary and mobile energy storage, we cannot let an opportunity to establish a domestic manufacturing base for these technologies pass us by. And unfortunately, we may already be losing that race. New R&D activities with the Department of Energy are critical to advancing energy storage technologies, and we should pursue this aggressively to ensure U.S. participation in this field.

Chairman Gordon is working on legislation to support these programs at DOE, and the witnesses have been provided a copy of the discussion draft of that legislation. I look forward to their comments and suggestions to strengthen this bill and to accelerate our progress in energy storage technology.

[The prepared statement of Chairman Lampson follows:]

PREPARED STATEMENT OF CHAIRMAN NICK LAMPSON

Good afternoon and welcome to our subcommittee's hearing on one of the oldest and most important energy technologies available—advanced batteries and other storage devices. As long as people have been generating energy we have had an interest in storing it because so often, the rate at which we produce energy doesn't match the rate at which we use it. Also, there are times when we need portable power. We would not be able to converse on cellular telephones, work remotely on laptop computers, or shine a flashlight where we needed it without batteries.

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Chairman Gordon and Ranking Member Hall are working on legislation to support these programs at DOE, and the witnesses have been provided a copy of the discussion draft. I look forward to their comments and suggestions to strengthen this bill and accelerate our progress in energy storage technology.

Chairman LAMPSON. At this time, I would like to recognize our distinguished Ranking Member, Mr. Inglis, of South Carolina, for his opening statement.

Mr. INGLIS. Thank you Mr. Chairman, and thank you for holding this hearing on the status of technologies that can accelerate the arrival of clean, renewable energy.

General Electric manufactures wind turbines in South Carolina's Fourth District. Inside that facility, as soon as one of the nacelles is finished, it is put on a truck and shipped out. GE tells me that the production line isn't slowing down. In fact, they are trying to add production capacity to meet increased demand, which is a very good thing for Greenville, South Carolina.

These wind turbines and other technologies, such as solar panels and vehicle batteries, can speed the growth of our renewable energy sector, but the energy storage question is a significant hurdle that stands in the way. There is no doubt that we can cross that hurdle, and there is no question that it will just—that it will be worth it. Getting over the hurdle means not just clean exhaust from our cars, but consistent and stable energy supply to the grid, even when the sun isn't shining and the wind isn't blowing. That kind of reliability is what is necessary before these sources become commercially viable as alternatives to oil and gas, both at our power plants and in our cars and trucks.

I am looking forward to learning from these two expert panels about how the Federal Government can help clear that energy storage hurdle. In addition, I am also interested in fuel cells as batteries, and I shall return to that in question time.

Thank you, Mr. Chairman, for this hearing, and I look forward to hearing from our witnesses.

[The prepared statement of Mr. Inglis follows:]

PREPARED STATEMENT OF REPRESENTATIVE BOB INGLIS

Good morning. Thank you, Mr. Chairman, for holding this hearing on the status of technologies that can accelerate the arrival of clean, renewable energy.

General Electric manufactures wind turbines in South Carolina's Fourth District. Inside the facility, as soon as one of these nacelles is finished, it's put on a truck and shipped out. GE tells me that that production line isn't slowing down. In fact, they're trying to add production capacity to meet increased demand.

These wind turbines, and other technologies, such as solar panels and vehicle batteries, can speed the growth of our renewable energy sector. But the energy storage question is a significant hurdle that stands in the way. There's no doubt that we can cross that hurdle, and there's no question that it will be worth it. Getting over that hurdle means not just clean exhaust from our cars, but consistent and stable energy supply to the grid, even when the sun isn't shining and the wind isn't blowing. That kind of reliability is what is necessary before these sources become a commercially viable alternative to oil and gas, both at our power plants, and in our cars and trucks.

I'm looking forward to learning from these two expert panels how the Federal Government can help clear the energy storage hurdle.

In addition, I'm also interested in fuel cells as "batteries." I'll return to that in my questions.

Thank you again, Mr. Chairman and I look forward to hearing from our witnesses.

Chairman LAMPSON. Thank you, Mr. Inglis. And now, I am honored to recognize the author of this legislation, Chairman Bart Gordon, for his opening statement.

Mr. Gordon.

Chairman GORDON. Thank you, Chairman Lampson. I want to really congratulate you and Ranking Member Inglis. We have had almost a forced march the first part of this year. Our Ranking, as well as Majority, staff have done an excellent job. You have turned out good legislation, and I hope that this could maybe be one more element that we can put on the menu for an energy bill for the future. And so again, I thank you for your past work, and I thank you for holding this hearing, ensuring that the United States is competitive in energy storage technologies.

And I understand the witnesses have seen a discussion draft of the legislation I am working on to accelerate the Department of Energy's energy storage programs, and I look forward to your comments.

Many of us here agree that energy storage technologies offer significant economic, environmental, and security benefits.

A recent study from Lawrence Berkley National Laboratory determined that the short-term power interruptions cost the United States economy over $50 billion annually.

Strategic deployment of energy storage systems could increase reliability of the grid and reduce the impact of these outages. Energy storage systems can also enhance the use of renewable energy sources, diversify our energy mix, and lower emissions.

Broad deployment of energy storage technologies also can improve overall efficiency of the energy grid—or the electric grid. Storing low cost energy generated at nighttime for houses during high demand in the daytime makes sense.

Energy storage is also critical for the next generation of vehicles, which will help reduce our dependency on foreign oil and lower greenhouse gas emissions.

There is more work to be done to ensure batteries for electric cars are lighter, more powerful, and less costly.

I also think that public-private partnerships can improve the production process for advanced vehicle components so the U.S. becomes a leader in manufacturing these breakthrough technologies.

With so many benefits of energy storage technologies, I think additional federal investment to research, test, and advance these systems should be a priority, and I am very pleased that Ranking Member Hall has also been interested in these issues, and we look forward to working with him to accommodate his interests in getting a good bill together.

And again, I thank the witnesses for joining us today.

[The prepared statement of Chairman Gordon follows:]

PREPARED STATEMENT OF CHAIRMAN BART GORDON

Thank you Chairman Lampson. I am very pleased that the Energy and Environment Subcommittee is holding this hearing today to receive testimony on what I view to be a critical objective—ensuring the United States is competitive in energy storage technologies.

I understand the witnesses have seen a discussion draft of legislation I am working on to accelerate the Department of Energy's energy storage programs, and I look forward to your comments.

Many of us here agree that energy storage technologies offer significant economic, environmental and security benefits.

A recent study from Lawrence Berkeley National Laboratory determined that short term power interruptions cost the U.S. economy over 50 billion dollars annually.

Strategic deployment of energy storage systems could increase the reliability of the grid and reduce the impact of these outages. Energy storage systems also can enhance the use of renewable energy sources, diversifying our energy mix and lowering emissions.

Broad deployment of energy storage technologies also can improve overall efficiency of the electric grid. Storing low cost energy generated at nighttime for use during high demand in the daytime makes sense.

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I also think public-private partnerships can improve the production process for advanced vehicle components so that the U.S. becomes a leader in manufacturing these breakthrough technologies.

With so many benefits of energy storage technologies, I think additional federal investment to research, test and advance these systems should be a priority.

I thank the witnesses for testifying today and I look forward to your comments on the draft legislation.

Chairman LAMPSON. Thank you, Chairman Gordon. I acknowledge the presence of a number of other Members of the Committee, and I ask unanimous consent that all additional opening statements submitted by Subcommittee Members be included in the record. Without object, so ordered.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good morning. Mr. Chairman, thank you for calling this important hearing to examine the benefits and challenges of energy storage systems and to identify necessary research to overcome the challenges of commercialization and deployment of such systems.

The potential impacts of insufficient power storage range from simply inconvenience to life-threatening, and affect individuals, businesses, and industries. Today's electricity generation system has little ability to store electricity on the grid. Because of this, the electric power system must constantly be adjusted to ensure that the generation of power matches the consumption of power. I believe it is vital for the Congress, the Department of Energy, utilities and the private sector to work on a comprehensive solution to upgrade the electricity grid that will meet the electricity needs of today as well as the future to reduce our dependence on foreign resources and maintain our environment and economy.

When looking at potential options for energy storage, we must realize that no option will replace fuel generated electricity, which is primarily produced from coal. In fact, nine out of every ten tons of coal mined in the United States today is used to generate electricity, and about 56 percent of the electricity used in this country is coal-generated electricity. Therefore, I firmly believe it is imperative to continue our efforts to develop clean coal technologies as part of the solution to achieving U.S. energy dependence, continued economic prosperity and improved environmental stewardship. We must also continue to work on a diverse energy portfolio and recognize the technology that exists today so that we can utilize this technology while developing energy solutions for the future.

Again, I look forward to hearing from our witnesses on these issues.

Chairman LAMPSON. Now, it is my pleasure to introduce our first panel of witnesses we have here with us. First is Ms. Patricia Hoffman, who is the Deputy Director for Research and Development and the Acting Chief Operating Officer at the Office of Electricity Delivery and Energy Reliability at the U.S. Department of Energy—long title. Mr. Brad Roberts is the Chairman of the Electricity Storage Association. Mr. Larry Dickerman is the Director of Distribution Engineering Services at American Electric Power, and Mr. Thomas Key is the technical leader for the Renewables and Distributed Generation at the Electric Power Research Institute. Welcome each and every one of you.

Now, you will each have five minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When all four of you have completed your testimony, we will then begin questioning. Each Member will have five minutes to question the panel.

Ms. Hoffman, we will begin with you.

Panel I:

STATEMENT OF MS. PATRICIA A. HOFFMAN, DEPUTY DIRECTOR R&D, OFFICE OF ELECTRICITY DELIVERY AND ENERGY RELIABILITY, DEPARTMENT OF ENERGY

Ms. HOFFMAN. Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to testify on behalf of the Department of Energy on energy storage technologies.

The Department of Energy places great emphasis on the promise of energy storage and is researching a variety of storage technologies. Within DOE, applied research into energy storage technology primary occurs within two offices, the Office of Energy Efficiency and Renewable Energy (EERE), and the Office of Electricity Delivery and Energy Reliability (OE). The Department is committed to developing technologies that can help advance President Bush's Twenty in Ten Plan, a legislative proposal to displace 20 percent of expected gasoline usage in 2017 through the greater use of clean, renewable fuels and increased vehicle efficiency. The development and use of Plug-in Hybrid Electric Vehicles (PHEVs) will help us work toward the goal of this Plan. PHEVs present a unique opportunity for the Nation to transition from using exclusively oil, much of which comes from foreign sources, to fueling our vehicles, in part, with domestically produced electricity from the grid.

High energy density batteries are key to the successful commercial deployment and development of these vehicles. Thus, EERE is researching lithium ion batteries, which have two to three times the energy density compared to the nickel-metal hydride batteries currently in use for todays hybrid electric vehicles.

It is clear that Plug-in Hybrid Electric Vehicles will have impacts far beyond the transportation sector and become an integral, although not always connected, element of our "stationary" electric system. When considering the potential impact of widespread use of PHEVs on our nation's energy demand, it is essential to understand and address broader electric system impacts. For example, although ample generation capacity may exist on an aggregate scale to meet charging needs, how would PHEVs impact voltage-regulation requirements? Or, how would that generation capacity vary by region? Preparing answers today to questions such as these will allow PHEVs to successfully evolve from functioning solely as "people-movers" to becoming "stationary power" sources for residential customers to level the load and ultimately be a resource for the local utility.

Stationary storage systems provide energy management, complement renewable resources, and can improve power quality and reliability. This includes "ride-through" of power quality events such as voltage sags that range in length from cycles to seconds, often seen as the dimming or flickering of lights. Additionally, energy storage can be an uninterrupted power source, providing minutes to hours of electricity, and as such, can be viewed as "insurance coverage," mitigating risk.

Whether an energy storage device is paired with a renewable technology or simply installed alone at a residential, commercial, or industrial site, it can serve a number of valuable functions: acting as a balancing technology to solve intermittence issues, serving as an uninterruptible power supply, or leveling consumers' demand. Energy storage and photovoltaic (PV) hybrid systems, for example, would provide customers the flexibility to charge their storage device and charge their stored power in combination with the PV system to satisfy their peak demand requirement.

To date, large-scale utilitarian applications of energy storage in the electric system have not been extensive. Roughly 2.5 percent of the total electric power currently delivered in the United States passes through energy storage devices, and is primarily limited to pumped hydroelectric storage. The percentages are somewhat greater in Europe and Japan, at 10 and 15 percent respectively. The strategic placement of energy storage systems could provide load leveling within a regional control area, reduced transmission congestion, and provide ancillary services such as spinning reserve, voltage, and frequency regulation.

Energy storage is just one way to increase the reliability and resiliency of the electric grid. When storage devices are paired with so-called "intelligent" smart grid technologies, the grid could fully take advantage of renewable technologies, allow for an increased number of PHEVs, and enable demand response. Like storage, smart grid technologies could have a revolutionary impact on our electric system. Smart grid technologies include smart appliance chips, advanced meters, and energy management systems located at the customer's site. Intelligent agents and controls on the distribution system and wide-area system monitoring on the transmission system are also considered smart grid technologies.

The Department also recognizes that fundamental, basic research into the future of energy storage materials and systems is still required and can be a critical asset that accelerates our progress. One key opportunity the Department is pursuing is a new approach combining theory and synthesis of nanostructured materials, which have been identified as a key to enabling the design of radically improved electrode architecture for superior power and energy densities and increased lifetimes of energy storage systems.

Portable electronic devices, which are enabled by batteries, are a form of energy storage now ubiquitous throughout society. When considering how widely accepted these devices have become in a relatively short period of time, one can only imagine the potential for storing energy at a much larger scale. Energy storage has the capability to reshape the way we fuel our cars, power our homes, and impact our nation's economic future. Federal investment and research in the development and deployment of energy storage technologies in combination with innovative policies and infrastructure investment, has the potential to improve grid performance, reduce our dependence on oil, and promote our energy security, economic competitiveness, and environmental well-being.

I am privileged to contribute to these research efforts, and thank you for the opportunity to testify today. This concludes my statement, Mr. Chairman, and I look forward to answering any questions you and your colleagues may have.

[The prepared statement of Ms. Hoffman follows:]

PREPARED STATEMENT OF PATRICIA A. HOFFMAN

Mr. Chairman and Members of the Subcommittee thank you for this opportunity to testify on behalf of the Department of Energy (DOE) on *"Energy Storage Technologies: State of Development for Stationary and Vehicular Applications."*

The Department of Energy places great emphasis on the promise of energy storage and is researching a variety of storage technologies. Within DOE, applied research into energy storage technologies primarily occurs within two offices: the Office of Energy Efficiency and Renewable Energy (EERE) and the Office of Electricity Delivery and Energy Reliability (OE). EERE supports the Advanced Energy Initiative by advancing technologies such as biomass and biofuels, solar power, wind power, advanced vehicles, and hydrogen fuel cells. Moreover, OE performs research and development, and conducts demonstrations on stationary storage applications related to the electric system. OE leads national efforts to modernize the electricity delivery system; enhance the security and reliability of America's energy infrastructure; and facilitate recovery from disruptions to energy supply. Additionally, basic research supported by the Office of Science can lead to solutions to technology challenges and enhance the energy, power, shelf life, cycle life, cost, and reliability of energy storage systems. These functions can help DOE achieve its strategic goal of promoting a diverse supply and delivery of reliable, affordable, and environmentally responsible energy.

Vehicular Storage

The Department is committed to developing technologies that can help advance President Bush's Twenty in Ten Plan, a legislative proposal to displace twenty percent of expected gasoline usage in 2017 through greater use of clean, renewable fuels and increased vehicle efficiency. The development and use of Plug-in Hybrid Electric Vehicles (PHEVs) will help us work toward the goal of this Plan. PHEVs present a unique opportunity for the Nation to transition from using exclusively oil, much of which comes from foreign sources, to fueling our vehicles, in part, with domestically-produced electricity from the grid. High energy-density batteries are key to the successful commercial development and deployment of these vehicles. PHEVs have the potential to displace a large amount of gasoline if they deliver up to 40 miles of electric range without recharging—a distance that would include most daily round-trip commutes, since more than 70 percent of Americans drive less than 40 miles per day. That is why EERE is increasing its investment in this technology. Propulsion over a 40, or even a 20-mile range, will require storage technologies with high specific power and energy, deep discharge, and long cycle life. Thus, EERE is researching lithium ion batteries, which have two to three times the energy density (300–400 kWh/L) compared to the nickel-metal hydride batteries currently in use for today's hybrid electric vehicles.

The Department has also made progress on the issue of safety in lithium ion batteries for automobiles; however, other interrelated factors such as durability, power density, and cost must also be addressed before the technology can become commercially viable. Currently, the program is focusing on researching materials and nonflammable electrolytes so future lithium ion technologies will become more tolerant to abuse. The FY 2008 Congressional Budget includes $42 million to support advanced battery R&D, compared to $41 million in the FY07 operating plan.

Over the next three years, pending appropriations from Congress, DOE plans to invest $17.2 million in PHEV battery development projects that aim to address critical barriers to the commercialization of PHEVs, specifically battery cost and battery life. Five projects were recently selected for negotiation of awards under DOE's collaboration with the United States Advanced Battery Consortium. DOE will also spend nearly $2 million on a study exploring the future of PHEVs. The study will: evaluate how PHEVs would share the power grid with our nation's other energy needs; monitor the American public's evolving view of PHEVs; and provide the first national-level empirical data on how driving behavior differs with these vehicles compared to conventional gasoline, diesel, and hybrid vehicles. It will also assess a possible reduction of greenhouse gas emissions with the increased use of PHEVs and identify how automakers could optimize PHEV design to increase performance while also reducing cost. As part of the study, researchers and auto industry partners will build a simulation model to test different PHEV design concepts.

The possibility of increasingly providing fuel for the Nation's cars and light trucks with domestically-produced electricity and reducing the use of oil, much of which is imported, is very exciting. A previous study from DOE's Pacific Northwest National Laboratory suggests that up to 84 percent of U.S. cars, pickup trucks, and sport utility trucks could be powered by plugging into the existing electricity infrastructure and by utilizing this battery capacity to level loads.

It is clear that PHEVs will have impacts far beyond the transportation sector and become an integral, although not always connected, element of our "stationary" electric system.

When considering the potential impact of widespread use of PHEVs on our Nation's energy demand, it is essential to understand and address broader electric system impacts. For example, although ample generation capacity may exist on an aggregate scale to meet charging needs, how would PHEVs impact voltage regulation requirements? Or, how would that generation capacity vary by region? Preparing answers today to questions such as these will allow PHEVs to successfully evolve from functioning solely as "people movers" to becoming "stationary" power sources for residential consumers that can also support utilities.

Further studies will be conducted in partnership with the automotive manufacturers, national laboratories, utilities, and universities to define PHEV battery requirements; consumer behavior for charging vehicles and managing residential loads; grid interface and interconnection requirements; and the effects PHEVs would have on the grid. The Department is expecting preliminary results from these studies in the summer of 2008.

Finally, through Executive Order 13423 *Strengthening Federal Environmental and Energy Management,* the President has committed the Federal Government to add PHEVs to its own fleet as the vehicles become commercially available at a cost reasonably comparable, on the basis of life cycle cost, to non-PHEVs.

Stationary Storage

Stationary storage systems provide energy management, complement renewable resources, and can improve power quality and reliability. This includes "ride-through" of power quality events such as voltage sags that range in length from cycles to seconds to providing minutes to hours of electricity as an uninterruptible power source. A study by the Electric Power Research Institute found that 98 percent of power quality events last less than 15 seconds. Power quality problems are defined as subtle deviations in the quality of delivered electricity (sometimes lasting only tens of milliseconds in length), often seen as the dimming or flickering of lights. Short-term events lasting up to five minutes can cause hours of downtime in operations. A detailed survey of cost and outage data throughout the U.S. conducted by Lawrence Berkeley National Laboratory estimates the cost of such outages to be some $53 billion annually (LBNL 55718). Energy storage can be drawn upon to mitigate power quality problems and prevent momentary outages, and as such, can be viewed as "insurance coverage," mitigating risk. Stationary storage systems that are currently being used include conventional batteries (Ni-Cd, lead acid), compressed air, pumped hydro, flow batteries, sodium sulfur and metal-air batteries, fly wheels, and capacitors. These systems are critical bridging technologies whose applications including load balancing and improving overall system performance.

Stationary Storage—Residential, Commercial or Industrial Applications

Varying storage technologies can be used in residential, commercial, or industrial applications. Whether an energy storage device is paired with a renewable technology or simply installed alone at a customer's site, it can serve a number of valuable functions: acting as a balancing technology to solve intermittence issues, serving as an uninterruptible power supply (UPS), or leveling consumer's demand. Energy storage and photovoltaic (PV) hybrid systems, for example, would provide customers the flexibility to charge their storage device and discharge their stored power in combination with the PV system to satisfy their peak demand requirement. This system can begin to address power quality issues.

Many demonstrations are ongoing. The Department, in partnership with New York State Energy Research and Development Agency (NYSERDA), has funded a residential energy storage and propane fuel cell demonstration project that uses an 11kW, 20 kWh Gaia Power Technologies "PowerTower" energy storage system in conjunction with a Plug Power "GenSys" propane fuel cell. The demonstration illustrated demand reduction 1) when the "PowerTower" provides an energy boost if the user load exceeds a preset threshold and 2) when the PlugPower propane fuel cell becomes a primary electricity source in conjunction with the PowerTower. This system was in operation from January 2006 to July 2006. The partners include the Delaware County Electric Cooperative, Gaia Power Technologies and EnerNex Corporation.

Another project being funded by DOE and NYSERDA is the ongoing Flywheel-Based Frequency Regulation Demonstration project (FESS), located at an industrial site in Amsterdam, New York. It regulates grid frequency by utilizing a high-energy flywheel storage system consisting of seven Beacon Power flywheels that have been adapted to operate on the National Grid (formerly Niagara Mohawk) distribution system. This system will be capable of providing 100 kW of power for frequency regulation, about one-tenth the scale of the needed final product. Frequency regulation can serve to balance the ever-changing differences between electricity generation and load. Using flywheels to provide frequency regulation will allow demand to be met quickly and will allow generators to operate at higher output for optimum efficiency and lower emissions.

Stationary Storage—Utility Applications

As it exists today, the U.S. electric utility infrastructure consists of a vast network of power plants and transmission and distribution lines that span the entire continent. This system requires that the generation and consumption of electric energy be instantaneously balanced. As the load changes, generators must ramp up or down to meet demand for electricity. Yet an equipment failure can cause an instantaneous imbalance between generation and load, which could potentially lead to other system damage or a power outage. Using advanced storage technologies to compensate for changes in demand for electricity could improve grid reliability and stability.

To date, large-scale applications of energy storage to the electric system have not been extensive. Roughly 2.5 percent of the total electric power currently delivered in the United States passes through energy storage devices, and it is primarily limited to pumped hydroelectric storage. The percentages are somewhat greater in Europe and Japan, at 10 percent and 15 percent, respectively. The strategic placement of electricity storage systems could provide: 1) load leveling (within a regional control area), allowing generators to operate closer to their optimum economical and environmental set points; 2) reduce electric transmission congestion; 3) provide stabilizing energy to minimize disturbances on the transmission and distribution system; and 4) provide ancillary services such as spinning reserve, voltage, and frequency regulation.

The Department has also invested in several storage demonstrations for utility applications. For example, in partnership with the California Energy Commission and ZBB Energy Corporation (Menomonee Falls, Wisconsin), DOE is planning to demonstrate a 2MW, 2MWh zinc-bromine battery at a Pacific Gas & Electric substation that reduces distribution system congestion. The battery installation operates in stand-by mode to supply extra power when the substation reaches overload conditions. The installation will be mobile so that it can be deployed to wherever the most serious peaking loads occur.

In partnership with Palmdale Water District (Palmdale, California), the Department is demonstrating a 450 kW supercapacitor device that will minimize the impact of variable winds on a 950 MW wind turbine attached to the microgrid for the Palmdale, California, Water District's treatment plant. During power outages, this energy storage will also provide ride-through for critical loads until emergency generation can be brought online. In addition to providing reliable energy for the microgrid, the project will also help reduce transmission and distribution congestion in the area.

Energy storage is just one way to increase the reliability and resiliency of the electric grid. When storage devices are paired with so-called "intelligent" smart grid technologies, the grid could fully take advantage of renewable technologies, allow for increased numbers of PHEVs, and enable demand response. Like storage, smart grid technologies could have a revolutionary impact on our electric system. The result will be new innovative tools and techniques, better sensors, improved diagnostics, and enhanced equipment design and operation that will increase energy efficiency, system utilization, reliability, and security. Smart grid technologies such as smart appliance chips, advanced meters, and energy management systems would be located at the customer level. The distribution system would have to include smart grid technology through intelligent agents and controls and the transmission system would have to incorporate wide area system monitoring.

Collaboration with the Office of Science

The Department recognizes that fundamental, basic research into the future of energy storage materials and systems is still required and can be a critical asset that accelerates our progress. We still seek: a greater understanding of storage device performance degradation and failure mechanisms; the achievement of higher power density and longer life; enhanced energy density; new electrolytes for high-efficiency and high-current operation; and safety and abuse tolerance. Developing solutions to these technology challenges could enhance the energy, power, shelf life, cycle life, cost, and reliability of energy storage systems.

Thus, the OE and EERE continue to coordinate with the Office of Science in several research areas, including storage, to ensure the transfer of basic research to applied R&D. OE would like to expand this coordination in target materials research for electrical energy storage (EES). This R&D focus area was the subject of an Office of Basic Energy Sciences workshop held by EERE, OE, and the Office of Science during April 2–4, 2007, to explore research needs and opportunities. The findings, which noted that revolutionary breakthroughs in EES have been singled out as perhaps the most crucial need for the Nation's secure energy future, can be found in the workshop report, *Basic Research Energy Needs for Electrical Energy Storage.*

The proposed coordinated basic-applied EES research effort aims to underpin the applied technology research with transformational basic sciences, while at the same time energizing the basic research with insights and opportunities that come from advances in applied research programs. This process will be initiated in FY 2008 and result in designated research projects in FY 2009. The goal is to facilitate the successful translation of breakthrough knowledge gained in basic research to applied technologies, and to cultivate the U.S. capabilities to maintain a global leadership in energy storage systems for transportation and electricity transmission and distribution.

One key opportunity DOE's Office of Science is pursuing is a new approach combining theory and synthesis of nanostructured materials, which have been identified as key to enabling the design of radically improved electrode architectures for superior power and energy densities and increased lifetimes of energy storage systems.

An essential part of this integrated research activity is the development of methods of analysis that will help elucidate structure activity relationships that serve as the underpinning for predictive model development and validation. Basic research will provide proof of novel concepts, which will lead to module level applied research for successful approaches. Introduction of promising concepts to industry will enable advances in manufacturing, cost and commercial perspective to continued development of commercially viable EES technologies.

CONCLUSION

Portable electronic devices, which are enabled by batteries, a form of energy storage, are now ubiquitous throughout society. When considering how widely accepted these devices have become in a relatively short period of time, one can imagine the potential inherent in storing energy at a much larger scale. Energy storage has the capability to reshape the way we fuel our cars, power our homes, and impact our Nation's economic future. Federal investment in the research, development, and deployment of energy storage technologies in combination with innovative policies and infrastructure investment, has the potential to improve grid performance, reduce our dependence on oil, and promote our energy security, economic competitiveness, and environmental well-being. I am privileged to contribute to these research efforts and thank you for the opportunity to testify today.

This concludes my statement, Mr. Chairman. I look forward to answering any questions you and your colleagues may have.

BIOGRAPHY FOR PATRICIA A. HOFFMAN

Patricia Hoffman is the Deputy Director for R&D and the acting Chief Operating Officer for the Office of Electricity Delivery and Energy Reliability at the U.S. Department of Energy. The Office of Electricity Delivery and Energy Reliability leads the Department of Energy's (DOE) efforts to modernize the electric grid through the development and implementation of national policy pertaining to electric grid reliability and the management of research, development, and demonstration activities for "next generation" electric grid infrastructure technologies.

As Deputy Director for R&D, Patricia Hoffman responsible for developing and implementing a long-term research strategy for modernizing and improving the resiliency of the electric grid. Patricia directs research on visualization and controls, energy storage and power electronics, high temperature superconductivity and renewable/distributed systems integration.

As the acting Chief Operating Officer, Patricia Hoffman is responsible for the business management of the office including human resources, budget development, financial execution, and performance management.

Before joining the Office of Electricity Delivery and Energy Reliability, Patricia Hoffman was the Program Director for the Federal Energy Management Program which implements efficiency measures in the federal sector and the Program Manager for the Distributed Energy Program that developed advanced natural gas power generation and combined heat and power systems.

Before this, Patricia managed the Advanced Turbine System program resulting in Solar Turbine Incorporated's Mercury 50 industrial gas turbine product.

Patricia holds a Bachelor of Science and a Master of Science in Ceramic Science and Engineering from Penn State University.

Chairman LAMPSON. Thank you, Ms. Hoffman.

Mr. Roberts.

STATEMENT OF MR. BRADFORD P. ROBERTS, CHAIRMAN, ELECTRICITY STORAGE ASSOCIATION

Mr. ROBERTS. Good morning, Mr. Chairman and Members of this subcommittee. It is a privilege to be invited here today and be given the opportunity to offer views and perspectives of the Electricity Storage Association on the value of deploying energy storage in the electrical grid of the United States.

My name is Bradford Roberts, and I am the current Chairman of the Board of the Electricity Storage Association. The ESA was founded from the Utility Battery Group, a utility group focusing on the benefits of using large-scale storage in their systems. ESA memberships currently number approximately 100 member organizations, which includes most of the major utility companies in the U.S., leading manufacturers of energy storage systems around the world, technologies from academia, at engineering firms, plus potential investors in energy storage.

Over this period, ESA has worked very closely with DOE's Energy Storage Program, Sandia National Labs, and various state agencies, such as the California Energy Commission, the New State Energy research and development authority, and the Electric Power Research Institute that is here today. ESA members have contributed key advancement to electricity storage technology using the very limited funds that have been available from DOE in the past. These activities have helped build a strong foundation for meeting the needs of a growing electric grid that must now capitalize on the use of renewable sources and become more reliable, take advantage of smart-grid technology and be more resilient to threats of any kind.

This brochure that was in the package that was given to you shows examples of storage projects done around the world by ESA members. Studies and projects funded by DOE and state agencies have helped define the most significant use of energy storage. The most compelling are: help control power cost volatility, make more efficient use of fossil fuels like natural gas and oil to reduce dependency on foreign sources; benefit the performance of the transmission and distribution system, nationwide; enhance the use of renewable energy sources and make them more dispatchable; help improve the overall performance of combined heat and power systems; improve the grid's stability, reliability, and security.

Very large-scale systems like pumped hydro have been successful in providing bulk storage for the overall grid for some time. But only recently, in the last few years, have practical and affordable distributed energy systems begun to appear. Storage systems can capture low-cost energy at night and discharge it during peak daytime periods to help control price volatility. Storage systems can peak shave at the substation level and defer system upgrades. Small fast-acting dynamic energy storage systems such as flywheels can provide vital ancillary services to the grid such as spinning reserve and frequency control. Wind energy generation at night can be transported on lightly loaded transmission systems to load centers and discharged at peak times the next day.

Other great amounts of electrical storage in the grid can provide protective power to vital assets in the community, such as hospitals, airports, critical industries, such as data centers, communications facilities and so on. As the amount of storage grows and these resources become more widely distributed, the entire grid will become more secure and less vulnerable to manmade or natural disasters. Storage has been identified as a critical component for the future of smart grids and will play a vital role in demand side management programs and make them work more effectively.

The groundwork developed by ESA members working with DOE and Sandia has identified what we can realize with an expanded incentive program at this time. Many technologies have the proof-of-concept stage and are ready for commercial application and will provide real benefits to the grid.

Some of the recommendations we make are: expand the scope and size of government funding for storage programs that interact with the grid; provide incentives to national producers of storage systems and key sub-entities of those systems; provide funding to demonstrate the benefit of both large-scale and short-term balancing effect on wind power; provide funds to demonstrate the advanced storage to provide reliability enhancement for the grid; develop legislation to treat energy storage as a necessary component of renewable sources and provide federal financial support to incent end-users to develop and deploy storage systems; also ask FERC to require independent system operators to allow new energy-store technologies to compete in the commercial markets and take advantage of their faster response.

Thank you for this opportunity to be here, and I look forward to your questions.

[The prepared statement of Mr. Roberts follows:]

PREPARED STATEMENT OF BRADFORD P. ROBERTS

Good morning, Mr. Chairman and distinguished Members of the Subcommittee on Energy and Environment. It is a privilege to be invited here today and be given the opportunity to offer views and perspectives of the Electricity Storage Association (ESA) on the value of deploying energy storage in the electrical grid of the United States.

My name is Bradford Roberts, and I am the current Chairman of the Board of the Electricity Storage Association (ESA). The ESA is a trade organization founded 17 years ago to promote the value of electrical energy storage in our nation's grid and other electrical systems around the world. The ESA was founded from the Utility Battery Group (UBG), a utility group focusing on the benefits of using large-scale storage in their systems. ESA membership currently numbers approximately 100 member organizations encompassing most of the major utility companies in the U.S., leading manufacturers of energy storage systems around the world and leading technologists from academic and engineering firms with interest in designing storage applications.

Over the last 17 years the ESA has worked closely with the Department of Energy's Energy Storage Program, Sandia National Laboratories and various State agencies such as the California Energy Commission (CEC), the New York State Energy Research and Development Authority (NYSERDA) and the Electric Power Research Institute (EPRI).

ESA members have contributed key advancements to electricity storage technologies using the very limited funds in the DOE Energy Storage program. These activities have helped build a strong foundation for meeting the needs for the growing electricity grid that must now capitalize on the use of renewable energy sources, become more reliable, take advantage of smart grid technology and be resilient to threats of any kind. Storage of electricity is able to address these needs by reducing the need for fossil fuels, reducing cost of electricity and at the same time increase the reliability and robustness of the electric power system.

Primary Benefits of Storage in the Grid

Studies and projects funded by the DOE Energy Storage Program have helped define the most significant uses of electric energy storage. The most compelling of these uses are:

- Control power cost volatility
- Make more efficient use of fossil fuels like natural gas and oil to reduce dependency on foreign sources

- Benefit the transmission and distribution systems
- Enhance the use of renewable energy sources
- Improve the overall performance of combined heat and power systems
- Improve the grid's stability, reliability and security.

Very large-scale systems like pumped hydro plants have been successful in providing bulk storage for the overall grid's use but only in the last few years have practical and affordable distributed storage systems begun to appear. Other smaller electricity storage technologies, many of them marketed and deployed by our members, offer more flexibility in deployment on a distributed basis throughout the grid. These technologies offer a variety of benefits to the key items mentioned above.

Storage systems can capture low-cost energy at night and discharge it during peak daytime periods to control price volatility. Some storage systems can peak shave at the substation level and defer system upgrades. These large systems and smaller fast-acting dynamic energy systems such as flywheels can provide vital ancillary services to the grid such as spinning reserve and frequency regulation. Wind energy generated at night can be transported on a lightly loaded transmission system to load centers and discharged at peak times. Excess electricity from combined heat and power (CHP) systems can be used to charge local storage systems and further improve total grid efficiency. Further, greater amounts of stored electrical energy in the grid can provide protected power to vital assets in the community such as hospitals, airports and critical industries such as data centers and communications facilities. As the amount of storage grows and these resources become more widely distributed, the entire grid will become more secure and less vulnerable to man-made or natural disasters. Storage has been identified as a critical component in all projected and studied future power systems including smart grids and will also play a vital role in enabling demand-side management schemes without compromising end-users' interest.

ESA Recommendations for an Expanded Electricity Storage Program

The groundwork developed by ESA member companies working with the DOE and Sandia National Labs energy storage program has identified the value that can be realized with an expanded incentive program at this time. Many technologies have passed the "proof-of-concept" stage and are ready for commercial applications that will provide real benefit to the grid. At a time of growing concern for the environment, expanded storage applications can begin to pay dividends. The following recommendations are made:

1. Expand the scope and size of government funding of storage programs that will interact with the grid at all levels from residential to substation sizes.
2. Provide incentives for national producers of storage systems and key subcomponents.
3. Provide funding to demonstrate the benefits of both large-scale storage and short-term balancing of wind energy to improve overall system performance.
4. Provide funding to demonstrate the use of advanced storage to provide reliability enhancement of grid power to critical load customers (hospitals, data centers, critical process manufacturers).
5. Develop legislation to treat energy storage as a necessary component of renewable generation source and provide federal financial support to incent end-users and utilities to develop and deploy electricity storage systems. This should be a tax credit on a significant portion of total storage system investment to help deploy more installations nationwide.
6. Ask FERC to require Independent System Operators (ISOs) to update Market Rules to allow newer energy storage technologies to compete in commercial energy markets and take advantage of the faster response these systems can offer.

Summary

The Electricity Storage Association appreciates the efforts of the Energy Storage Programs at DOE and Sandia Labs. Our members remain committed to accelerating the application of storage at all levels to benefit the environment and improve our lives as we learn to use electricity more efficiently and responsibly in the 21st century.

BRADFORD P. ROBERTS

Brad Roberts is employed as the Power Quality Systems Director for the Power Quality Products Division of S&C Electric Company which specializes in low and medium voltage power protection systems.

Brad has over 35 years experience in the design and operation of critical power systems, ranging from single phase UPS systems to medium voltage applications. He began his engineering work as a systems reliability engineer in the Apollo Lunar Module Program at Cape Kennedy. He held senior management positions in two of the major UPS manufacturers during his career. Brad is a senior member of IEEE and has published over 40 technical papers and journal articles on critical power system design and energy storage technology.

Brad is a registered professional engineer and has a BSEE (Bachelor of Science in Electrical Engineering) degree from the University of Florida. He is Past-Chairman of the IEEE Power Engineering Society's Emerging Technologies Committee and Chairman of the Board of Directors for the Electricity Storage Association. He has been a member of the ESA Board for 10 years.

Brad is the 2004 recipient of the John Mungenast International Power Quality Award.

Chairman LAMPSON. Thank you, Mr. Roberts. Mr. Dickerman, you may proceed.

STATEMENT OF MR. LARRY DICKERMAN, DIRECTOR, DISTRIBUTION ENGINEERING SERVICES, AMERICAN ELECTRIC POWER

Mr. DICKERMAN. Good morning Mr. Chairman and distinguished Members of this subcommittee. Thank you for inviting me here today. And also, I thank you for the opportunity to provide the views of American Electric Power (AEP) on the significance of deploying energy storage to improve security, reliability and performance of America's electricity infrastructure.

My name is Larry Dickerman. I am the director of distribution engineering services for American Electric Power. American Electric Power is a 5,000,000-customer utility in 11 states. We are one of the largest generators in the country, having 38,000 megawatts of capacity. We are the largest transmission utility in the country with 39,000 miles of transmission line. We are the largest distribution company in the country with 207,000 miles of distribution.

But of particular importance for the Committee Members here today, AEP is leading the utility in U.S. deployment of large-scale energy storage. Of particular note is a success: AEP installed the first-ever megawatt-sized scale NAS battery, sodium sulfide battery, in the Western Hemisphere in 2006. Based on our experience, AEP believes that storage has an important role in the grid of the future in that it can defer capital projects by improving the utilization of existing assets. It can improve security and reliability. It can be deployed quickly, and it can work well with renewable resources such as wind.

As we believe storage should be incented through mechanisms such as a federal tax credit in the range of 30 percent, to accelerate widespread deployment. Over the last 100 years, AEP has been an industry leader in development, advancing and deploying new technology, and has always recognized the value of storage, as is evidenced by our Smith Mountain Pump-Hydro Facility. Over the last decade, AEP tested and evaluated the feasibility of new battery and super-capacitor technologies in our engineering laboratories. Based on those tests, AEP decided to move it from the laboratory and into further prototype testing with the sodium sulfide batteries for distributed energy storage system to support our grid.

The major actors in selecting the NAS technologies over alternative technologies were its safe and reliable commercial operation experience in Japan, compact footprint, about the size of a double-decker bus, high efficiency and zero emissions, and you can relocate it if you need to.

Based on successful laboratory and demonstration projections, AEP worked with NGK and with S&C Electric Company to deploy AEP's first commercial one-megawatt NAS battery in 2006 on a 12-kv distribution feeder in Charleston, West Virginia. This battery can provide enough energy for about 600 homes for seven hours.

As a next step, AEP also recently announced a new initiative to deploy more energy storage on its system, and this initiative includes six megawatts of additional NAS-based energy storage by the end of next year, at least 25 megawatts of NAS-battery capacity by the end of the decade, and adding another 10,000 megawatts of advanced storage technology in the decade after that.

The aim of these initiatives is to achieve many benefits, including reducing peak load on lines and equipment, providing backup energy to improve security and reliability, offering shorter deployment time versus traditional solutions, complimenting the modern grid concept, and enhancing the use of wind generation at peak demand.

Although this technology, in most cases, rests on the distribution side—that is physically where it is at on a distribution system—other benefits of energy storage extend to all parts of the electricity infrastructure, including helping to optimize generation.

The Department of Energy played a critical role in helping to deploy AEP's project in West Virginia, by covering the one-time engineering costs that were needed for this first-of-a-kind installation in the Western Hemisphere. The partnership of DOE and AEP to deploy the first ever megawatt sized battery facility in the United States was an ideal way of taking a new technology from research and development to real-world operation to accomplish something for a utility like AEP.

Given the benefits of storage, AEP supports the continuous development of storage technology and the adoption of incentives such as a 30 percent federal tax credit for deployment of distributed energy storage to accelerate the widespread use of storage to improve security, reliability, and performance of the United States' electric grid infrastructure.

Again, thank you for inviting me here today.

[The prepared statement of Mr. Dickerman follows:]

PREPARED STATEMENT OF LARRY DICKERMAN

Summary

American Electric Power is one of the largest electric utilities in the United States, delivering electricity to more than five million customers in 11 states. AEP ranks among the Nation's largest generators of electricity, owning more than 38,000 megawatts of generating capacity in the U.S. AEP also owns the Nation's largest electricity transmission system, a nearly 39,000-mile network that includes more 765 kilovolt extra-high voltage transmission lines than all other U.S. transmission systems combined. AEP's utility units operate as AEP Ohio, AEP Texas, Appalachian Power (Virginia, West Virginia), AEP Appalachian Power (Tennessee), Indiana Michigan Power, Kentucky Power, Public Service Company of

Oklahoma and Southwestern Electric Power Company (Arkansas, Louisiana and east Texas). Combined, these utility units operate and maintain over 207,000 miles of distribution lines in service territory covering approximately 197,500 square miles.

AEP is the leader among U.S. utilities for deployment of large-scale battery-based energy storage. Over the last 100 years, AEP has been an industry leader in developing, advancing and deploying new technologies and has always recognized the value of energy storage. In 1965, AEP's Smith Mountain, a 600MW pumped hydro energy storage facility in Virginia, came on line with the ability to provide peaking power within minutes and thereby better utilize the company's existing generation and transmission assets.

Over the last decade, AEP tested and evaluated the feasibility of new battery and supercapacitor technologies in its engineering laboratories. Based on those tests, AEP decided to use sodium sulfide (NAS) batteries for a distributed energy storage system to support its distribution grid. The major factors in selecting the NAS technology over the alternative storage technologies were its commercial operation experience, compact footprint, high efficiency, zero emissions and relocation ability.

Based on successful laboratory and demonstration projects, AEP worked with NGK Insulators and S&C Electric Company to deploy AEP's first commercial 1MW NAS battery in 2006 on a 12kV distribution feeder in Charleston, WV, and recently announced a new initiative to deploy more energy storage on its system including 6MW of additional NAS-based energy storage by the end of 2008; at least 25MW of NAS battery capacity in place by the end of this decade and adding another 1,000MW of advanced storage technology in the next decade.

Energy storage technologies, such as the NAS battery, offer many benefits to improve the reliability and performance of the distribution system. These benefits include reducing peak load, providing backup energy and offering shorter deployment. In addition, energy storage also complements the "modern grid" concept. Although this technology in most cases rests on the distribution side, other benefits of energy storage extend to all parts of the electric utility infrastructure, including helping to optimize generation.

The Department of Energy (DOE) played a critical role in helping deploy AEP's project in West Virginia by covering the non-repeat engineering costs that were needed for this first-of-a-kind installation in North America.

AEP supports the adoption of incentives for deployment of distributed stationary energy to improve security, reliability and performance of the United States electric grid infrastructure.

Good morning Mr. Chairman and distinguished Members of the House Committee on Science and Technology. Thank you for inviting me here today. Also, thank you for this opportunity to offer the views of American Electric Power (AEP) and for soliciting the views of our industry and others on the significance of deploying energy storage for improvement in security, reliability and performance of America's electricity infrastructure.

My name is Larry Dickerman, and I am the Director of Distribution Engineering Services of American Electric Power (AEP). Headquartered in Columbus, Ohio, we are one of the Nation's largest electricity generators—with over 38,000 megawatts of generating capacity—and serve more than five million retail consumers in 11 states in the Midwest and south central regions of our nation. In addition, AEP also owns the Nation's largest electricity transmission system, a nearly 39,000-mile network that includes more 765 kilovolt extra-high voltage transmission lines than all other U.S. transmission systems combined. We also operate and maintain over 207,000 miles of distribution lines in a service territory covering approximately 197,500 square miles. But of particular importance for the Committee Members here today, AEP is the leading utility in the U.S. for deployment of large-scale energy storage, which improves the security, reliability and performance of our distribution grid. Of particular note, AEP installed the first-ever, megawatt (MW)-scale NAS battery in the Western hemisphere in 2006.

Over the last 100 years, AEP has been an industry leader in developing, advancing and deploying new technologies and has always recognized the value of energy storage. In 1965, for example, AEP's Smith Mountain, a 600MW pumped hydro energy storage facility in Virginia, came on line with the ability to provide peaking power within minutes, thereby reducing peak demand and better utilizing the company's generation and transmission assets.

Grid Modernization and Energy Storage

In many respects, the distribution grid of 2007 is not much different than the grid of 1965. Consequently, many associated with the electric utility industry are talking about developing a "smart grid," "modern grid" or "the grid of the future." I first want to address what is meant by these terms and how energy storage fits into the concept of a "modern grid." One clear analogy is the progress that has been made with automobiles since 1965. In 1965, automobile builders compromised on components so cars could meet a variety of demands such as acceleration and steady state driving. In addition, the components could not communicate and had limited adaptability to meet different demands. An automobile built in 2007 is far different in that a communication system provides information to on-board computers and components have the ability to adapt how they operate based on input about varying conditions. Consequently, a modern car performs better, stops better, pollutes far less and gets better gas mileage. More recently, this dynamic optimization has been taken a step further with on board batteries in Hybrid Electric Vehicles. The on-board batteries provide further opportunities to size the engine for steady state conditions, while the battery provides power for acceleration and other peak demands.

The utility grid in the United States is an enormously complex system that like automobiles can benefit from a modern communication infrastructure, interconnected computers, devices that can dynamically change and store energy. To achieve dynamic optimization similar to what has been achieved in the automotive industry, the "modern grid" will require:

- Inexpensive communication systems that work over large areas;
- Computer protocols determining how each connects/communicates with various pieces of equipment;
- Equipment from suppliers that can receive communication and dynamically adapt; and
- Electricity storage devices to optimize use of assets and improve reliability.

A "modern grid" using this technology would improve reliability, improve the utilization of existing assets, move demand off peak, help customers reduce usage, and help with the integration of distributed resources.

AEP Efforts to Deploy Energy Storage

A key component of the "modern grid" and of particular interest today is energy storage. Over the last decade, AEP tested and evaluated the feasibility of new battery and supercapacitor technologies in its engineering laboratories. Based on those tests, AEP decided to use sodium sulfide (NAS) batteries for a distributed energy storage system to support its distribution grid. The major factors in selecting the NAS technology over the alternative storage technologies were:

- 15 years of commercial operational experience in Japan at sizes over 1MW (1MW produces enough energy to power 600 homes).
- The ability to have high energy and power density in a compact footprint the size of a double-decker bus.
- High efficiency through the charge/discharge cycle.
- No emissions, vibrations or noise concerns.
- Ability to economically relocate and recycle.

AEP first tested a small 12.5kW module (enough power to feed seven homes) in our laboratories and installed a 100kW demonstration unit (enough power to feed 60 homes) for peak shaving and backup power to one of our office buildings in 2002. As a next step, AEP worked with NGK Insulators (manufacturer of NAS batteries) and S&C Electric Company (manufacturer of the system to connect DC battery to an AC power grid) to deploy its first commercial 1MW, 7.2MWh[1] NAS battery in 2006 on a 12kV distribution feeder in Charleston, WV. This site was chosen to alleviate overloading of an existing distribution transformer. By installing the battery, AEP was able to reduce its daily peak load and, therefore, defer substantial capital investment on a new distribution substation. Department of Energy (DOE) played a critical role in this project by covering the non-repeat engineering costs that were needed for this first-of-a-kind deployment in North America and we deeply appreciate their assistance.

Following the successful operation of the NAS battery in West Virginia, AEP recently announced a new initiative to deploy more energy storage on its system including (see the attached press release):

[1] 7.2MWh can feed 1MW of electricity for 7.2 hours.

- An additional 6MW added of NAS-based energy storage by the end of 2008.
- At least 25MW of NAS battery capacity in place by the end of this decade.
- Adding another 1,000MW of advanced storage technology in the next decade.

AEP, NGK and S&C are now in the process of further developing NAS battery technology by implementing an "islanding" feature to improve distribution reliability. With "islanding," the battery can be deployed at the end of a long remote distribution line and provide power even when the normal feed is interrupted. AEP will demonstrate the "islanding" technology with four megawatts of the six megawatts planned for 2008. The islanding feature will also demonstrate the use of communication and control systems necessary for the deployment of a "modern grid."

The other two megawatts scheduled for 2008 will be deployed at a site near wind generation that will help AEP understand how electrical storage can enhance wind generation. NAS batteries can help by storing energy whenever the wind does blow and giving the energy back when needed most during times of peak demand. NAS batteries can be utilized with wind and all forms of generation today, but likely will become even more attractive as the price for NAS batteries decreases through greater volumes and the need increases due to a greater number of wind generators.

Electricity Storage Benefits

Energy storage technologies, such as the NAS battery, offer many benefits to improve the reliability and performance of the distribution system. Although this technology in most cases rests on the distribution side, other benefits of energy storage extend to all parts of the electric utility infrastructure, including helping to optimize generation. A list of benefits of energy storage includes but is not limited to the following:.

- Improving service reliability and power quality by being a backup energy source ("islanding") during outages.
- Reducing peak load (or lead leveling) and hence reducing the need for other local capacity upgrades in distribution.
- Complementing "smart grid" or "modern grid" benefits by taking advantage of the distribution grid's communication and control features.
- Much shorter deployment time than most conventional solutions to address many immediate grid problems.
- Enhancing the use of wind generation during periods of peak demand.

Most importantly, in a given application, many of these benefits can be achieved at the same time.

AEP Perspective on a Federal Energy Storage Research, Development and Deployment Program

In the past, the United States led the world in pure research on energy storage. For example, the concept of the NAS battery was pioneered in the United States in 1965 for electric vehicle applications. Others in the U.S. and Europe continued to advance the technology. However, in the mid 1980s, the Tokyo Electric Power Company and NGK, with support from the Japanese government, launched a development and demonstration program that successfully commercialized the technology for utility-scale applications. Because of this, AEP would suggest and strongly support a federal energy storage research, development and deployment program that would join technology experts with end-users of energy storage to actively develop, guide, and implement a government-supported storage program. To do this, federal funding needs to be balanced between research and "real world" applications to advance the technology. A few sample projects could include:

- Implementing large scale battery "islanding" capability to improve reliability in rural areas.
- Developing a "smart" or "modern grid" installation and integrate energy storage.
- Using energy storage to improve security to critical infrastructure that includes police, fire stations, water pumps and hospitals.
- Exploring greater benefits of the technology on the entire energy infrastructure, including distribution, transmission and generation.

Legislation to establish federal financial support is needed to encourage end-users to overcome their respective entry costs to deploy large-scale energy storage systems. For example, an investment tax credit in the range of 30 percent of the initial investment in an energy storage facility would help accelerate deployment across the industry. (Note that in Japan, the government has subsidized early end-users of energy storage for grid support and currently covers one third of the cost of energy storage facilities that support the deployment of wind power systems.)

AEP Perspective on Renewable Resources

AEP strongly supports the increased use of renewable energy sources and believes that further technological advances and commercial deployment of energy storage technologies will significantly increase the use of renewable energy sources. Today, we have 467MW of wind generation under purchased power agreements, but we intend and fully expect to increase our renewable portfolio into the future. That said, we oppose the federal Renewable Portfolio Standard (RPS) recently adopted by the House (and similar measures) as a costly and unnecessary government mandate.

The RPS adopted by the House, for example, will likely cost electricity consumers billions of dollars in higher electricity cost without the development of significant additional renewable generation or, more importantly, without any technological advances. Simply put, many retail electric suppliers will be unable to meet the RPS through their own generation and will purchase renewable energy credits. As a result, AEP anticipates a wealth transfer from electric consumers in states with little or no renewable resources to those states with abundant renewable resources (which would likely be developed without a federal mandate) and/or the Federal Government. In fact, we calculate that this proposal, if implemented, would cost our customers approximately between $6–$8 billion dollars (with some purchases of credits) in total cumulative costs by 2020.

Rather than focusing on an RPS, the Congress should promote technologies to the degree where economic and environmental benefits are optimized. For example, combining energy storage and wind generation will in the long run increase the availability of this resource and may meet the definition of economic and environmental optimization. Unfortunately, this combination would not help AEP meet the RPS mandate adopted by the House beyond the original addition of the wind generation. In short, mandates may be well intentioned, but are not always the most effective way to proceed from both an economic and environmental perspective.

Conclusion

In conclusion, energy storage is an important technology for the transformation of the existing electricity grid in the United States. A strong and cooperative partnership of industry and government can and will promote research and development and, ultimately, commercial deployment. AEP is committed to being a part of this important process, and helping you achieve the best outcome at the most reasonable cost as quickly as practicable. Thank you again for this opportunity to share these views with you.

AEP
AMERICAN ELECTRIC POWER

NEWS from AEP

MEDIA CONTACT:
Pat D. Hemlepp
Director, Corporate Media Relations
614/716-1620

ANALYSTS CONTACT:
Julie Sloat
Vice President, Investor Relations
& Strategic Initiatives
614/716-2885

FOR IMMEDIATE RELEASE

AEP TO DEPLOY ADDITIONAL LARGE-SCALE BATTERIES ON DISTRIBUTION GRID

Installations will boost reliability, integrate wind generation, prepare for future; new batteries a step toward AEP's goal of 1,000 megawatts of advanced storage

COLUMBUS, Ohio, Sept. 11, 2007 – American Electric Power (NYSE: AEP), as part of the company's comprehensive effort to integrate new technologies for reliability, renewable energy and energy efficiency to meet customers' future needs, is expanding its use of large-scale battery technology on its electricity grid.

AEP, the only U.S. utility currently using advanced energy storage technology as part of its electricity infrastructure, will be adding stationary sodium sulfur (NAS®) battery technology in its West Virginia and Ohio service territories next year.

The company will also work with wind developers to identify a third location within AEP's 11-state service territory for NAS battery deployment next year, using the storage capability to help offset the intermittent nature of wind generation.

AEP has placed an order for the three new NAS batteries with NGK Insulators Ltd. of Japan, the manufacturer and co-developer, along with the Tokyo Electric Power Co., of the technology. AEP anticipates delivery in spring 2008.

The six megawatts added to AEP's system during this deployment is a step toward the company's goal of having 1,000 megawatts of advanced storage capacity on its system in the next decade.

"We are extremely impressed with both the performance and the potential of this technology after using it in real-world applications and from experience we've gained through our long relationship with NGK," said Michael G. Morris, AEP's chairman, president and chief executive officer. "These new installations will move us a step closer to the full potential of advanced energy storage technologies in areas like reliability improvement, peak-load shaving and the use of stored energy from renewable sources like wind to supplement available generation resources.

"We're first movers on advanced storage among U.S. utilities, a position we've held on a wide number of technologies in our century of existence," Morris said. "Our near-term goal is to have at least 25 megawatts of NAS battery capacity in place by the end of this decade. But this is just a start. Our longer-term goal is to add another 1,000 megawatts of advanced storage technology to our system in the next decade. We will look at the full spectrum of technologies – flow batteries, pumped hydro, plug-in hybrid vehicles and various other technologies in early stages of development today – to determine their feasibility and potential for commercial application.

"In our view, advanced storage technologies, like NAS batteries, and other emerging technologies to increase customers' ability to benefit from energy efficiency will play equally important roles in delaying or avoiding costly future investments in new energy delivery or generation infrastructure," Morris said. "I believe other companies will begin deploying storage technologies in the coming years."

AEP plans to add two megawatts of NAS battery capacity near Milton, W.Va., to enhance reliability and allow for continued load growth in that area. AEP will also add two megawatts of NAS battery capacity near Findlay, Ohio, to enhance reliability, provide support for weak sub-transmission systems and avoid equipment overload.

A specific site for the third NAS battery, which is expected to be integrated with wind generation, will be announced in the coming weeks.

The combined cost for the three installations, including associated site preparation, equipment and control systems, will be approximately $27 million.

AEP has identified other potential sites for future deployment of advanced storage technologies.

In 2006, AEP installed the first megawatt-class NAS battery system to be used on a U.S. distribution system. That installation, on a substation near Charleston, W.Va., operated by AEP utility unit Appalachian Power, delayed the need for upgrades to the substation. A similar, but much smaller, NAS-based system installed in 2002 at an AEP office park in Gahanna, Ohio, was the first U.S. demonstration of the NAS technology.

The agreement to purchase additional NAS batteries was reached during an August visit to NGK in Japan by Holly Koeppel, AEP's chief financial officer.

“AEP and NGK have had a very close business relationship for more than five years,” Koeppel said. “Our meeting in August generated the agreement for our deployment of additional batteries, but it also provided an opportunity for us to arrange an upcoming meeting with NGK for other Ohio utilities and state officials. Advanced storage technologies like NAS batteries are important to our industry’s future. That’s why we continue to lead the public policy and technology integration efforts.”

The deployment of additional advanced storage capacity is part of a comprehensive AEP initiative focused on preparing the company’s 11-state distribution system to meet future needs of customers.

“We’re looking at where we need to be in the year 2020 and will be making changes to transition our system to the grid of the future,” Morris said. “We have teams of employees examining the current and likely future needs of customers as well as the variety of technologies under development that could meet those needs. We’re looking at ways to improve reliability and efficiency of our system as well as ways to reduce consumption, which delays or avoids the need for additional generation.

“Some elements, like additional large-scale storage systems to enhance reliability, advanced metering systems to provide customers with options for reducing energy use and further integration of renewable resources, are among the likely solutions customers will see in the near term,” Morris said. “We’re also testing distributed energy resources and ‘smart grid’ or ‘self-healing grid’ technologies designed to seamlessly separate sections of the distribution grid when problems develop elsewhere, with customers seeing no disruption in power supply or quality in situations where outages would be likely today. But implementation of these technologies is a bit further off.”

American Electric Power is one of the largest electric utilities in the United States, delivering electricity to more than 5 million customers in 11 states. AEP ranks among the nation’s largest generators of electricity, owning more than 38,000 megawatts of generating capacity in the U.S. AEP also owns the nation’s largest electricity transmission system, a nearly 39,000-mile network that includes more 765 kilovolt extra-high voltage transmission lines than all other U.S. transmission systems combined. AEP’s transmission system directly or indirectly serves about 10 percent of the electricity demand in the Eastern Interconnection, the interconnected transmission system that covers 38 eastern and central U.S. states and eastern Canada, and approximately 11 percent of the electricity demand in ERCOT, the transmission system that covers much of Texas. AEP’s utility units operate as AEP Ohio, AEP Texas, Appalachian Power (in Virginia and West Virginia), AEP Appalachian Power (in Tennessee), Indiana Michigan Power, Kentucky Power, Public Service

Company of Oklahoma, and Southwestern Electric Power Company (in Arkansas, Louisiana and east Texas). AEP's headquarters are in Columbus, Ohio.

This report made by AEP and its Registrant Subsidiaries contains forward-looking statements within the meaning of Section 21E of the Securities Exchange Act of 1934. Although AEP and each of its Registrant Subsidiaries believe that their expectations are based on reasonable assumptions, any such statements may be influenced by factors that could cause actual outcomes and results to be materially different from those projected. Among the factors that could cause actual results to differ materially from those in the forward-looking statements are: electric load and customer growth; weather conditions, including storms; available sources and costs of, and transportation for, fuels and the creditworthiness of fuel suppliers and transporters; availability of generating capacity and the performance of AEP's generating plants; AEP's ability to recover regulatory assets and stranded costs in connection with deregulation; AEP's ability to recover increases in fuel and other energy costs through regulated or competitive electric rates; AEP's ability to build or acquire generating capacity when needed at acceptable prices and terms and to recover those costs through applicable rate cases or competitive rates; new legislation, litigation and government regulation including requirements for reduced emissions of sulfur, nitrogen, mercury, carbon, soot or particulate matter and other substances; timing and resolution of pending and future rate cases, negotiations and other regulatory decisions (including rate or other recovery for new investments, transmission service and environmental compliance); resolution of litigation (including pending Clean Air Act enforcement actions and disputes arising from the bankruptcy of Enron Corp. and related matters); AEP's ability to constrain operation and maintenance costs; the economic climate and growth in AEP's service territory and changes in market demand and demographic patterns; inflationary and interest rate trends; AEP's ability to develop and execute a strategy based on a view regarding prices of electricity, natural gas and other energy-related commodities; changes in the creditworthiness of the counterparties with whom AEP has contractual arrangements, including participants in the energy trading market; actions of rating agencies, including changes in the ratings of debt; volatility and changes in markets for electricity, natural gas and other energy-related commodities; changes in utility regulation, including the potential for new legislation in Ohio and membership in and integration into regional transmission organizations; accounting pronouncements periodically issued by accounting standard-setting bodies; the performance of AEP's pension and other postretirement benefit plans; prices for power that AEP generates and sells at wholesale; changes in technology, particularly with respect to new, developing or alternative sources of generation; other risks and unforeseen events, including wars, the effects of terrorism (including increased security costs), embargoes and other catastrophic events.

BIOGRAPHY FOR LARRY DICKERMAN

Larry Dickerman is the Director of Distribution Engineering Services. Prior to his present position, Larry led various organizations for AEP including Distribution Dispatch & Emergency Restoration Planning, Distribution Asset Management and Operations Improvement. Larry is a 32-year employee with AEP.

Larry graduated from N.C. State University in 1974 with a BSEE and is a registered professional engineer in Virginia. Larry now resides in the Columbus, Ohio area.

Chairman LAMPSON. Thank you very much. Mr. Key.

STATEMENT OF MR. THOMAS S. KEY, TECHNICAL LEADER, RENEWABLES AND DISTRIBUTED GENERATION, ELECTRICAL POWER RESEARCH INSTITUTE

Mr. KEY. Thank you, and good morning, Mr. Chairman and distinguished Members. I am representing the Electric Power Research Institute. I shall focus on the role energy storage plays in the electric grid, both today and in the future.

As a starting point, I want to recognize that electric energy storage is both valuable and expensive. Consider your retail electric rates at home that are around $.10 per kilowatt hour, yet most of us will gladly pay dollars when we replace a battery in a flashlight or cars or a portable appliance. We think it is worth it, and it is much the same way in the electric power grid. We are generally willing to pay more to store kilowatt hours of electricity than it costs us to make them by conventional means. The key is to have the energy in the right place at the right time, and this is an investment that we are willing to make.

Today, our electric energy system delivers about 4,000 terawatt hours, and it runs with very little storage. I would like to explain this. We are getting by without much storage because of the ingenious system of interconnecting many generators and consumers, by forecasting demand, scheduling supply, and maintaining reserve generation as backup. If the electric load turns off in one place, another one turns on somewhere else. In effect, we are running a massive just-in-time delivery system, and as we have seen, it can be tricky to keep this system balanced.

We depend heavily on natural gas, to both regulate up and down and to cover peak period. Gas currently accounts for 47 percent of our supply capacity. Pump storage, our only significant method for electric storage, accounts for a little over two percent. In the future, we expect this situation to change. It will be increasingly difficult to operate this grid without additional energy storage. This change is our response to reducing carbon emissions, higher fossil fuel prices and to enable more diversified ways of generating and using electricity.

We need more energy storage to support the new mix of lower-emitting and less-controllable electric supply, including solar and wind, but also nuclear and clean coal. We shall need energy storage to enable a more effective participation by customers in managing their own use of electricity. One way storage can benefit the grid is to improve our use of the generators, the transformers, and the power lines. Currently, our utilization of these assets is below 50 percent. This is because of large variations in the electricity demand, day to night and seasonally, and because of our practice of just-in-time delivery.

To find large-scale storage options, EPRI is looking at new ideas in compressed air systems to supplement existing hydro. This will allow us to use existing transmission lines much more effectively. On a smaller scale, distributed storage, using batteries, pumped water, or compressed air can improve grid asset utilization closer to the point of use. This is at a substation or feeder level. EPRI is working on a future, smart distribution grid using distributed resources, including storage, to help manage electricity use. With more cost-effective storage technologies, we can increase efficiency and interact better with other new technologies such as rooftop photovoltaic and plug-in hybrid vehicles. These new storage technologies will be needed to enable future solar and wind, by giving our operators more options in balancing renewable supply and demand.

Cases are already documented where wind has challenged operators in New Mexico, California, and Hawaii. In all of these cases, storage is considered as part of the solution.

I would like to point out some challenges for electric storage, related to economics and risk. Costs are very high and siting and permitting can be difficult for large-scale storage. This is illustrated by the very modest amount of pumped hydro in the U.S. today. Energy storage by its nature, creates value streams for several different stakeholders. With the regulation, it is difficult to aggregate the value and secure financing. This was illustrated by a compressed air plant that was not built to support West Texas Wind in 2002.

Distributed energy storage will require significant investment for development and demonstration. The utility industry is usually in a position to make this investment. We believe that the DOE programs are on the right track to address the utilities interest, but there are many more opportunities in the future to partner on first-of-a-kind applications in different regions and under different grid-operating condition.

In the future, EPRI shall continue to work with its members and the Department of Energy to help realize the untapped benefit of new energy storage technologies in the electric grid.

We believe that the expanded use of energy storage is important to improving the efficiency, reliability, and security of the electric power network. Energy storage application in both the transmission and distribution grid will be essential to meet the growing demand for electricity using low emitting technologies and gaining the full value of end-use energy management. Thank you, sir.

[The prepared statement of Mr. Key follows:]

PREPARED STATEMENT OF THOMAS S. KEY

Thank you, Mr. Chairman and Members of the Subcommittee. I am Thomas Key, Technical Leader, Renewable and Hydropower Generation for the Electric Power Research Institute (EPRI), a non-profit, collaborative organization conducting electricity related R&D in the public interest. EPRI has been supported voluntarily by the electric industry since our founding in 1973. Our members, public and private, account for more than 90 percent of the kilowatt hours sold in the U.S., and we now serve more than 1,000 energy and governmental organizations in more that 40 countries.

We appreciate the opportunity to provide testimony on *"Energy Storage Technologies: State of Development for Stationary and Vehicular Applications."* My testimony today comes from the viewpoint of the electric power system and focuses on the role that electric energy storage plays in the power delivery system of today and in the future.

Today the power delivery system is a complex network of over 450,000 miles of transmission, five million miles of distribution, and 22,000 substations that tie together electricity supply and demand. At EPRI we partner with our members to ensure that this existing grid infrastructure is working reliably and safely, and that new technologies are available to meet future requirements. The power delivery system of the future, in a carbon constrained world, will be required to support both a new generation mix, with lower emissions, and a more effective participation by consumers in managing their efficient use of electricity. We believe that the ability to cost-effectively store electric energy will be an important part of this delivery system of the future.

Before I discuss the benefits of energy storage, I feel it would be worthwhile to explain how we operate the electric power system with only a small amount of electric energy storage today, and why this will change in the future.

The existing grid has operated for nearly a century as a massive just-in-time delivery system, providing electricity to meet demand practically as soon as it is generated and without storing in inventory. This is made possible by the size and diversity of the power grid, which allows system operators to ignore the small fluctuations associated with individual electrical load changes. When an electrical load turns on in one place, the effect is reduced by another turning off somewhere else. This characteristic allows system operators to follow load changes by throttling only a few generators. Large shifts in load occur daily over a period of hours and can generally be forecast, giving system operators the chance to schedule, dispatch and gradually ramp generation up and down according to the demand for electricity. Natural gas fueled turbines are the primary generation resources used to meet peak demands. Reserve generation, some actually spinning, is required to maintain reliability and to meet system contingencies.

This just-in-time electric delivery system requires that generation, transmission and distribution capacity are large enough to serve the maximum load that can occur at any point in time. The maximum load, for example on the hottest days in summer, can be significantly larger than the average load on the system, but may occur only once or twice a year. One consequence of the large variation in electricity demand and just-in-time delivery is that the power system assets are often under underutilized, such as at night and during temperate seasons. The overall utilization of electric generation in 2006, according to EIA data, was 48 percent. Utilization of the power delivery system in this traditional power system model is less than generation. Natural gas fueled turbines are the primary generation sources used to meet peak demands, and these plants remain idol most of the time. In effect natural gas also allows us to operate with only about two percent pumped hydro storage, a significantly lower supply than in Europe and Japan.

We believe that this traditional model will not work as well in the future as it has in the past. Our growing economy and rising standard of living continue to push the demand for electrical power upwards, but social, economic, and environmental reasons have made the construction of new generation, transmission, and distribution assets unattractive, particularly when those assets are underutilized. Even so new electric generation and related transmission resources will be needed. The changing nature of these resources will increase the need for energy storage on both the supply and demand sides. New electric energy storage technologies coupled with energy efficiency measures are keys to a better utilization of existing and future power system assets.

The large scale adoption of renewable energy technologies, with today's wind at the transmission level and future roof top solar at the distribution level, change the way utilities and grid operators will manage power delivery. Unlike conventional generation systems, which can be controlled by adjusting the fuel input, renewable energy technologies generate only when the wind is blowing or when the sun is shining. They cannot be controlled to meet demand and may provide insufficient energy to the grid when it is needed or too much energy to the grid when it is not needed. Specific cases are already documented where wind has challenged system operators in New Mexico, California and the Big Island of Hawaii. In all of these cases energy storage is being considered as a solution.

Another important factor related to the need for storage is the increasing cost of fossil fuels that has made their efficient use more vital than ever before. This is particularly true with the use of oil in the transportation industry. One important method of actualizing this improved efficiency is electrification with technologies such as the plug-in hybrid electric vehicle (PHEV). Energy storage technologies developed for PHEV applications, and made available via the smart electric distribution grid of the future, can provide grid support in the electric distribution system. In this application energy storage directly improves energy efficiency and reduces our dependence on foreign oil, with related advantages to security and society.

In the future cost effective energy storage will be needed to increase utility system asset utilization, support energy efficiency measures and allow the increased use of renewable energy sources, reducing the carbon intensity of the American economy. EPRI has identified several specific benefits to the expanded use of energy storage technologies in the electric grid, including the following:

- Enable integration of renewable energy such as wind and solar with the existing electric power delivery system;
- Improve reliability and security of the electric power delivery system by proving grid support both at transmission level and close to the point of use;
- Increase asset utilization of existing power delivery infrastructure, as well as potential deferment of the construction of new assets, by shaving peaks;
- Improve utilization of primary fuels and reduce domestic consumption of petroleum through the electrification of transportation; and
- Provide needed load following and regulation services to electricity markets.

A number of different energy storage technologies are being considered to bring these benefits to fruition. Each technology has advantages and disadvantages, which make it suitable for certain applications. For instance, sodium-sulfur batteries have made strong inroads in distribution level peak shaving applications, and lithium ion batteries are considered the energy storage technology of choice for plug-in hybrid electric vehicles. For utility-scale load leveling and storage of wind energy, pumped hydro has been the workhorse for the industry. However, suitable locations for new pumped hydro are considered to be limited, suggesting a promising opportunity for large-scale compressed air energy storage (CAES) that can be sited in many areas.

In a CAES system, electrical energy is used to compress air, which is then stored in a pressurized reservoir. The compressed air can later be used to generate electricity by passing it through an expansion turbine with heat input. The heat input is often delivered through the combustion of natural gas. Although natural gas is burned in these systems, the stored heat energy allows efficiencies that are more than double those of conventional gas turbines, with correspondingly low carbon intensity. CAES systems are usually designed on large scales, with power ratings in the hundreds of megawatts, and the capability to deliver that power for hours. Large underground caverns, salt domes or aquifers are used to store the compressed air. Two such systems have been built, one in Germany and the other in the U.S., with at least three others proposed in the U.S. to date.

The hurdles in bringing needed energy storage technologies on line are related primarily to economics and risk. Specific challenges are different for large scale central systems and for smaller, more distributed, energy storage technology options:

Hurdles to deployment of large-scale, transmission-connected energy storage:

Construction of proven large scale technologies, such as pumped hydro and CAES, would immediately assist operators in the integration of wind and nuclear energy. However, the costs of implementing these technologies can be unreasonably large. For example a 200MW compressed air energy storage plant capable of storing 800MWh of energy can be expected to cost $200 to $250 million, not including the cost of siting and permitting.

The very modest amount of pumped hydro built in the U.S. illustrates this issue. Today there are 38 pumped hydro plants with a summer peaking generating capacity of 21GW. Fifteen years ago FERC had license applications for 18GW of new pumped storage (42 plants total, with 31 in the west). However, deregulation, relatively cheap natural gas, and risk adverse private investors led nearly all developers to back out of construction. Only one large plant was build, the 800MW Rocky Mountain facility commissioned in 1995 in Northern Georgia.

Another hurdle is the aggregation of energy storage benefits, which are spread across a number of stakeholders. While there is little doubt that the net social benefits of these large storage plants are positive, the benefits are distributed among power produces, system operators, distribution companies, end-users, and society at large. The decision to build a plant, however, must be made by a single entity, and it is often unclear how that entity can capture enough benefit to justify the investment. A specific case in point is a CAES plant proposed to support wind development in West Texas in 2002. In a study commissioned by the Lower Colorado River Authority the sum total of all benefits for this large scale plant were clearly shown to exceed the cost. However, benefits were shared by wind plant operators, local power distributors, an independent system operator and rate payers. Not any single value stream, by itself, could secure financing.

Also impeding investment in large scale energy storage is that current situation where electric storage is not clearly defined as either a generation or a T&D asset in most jurisdictions. This presents a problem for deregulated utilities who would like to invest in storage. If a transmission utility invests in a system, and a ruling subsequently classifies that system as generation, the utility will have made a large investment it cannot recover.

Hurdles to deployment of smaller-scale, distributed electric energy storage:

Distributed energy storage holds great promise for improving utilization of distribution assets and enabling a future grid with PHEV, roof top solar and distributed power system communication and control ("smart grid"). The actualization of this potential requires significant investment to develop, demonstrate and deploy new technologies. The utility industry is generally not in a position to make this initial investment, although there is high interest for trying out promising grid-connected technologies. Department of Energy programs to develop, test, and demonstrate energy storage technologies are believed to be right on target regarding utility industry interests in the distributed systems. More opportunities to partner on first-of-a-kind applications in different regions, and under different grid operating conditions, will be welcomed.

In the future EPRI will continue to work with its members and the Department of Energy to help realize the untapped benefit of new energy storage technologies in the electric power industry. We believe that the expanded use of energy storage is important to improving the efficiency, reliability and security of the electric power delivery network. Energy storage applications in both the transmission and distribution grid will be essential to meet the growing demand for electricity, using low emitting generation technologies, and gaining the full value of end-use energy management.

BIOGRAPHY FOR THOMAS S. KEY

Mr. Key directs R&D in the Renewable Program at EPRI.

Experience

A nationally recognized leader in electric power system research, application of distributed generation and energy storage, and related testing, Mr. Key is credited as the father of the "CBEMA" curve for compatibility of electronic equipment. He has been a catalyst and major contributor IEEE standards for compatible interface of end-use equipment and distributed power systems.

Prior to joining EPRI he was a member of the technical staff at Sandia National Laboratory in Albuquerque where he pioneered some of the early work on grid integration of distributed solar electric systems. This included design and testing of photovoltaic power systems, development of grid-connected inverters for conditioning and control of distributed energy sources, and creation of power system design practices for grounding, and protection.

Since joining EPRI in 1990 he has developed criteria for a utility grid-compatible interface, characterized high-performance dc/ac inverters and electronic appliances, analyzed effects of power disturbances on sensitive electronic equipment, and developed design criteria and recommended practices for cost-effective application of power-enhancement equipment.

He is the author of more than 100 professional papers, reports, and technical articles.

Professional Affiliations and Activities

- Institute of Electrical and Electronics Engineers (IEEE)
- Proposed and chaired the first IEEE *Recommended Practice for Powering and Grounding of Sensitive Electronic Equipment*
- Initiated IEEE Standards Coordinating Committee for Power Quality
- Lecturer for Univ. of Wisc., EPRI, and IEEE Standards Board Seminars
- United States Navy, Civil Engineer Corps (Seabees), Retired

Achievements

- IEEE Fellow for Advancements in the field of Electric Power Quality
- John Mungenast International Power Quality Award distinguished power quality research.
- IEEE Outstanding Engineer Award, Region 3
- Originated and directed the EPRI Power System Compatibility Research Program

Education

- Master of Science in Electrical Power Engineering and Management, Rensselaer Polytechnic Institute, 1974
- Bachelor of Science in Electrical Engineering, University of New Mexico, 1970

DISCUSSION

Chairman LAMPSON. Thank you. I appreciate the testimony, and we will now enter into periods of questioning by Members. I shall recognize myself, as Chairman, for the first five minutes, and I would like to start with Mr. Roberts.

ENERGY STORAGE TO REDUCE ELECTRICITY CONGESTION

The Department of Energy has designated two national-interest electric-transmission corridors, the Mid-Atlantic Area and the Southwest Area. They include areas of growing population and growing electricity congestion. These designations have not been without controversy.

Do you think that advanced energy storage systems could help reduce some or much of the need to build more electric generation and transmission lines?

Mr. ROBERTS. Thank you, Mr. Chairman.

I think it is essential that storage be applied in the load centers in the larger cities in those regions. It will help relieve that congestion in the peak periods and will be very essential in making that happen and hopefully delaying those upgrades for a long period of time, hopefully.

Government Role in Energy Storage Deployment

Chairman LAMPSON. Mr. Key, in your testimony you state that another hurdle to energy storage deployment is the fact that the benefits are spread across a number of stakeholders, including power producers, system operators, distribution companies, end-users, and society at large. Is there a role for the Federal Government to help bring stakeholders together to encourage investment in energy storage systems so the investment burden doesn't lie with one entity?

Mr. KEY. I think we need help in these areas. I haven't prepared any recommendation related to how the Federal Government might help, but it is very difficult to build large plants, and there are clearly benefits, aggregate benefits to the public to do this, and we have seen that with our few existing plants that are still valuable today, and we are going to need more in the future.

Grid Modernization

Chairman LAMPSON. Mr. Dickerman, in your testimony, you discussed what is needed to modernize the grid, including electricity-storage devices and communication systems. In your opinion, do we need a new government body dedicated to facilitating or overseeing the modernization of the electric grid?

Mr. DICKERMAN. I think that, clearly, what is needed in this whole area is some clear thinking about how all of it fits together. If I might take a minute, I think the kind of transition we are talking about here is very much like what happened with vehicles, where a vehicle in 1985 and one today is very different, and there is a lot of communication protocol, and there is a lot of computer capability, and there is a lot of control of various devices that have optimized an automobile today.

Now, we are talking this afternoon about the importance of storage and further optimization. It is a very complex thing that we are talking about doing in an automobile. And electric utility grid is far more complex in many respects that there is so much of it, and it all operates together, and it operates in real time. So we can improve the operation of the electric utility grid substantially with communication and with control and with dynamic optimization and storage. But to do all of that, there are a lot of technologies that have to come together, and they have to come together in a way that is common across the entire nation, and so I do think that there needs to be some kind of group that comes together to really work through what does this look like and how do the technologies work together?

Ancillary Power Services

Chairman LAMPSON. Thank you. And for Mr. Roberts and Ms. Hoffman, several questions: as you know power generators provide a number of ancillary services to the grid to help it meet reliability and operating standards. You both mentioned spinning reserves and frequency regulations in your testimony. Ms. Hoffman also describes the Department's frequency demonstration project in New York. In the future, do either of you anticipate energy storage systems playing a large role in providing vital ancillary services to the grid?

Ms. HOFFMAN. Mr. Chairman, yes, I agree that storage systems will provide a large source for frequency voltage regulation and expanding reserves in the future.

Mr. ROBERTS. Mr. Chairman, I agree. One of the issues at stake here is, today, the response time for the generating systems to respond to frequency-regulation signals can be three or four minutes. Whereas fast-acting storage systems could respond in cycles, which would be more beneficial. It is stressful on many large plants to do this up-and-down regulation, and I think the power electronics that go with these types of systems adds R-control, which is reactive-power control as a side benefit of providing real power, so there is a real opportunity here, I think, to take care of these devices to do these functions.

STATE ENERGY STORAGE POLICIES

Chairman LAMPSON. I shall ask these last two things, and you can all just comment on them: outside of the Department of Energy's demonstration projects, are states or regions adopting policies to encourage the use of energy storage systems to provide ancillary services to the grid, and are there benefits to broad adoption of policies that encourage the use of them?

Ms. HOFFMAN. Both New York and the California Energy Commission have strong programs looking at energy storage demonstration projects as well as some of the demonstration projects that you have heard here from AEP and the Electric Power Research Institute. I believe those are very strong programs in looking at the strategy for appropriate placement of energy storage systems.

Mr. ROBERTS. I would agree with her comments. Those two states have taken a leadership role in this. I think other states are looking at how they might get involved, and I think the message is starting to spread around that there is real benefit here at the state level at the operation of the grids in those regions, and it is going to improve.

Chairman LAMPSON. Thank you very much. I shall now recognize Mr. Inglis for five minutes.

FUEL CELLS FOR ENERGY STORAGE

Mr. INGLIS. Thank you, Mr. Chairman. I am particularly interested in the storage of energy for transportation purposes, and in the discussion draft we have before us of the bill that we may be marking up soon, we talk about research on ultra-capacitor, flywheels, batteries and battery systems, including flow batteries, compressed air energy systems, power conditioning electronics, manufacturing technologies for energy storage systems and thermal management systems. I wonder if fuel cells are appropriately in that list. Ms. Hoffman, do you think so? Is a fuel cell appropriately in a list of batteries? Is it essentially a battery, you just put something in it and then it runs through and creates electricity. Should it be on the list?

ULTRACAPACITORS AND FUEL CELLS

Ms. HOFFMAN. A fuel cell is a type of exchange, so for storing energy, it does use hydrogen as part of the fuel cell component. I shall have to get back to you on that.

[The information follows:]

INFORMATION FOR THE RECORD

Fuel cells are not really an energy storage system. They can be considered generators that produce energy similar to solar energy, wind energy, and other distributed generation. Research on fuel cells is conducted by other DOE programs.

Mr. INGLIS. I just wonder if it might appropriately be in there. It is—of course, I have talked a lot about hydrogen and I am very excited about its potential applications to transportation. It is also true that batteries could be the competitor that wins the race to the car of the future. You know, if you have a really good battery, then perhaps you don't need hydrogen, either burning in an internal combustion engine like BMW wants to do it, or in a fuel cell, like General Motors wants to do it. And I was very interested in this story recently about Lynn Motor Company using an ultra-capacitor. I think they are based in Austin, Texas, and maybe manufacture in Canada—I saw the story, but they say that they have an ultracapacitors kind of concept that will enable a battery to be recharged in five minutes and to take a car 500 miles on a charge. Are you familiar with that or—I read the article and I thought, wow, this could be fabulous, and then I saw some questions about whether it would really work. Do you have any thoughts about that?

Ms. HOFFMAN. I don't have any comments on your specific example. I shall have to get back to you for the record on that specific example, but with respect to your comments on the types of vehicles and what horse is going to win the race, I think that versatility is an important aspect of having for our vehicle fleet as well as our stationary sources, and I believe that in that diversity, there are options for fuel cell cars as well as plug-in hybrid electric vehicles in providing the diversity that the country needs.

[The information follows:]

INFORMATION FOR THE RECORD

Zenn Motor Company, a Toronto-based producer of battery powered cars, has a technology agreement with EEstore, Inc. of Austin, TX and holds an exclusive license for EEstore batteries. The device, which is a type of supercapacitor, is not yet in production. EEstore claims that their batteries, when inserted in the Zenn motor Company's 25mph vehicle, would allow a range of 500 miles and would recharge in five minutes. Sandia National Laboratories, acting for DOE's Energy Storage Program, has requested a sample product and offered to test their device in order to verify these claims. The company has declined to provide a sample. The Department is not aware that any authoritative experts have verified the claims of the device.

Mr. INGLIS. And certainly, it really doesn't much matter who wins the race, does it? I mean as long as we can get away from what we have got now which is a terrible way to get around, in terms of the environmental benefits and national security risk that we are running, and the job creation opportunity by creating these new technologies. So do you think that—I don't know if anybody else wants to comment on whether they have seen that—or looked at the ultracapacitor technology involving that car. Mr. Roberts, have you seen that?

Mr. ROBERTS. Congressman, I have done some research, my company has done some research on that particular thing you read about in that article, and a lot of money has been invested in waiting to see when a prototype is finally delivered to see if these claims can be met, because they are pretty broad.

Mr. INGLIS. Yes.

Mr. ROBERTS. And so it is kind of stretching the boundaries right now, but until some demonstration is done to see, we won't really know.

I have a comment on the fuel-cell usage in stationary application. Fuel cells are—work very well, but they have no energy behind them. They have no punch. To make a stationary fuel cell really work effectively, you need to add some from of storage to it to give it the immediate energy it needs if there is a sudden load change or something, if you are applying it in an office building or something and the air conditioning turns on, a fuel cell can't deliver that surge of energy, and so storage actually enables fuel cells to work better.

Mr. KEYS. We have tested ultracapacitors and applied them, and I would just say that to drive a vehicle 500 miles, there must be some other fuel involved. There is just not energy, I think, today, although the research is very interesting in this area—and in fact, we have done a lot of it. Regarding fuel cells, I don't think they are really treated as a battery or as a storage system. The storage, of course is the hydrogen—or the natural gas or the fuel that goes into the hydrogen. So I think one problem with treating a fuel cell, because it uses hydrogen as energy storage, it is like we have used hydrogen in internal-combustion engines from a tank of hydrogen, so there is a bit of a problem, I think, if you go down that route.

Mr. DICKERMAN. I might offer a couple of comments as well. AEP has been involved with supercapacitors, and we have not seen results anything close to that, but what we have seen is that they have a real advantage in the fact that they can go through a lot of charge-discharge cycles, and we don't even know the limits yet. We have not been able to wear one out, so it is very positive in that regard.

In terms of fuel cells, I think fuel cells in storage, as Brad Roberts was alluding to, are a really great marriage, because we are also working with fuel-cell technology with Rolls Royce, one-megawatt-sized fuel cells for deployment on a utility grid. And the thing about the fuel cell is that it really likes to run flat out. In other words, you turn it on, and you run it at a megawatt, and it doesn't want to vary. If you put a storage device with it, then you can take up all of the variation and load with the storage device, so a two-megawatt unit—one megawatt, a fuel cell; a megawatt of storage—and then you have got something that can sort of follow the load and the efficiency of the fuel cell is very high. So I think it is an important technology related to this, and it is a technology that benefits from this.

Mr. INGLIS. Thank you.

Chairman LAMPSON. I would recognize Chairman Gordon at this time. He has stepped out, but in the interest of time, Mr. McNerney for five minutes.

RATING STORAGE TECHNOLOGY

Mr. MCNERNEY. Thank you, Mr. Chairman. I want to thank the panel for coming in today with your testimony. Storage is, I think, critical to global warning issues because storage is going to allow us to utilize wind energy, solar energy, and other forms of intermittent renewable energies on a large scale. Right now, we are not able to do that because of the intermittency problems. So I want to see what we can do in terms of the Federal Government encouraging this type of research.

Mr. Dickerman, you mentioned—well, I would like to know how you rate storage. Now, there are two ways to rate, by the installed capacity so to speak, how much power it can generate and how much energy it can store, and then how would you use that to—how would you use that, economically, to decide whether a storage technology is viable for a particular application?

Mr. DICKERMAN. That is a great question. I think one of the issues with a technology like storage is that it is a fairly complex set of economics, because you are talking about multiple benefits at the same time, so we can deploy a storage device to just shave a peak, so essentially what that gives you is about enough energy to serve 600 homes for seven hours, if it is a megawatt. We are probably going to tend to be deploying more in the two megawatt size, so about 12,000 homes for about seven hours. So that is the basic grading. You can use it for just peak shaving, and in that case, it might defer capital like a new station transformer or line upgrades or things of that nature.

But we are also working now to island the technology, that is to make it such that if you lose the feed to an area—imagine a remote rural area with relatively poor reliability, single-feed. You lose the feed because a tree comes across a line. Then, the battery can continue to feed that area. So that has a value as well. And then there is this value that is much harder for us to get our arms around that we were talking about. As it sits, there are regulation values for generation and that type of thing, so there are several things happening at the same time in terms of building up the value, so each of the projects we are looking at, we are sort of tailoring the economics and saying how much do we save in terms of differing capital because it reduces the load of peak. What is the value of the reliability that we are gaining? And basically, those are the two factors. We are not really yet to the point of trying to decide what is the value of some of those other aspects that might benefit generation.

Mr. MCNERNEY. Well, that is right. With wind energy, which I am familiar, you have, say, $1,500 a kilowatt installed, and then you have $.05 to $.06 per kilowatt hour produced. And I don't have a clear idea of how storage impacts those economics.

Mr. DICKERMAN. Specifically on wind generation?

Mr. MCNERNEY. Well, wind, but it would be, you know, certainly the analysis would be transferable, I am sure.

Mr. DICKERMAN. Well, in the case of wind, for example, wind can probably be best thought of as a negative load. So load is something that you can predict somewhat, and you can follow load with the generation that you have got. But the generation that we are used to dispatching, you know what it is. You know you can dispatch it. If it is 100 megawatts, you know it is available; you turn it on, and it meets the need. Wind generation, you don't know if it is going to be there, because you don't know when the wind is going to blow, so there is an uncertainty. So it is uncertain in the same way that load is uncertain, and you have to follow load, and you also have to follow wind generation because you don't know what is going to happen. What the battery does is it enables you to store it and then make it available on peak when it means the most to you. And obviously, the price—the real price of producing energy goes up as the demand goes up throughout the day.

FOREIGN ENERGY STORAGE

Mr. MCNERNEY. Ms. Hoffman, you had said something that peaked my interested, that we have—2.5 percent of our energy in this country goes through storage, and 10 to 15 percent goes in Europe. What are the technologies they use in Europe that allow that high a percent of their electric power to go through storage? How economic is that?

Ms. HOFFMAN. I believe I had mentioned Japan. Japan did the first sodium-sulfur battery, so they do have—it is the same suite of storage technologies that we are talking about here for the United States.

And I am sorry. I missed the other part of your question.

Mr. MCNERNEY. Well, what is the economics of that? How much do they pay, premium, for that storage capacity.

Ms. HOFFMAN. I shall have to get back to you on that for the record.

[The information follows:]

INFORMATION FOR THE RECORD

The primary storage technology in Japan, as in the U.S., is pumped hydro. However, as Japanese government mandates increasingly require more storage to offset intermittent wind generation, sodium-sulfur storage systems are being widely deployed there. Due to the success of this technology in Japan, U.S. companies such as American Electric Power and the NY Power Authority have chosen to install pioneering field tests in the U.S. The Department supports these tests through collaboration on facility design, monitoring, and economic analysis of the systems.

At approximately $1,500/kWh, the price of NAS batteries is about three times that of conventional lead acid batteries. However, because their lifetime is considerably longer, the cost per cycle is only a third of the cost for lead acid batteries. Maintenance costs are also considerably lower for NAS batteries.

Mr. MCNERNEY. Thank you. Thank you, Mr. Chairman.

Mr. KEY. Well, the storage in Japan and in Europe is pump storage, sir. There is very little battery storage, you know, that would add up to that percentage in the world.

Mr. MCNERNEY. Thank you, Mr. Chairman.

Chairman LAMPSON. Thank you, Mr. McNerney. Ms. Biggert, five minutes.

NAS BATTERY TECHNOLOGY

Ms. BIGGERT. Thank you, Mr. Chairman. Ms. Hoffman, what are the origins of the NAS battery technology? I thought that this technology was developed in the United States. And did the government play a role in that development?

Ms. HOFFMAN. I am going to defer to Mr. Dickerman for that.

Mr. DICKERMAN. The NAS battery technology was developed in 1965 and Ford Motor Company was involved, and it was a technology that was, of course, considered at that time as having possible application in vehicles. It was taken to a certain extent, and basically the technology, then, was picked up by the Japanese and a combination of NGK with support of Tokyo Electric, the Japanese government continued to develop it and brought it to the kind of maturity to where it could be used in the Japanese electric-grid infrastructure.

Ms. BIGGERT. Was it ever used by the government, do you know, or Department of Energy had any research on that?

Mr. DICKERMAN. That, I don't know.

PREVENTING OTHERS FROM CAPITALIZING ON U.S. INVENTIONS

Ms. BIGGERT. I guess I am just wondering because it seems like this is another example where technology was developed in the U.S., and then commercialized and deployed by foreign companies and governments. Just like we have developed the nuclear technologies, particularly the recycling, and then it has been commercialized by France, and now they are selling this back to the United States, so—and we are having to buy from overseas because we have failed to capitalize on the inventions and the technology here, so do you have—anybody have any ideas about how to prevent this? How we can make sure—Mr. Roberts?

Mr. ROBERTS. I would like to comment on that. That part is true, but taking that battery energy and delivering it into the grid requires very sophisticated power electronic equipment, and we are in a leadership position in that field in the United States, and we have been very fortunate that we have developed that marketplace. And we are one of the leaders, my company is one of the leaders in that arena. And our initial developments and all of our work are a very good example of DOE programs that go back about ten years ago, so——

Ms. BIGGERT. Mr. Dickerman.

Mr. DICKERMAN. Yes, I think there is really four stages to development of any technology. There is the basic research, and quite often that involves academic institutions, pure-research kind of programs in various places around the country. And then there is applied research, where you start thinking about what you can do with it. Then, I think where things tend to break down is there is a need for demonstration projects, and at that point, you have to take the technology from something that is applied research, like we did with this NAS battery, or like we are doing with the islanding aspect of the NAS battery, and actually do something that has to work and actually serve a useful purpose. And at that point, there needs to be a greater collaboration between industry and between the organizations that are doing the research and understand the technology to create the real handoff as to how can you use this technology in a real way to accomplish a real purpose. And then, once that happens, I think there has to be incentives for widespread use, and what happens is, quite often, the technology, initially, even if it works, is at a price point where it really isn't competitive yet, and it needs an incubation period through some type of incentive. So basic research, applied research, demonstration projects, incentives for widespread use: I think that is what is needed, and where things break down is in the demonstration project phase with industry, I think.

DEPLOYING TECHNOLOGY IN THE U.S.

Ms. BIGGERT. Well, why did AEP, then, need DOE's help when—deploying that technology here when it has been in use for 15 years in Japan.

Mr. DICKERMAN. Because it had not been employed on a U.S. infrastructure, and the U.S. infrastructure had some fundamental differences in the power electronics that Brad Roberts was talking about, and our vision from the start was to take it to a different level. So in Japan, the technology just sits there and peak shaves. And to even do that, we needed to develop the technology further to apply it on a U.S. system. The thing that hasn't been done anywhere in the world is to island this kind of technology so that it can improve reliability and function with no connection to the electrical grid. That we are doing for the first time in the United States anywhere in the world.

ALTERNATIVE ENERGIES

Ms. BIGGERT. And Ms. Hoffman, in your testimony, you talked about replacing imported oil to use domestically produced fuel electricity to fuel our cars. But if we continue to, in this country—a trend I am not encouraging—gas or coal or nuclear for energy and not allowing drilling for natural gas on the outer continental shelf or in ANWAR, don't we run the risk of being more dependent on foreign gas? It seems like so much of this is based on natural gas which is really a commodity that we will run out of, and I think we need to keep it for, you know, the things that are really—plastics and fertilizers and things.

Ms. HOFFMAN. Thank you, Congresswoman. The Department is looking at advancing all of the generation types that I think the United States is going to acquire in the future to meet that demand for electricity, and we will continue to look at clean coal concepts, advanced nuclear, and renewable technology to the maximum extent possible. Thank you.

Ms. BIGGERT. Thank you, Mr. Chairman.

Chairman LAMPSON. You are welcome. The Chair now recognizes Ms. Giffords for five minutes.

THERMAL STORAGE TECHNOLOGIES

Ms. GIFFORDS. Thank you, Mr. Chairman, and thank you to our panelists who have come in today to talk about energy storage technologies. I am exited, Mr. Chairman, about this topic, because when I think about the challenges that we face as a nation and that the world faces, I think a lot of the solution to our energy needs can be talked about here in this room and hopefully put into action in terms of policy.

This technology is important, not just because of global warming, but because of our dependency on foreign oil. As you know, figuring this piece of the puzzle out is going to be critical. I am also really concerned, and Congresswoman Biggert talked about it, is this competitiveness issue that we are facing. We put money into research and development here in the United States, and then we see that technology furthered in other places, and that has got to change, and hopefully this Congress can be part of making that a reality.

A couple of questions: I am from Arizona, and everybody here on this committee knows because I always talk about Arizona. I am very proud of my state, and one of the beauties that we have in this state, of course, is our abundant supply of sunshine. We have over 350 days of sunshine every year. So it is really solar energy that has the greatest potential for renewable energy in Arizona. I noticed, Ms. Hoffman in your written testimony, and even in the testimony provided by the other panelists that there was no mention of thermal storage technologies, and that is obviously going to be critical for the development of solar power. So I was hoping that you would talk about this form of technology, what the Department of Energy is doing, and in each of your individual, respective area, where you see thermal storage development coming from and whether or not these applications can be used in other areas beside the concentration of solar power, which we are seeing developed out in areas like Arizona.

Ms. HOFFMAN. Thank you, Congresswoman. Thermal storage is an opportunity but the Department does not currently have any research programs in the area of thermal storage that I am aware of. I shall check on that and get back to you for the record. But it does have potential for residential usage for thermal storage, and it can provide a balance with your photovoltaic system.

Ms. GIFFORDS. Ms. Hoffman, let me clarify, so you are not aware of DOE having any research or any development into this area?

Ms. HOFFMAN. At this time. I shall check for the record, yes.

[The information follows:]

INFORMATION FOR THE RECORD

The Department of Energy is investing in the use of thermal storage with solar technology applications through a number of projects. The storage of solar energy in this manner removes the intermittency of sunlight, enabling concentrating solar power (CSP) systems to provide energy to homes and businesses day or night.

In the mid-1990s, the Department retrofitted the 10-megawatt Solar One Power Tower in Barstow, California with molten salt storage to demonstrate the functionality of solar power. That project, "Solar Two," succeeded in proving the viability of molten salt storage, at one point producing power around the clock for 150 hours in one test.

The Department strongly supports development of technology that dramatically reduces the cost of CSP power and emphasizes the development of storage technologies. Toward that end, the Department recently announced that it had selected twelve projects for further negotiations to enable DOE to invest up to $5.2 million to energize the U.S. market for CSP systems with a major focus on thermal storage. Also, both Sandia National Laboratories and the National Renewable Energy Laboratory are working to develop more efficient and lower cost thermal energy storage technologies for parabolic trough and advanced higher-temperature CSP systems.

Even though solar technologies are largely load following, as peak power production coincides with peak air conditioning loads in the southwest, without thermal storage the capacity factor is only about 25 percent. However, with storage, CSP technology can reach capacity factors exceeding 65 percent, making this a highly attractive power option for utilities looking for reliable renewable power to meet their intermediate and even baseload power needs. The Department's goals in the area of CSP include reducing the cost of solar power to be regularly available at less than 10 cents per kilowatt-hour by 2015.

Mr. ROBERTS. A comment on solar energy and storage: typically, around the county, solar energy peaks two to three hours before the load peaks, and if you apply storage, you can extend—capture all of that energy and extend it into the evening and take advantage of that sunshine that was shining brightly in the afternoon when everybody was still at work, and so that is one of the areas storage can level out, solar energy, and extend that peak period to meet the peak period of the actual load itself.

Mr. KEY. Thermal storage is of great interest to a number of our Members in the west because of concentrated photovoltaic. In fact, we expect as much as five gigawats of that type of generation, and the thermal storage is a very natural part of a power tower, and it is also being looked at and tried out for the trough technology. It is limited, pretty much to the Southwest. It is great, and it will be a big help with solar, and in fact, with just balancing the Western system which has such long distances and issues with stability.

Ms. HOFFMAN. Congresswoman, I shall clarify that there is a thermal storage program with concentrating solar power in our Energy Efficiency Office. I shall have to get back to you with more details on that program.

Ms. GIFFORDS. Please because, you know, here, again, in Arizona, you have an area with large tracks of lands, terrific sunlight, and also the scientist at the University of Arizona and other research institutions as well. The University of Arizona just announced a specific program that is going to go for building a center for solar excellence, and I think if we use that technology and we use the resources we have, we are able not just to help the fastest growing in the Nation, but also export that energy as well.

RECYCLING BATTERY TECHNOLOGIES AND ENVIRONMENTAL ISSUES

Let me just switch to another topic really quickly, which is the environmental impact of the storage in general and batteries in particular. You know, as we try to develop more and more of this technology, and again, in a state like Arizona where we have a lot of hard rock mining and a lot of the environmental impacts, I was just hoping that the panel could address the ability to recycle this technology and also the increased demand for some of these precious and rare metals that are going to go into the storage capacity.

Mr. ROBERTS. I shall start the responses, Congresswoman. All of the technologies, the battery technologies that are being used today are based on 100 percent recycling taking place at end of life in those technologies. That is something that is very important. The sodium-sulfur battery is a medically sealed box, so there is no emissions associated with it, and at the end of its life, it is totally recycled.

Mr. DICKERMAN. And for the years of operation in Japan, there haven't been any environmental or safety issues. Most of what is in that big box the size of a double-decker bus is sand, and that is most of the weight, but there really aren't any environmental issues that we have seen, and as I said, at the end of life, we expect to recycle the components.

Chairman LAMPSON. I recognize Mr. Bartlett.

TWENTY IN TEN PLAN

Mr. BARTLETT. With 10 kids, 16 grandkids, and two great-grandkids, I ask what I think is a rational question to those who would like to drill in ANWAR and offshore. If you could pump ANWAR and the offshore tomorrow, what would you do the day after tomorrow? And there will be a day after tomorrow. Wantonly consuming the small additional reserves that we have is not a prescription of security for tomorrow.

Mr. Key mentioned the challenge we have in getting batteries for cars that will get us very far, and that, of course, is because of the incredible energy density in our fossil fuels. One gallon of gasoline, it is a little, still cheaper than water in the grocery store, carries my Prius car 50 miles. How long would it take me to pull my Prius car 50 miles? This is incredible energy density. And to provide that—even anything approaching that energy density in batteries is a horrendous challenge, and that is why this is such a difficult challenge.

You know, in our aspiration for the future, we really need to be rational, and Twenty in Ten is not rational. There isn't even a prayer unless we have a devastating worldwide depression with demand destruction that we can even come close to displacing 20 percent of our gasoline in ten years. That is not going to happen if all of our corn was used for ethanol and just countered for fossil fuel input, it would displace 2.4 percent of our gasoline. If all of our soybeans were converted to diesel fuel, they would displace 2.9 percent of our gasoline. Those aren't my numbers. Those are National Academy of Science numbers. And if we use all of our wastelands to plant a mixture of grasses and use the cellulosic ethanol, that might produce as much displacement of fossil fuels as all of our corn. So you add up these three things, and you are way short of even ten percent.

You know, I am all for doing something rational, but you know, this is an impossible dream, and I don't want to set us up for disappointment. We are going to be enormously disappointed if we think we can even come close to displacing 20 percent of our gasoline in ten years. We can certainly reduce by far more than 20 percent of consumption of gasoline in 10 years by conservation. I was in France at the last election—and by the way, it is interesting that the new French president is the son of a Hungarian immigrant. He is doing a pretty good job, isn't he? And I looked there for people riding in a pickup truck as personal transportation. I saw not one, and I looked for people riding in an SUV. The only SUV I saw in Paris was parked behind a church. I did not see one on the street. If we really want to reduce our consumption of gasoline, we need to approach it rationally, not with some impossible dream, and continue to drive these huge SUVs and pickup trucks, one person in them, for personal transportation and displace 20 percent of our gasoline in ten years. Am I wrong?

Mr. ROBERTS. I would like to, Congressman, make one comment. I think everybody agrees that conservation and changing our ways has to take place. Along that way to that process, we need to use the energy resources we have much more efficiently—we are adding a lot of wind into the system—and to try to utilize it more effectively as quickly as we can. These programs that are listed in this bill, I think, would go a long way to helping that, but the real problem is, I think, as you suggested, that things have to change and attitudes have to change.

Mr. BARTLETT. I am a huge fan of wind and solar. I have an off-grid home. All of my electricity is produced by wind and solar, and I have a big bank of batteries to supply. But you must be very frugal in the way you use electricity if you are providing for yourself. There is nothing that will make you a better convert to conservation than producing your own electricity with wind machines and solar panels and watching how quickly that disappears if you are at all proliferate.

Thank you all very much for your testimony and your helping to move us forward. Thank you, Mr. Chairman, I yield back.

Chairman LAMPSON. Thank you, Mr. Bartlett. The Chair now recognizes Mr. McCaul for five minutes.

SOLAR TECHNOLOGY AND ENERGY TRADING

Mr. MCCAUL. Thank you, Mr. Chairman. Roscoe, I want to congratulate you on ten children. I have five children, but you manage to double the amount that I have. That is an incredible accomplishment.

I want to pick on an issue that was discussed earlier, and that is solar. My home state of Texas also has a lot of sunshine. Applied Materials in my district is working on solar panels, making great progress with those, and the real issue is storage, as you know. They tell me that the power grid can be used to—or their theory where they are going with all of this is to store the solar energy from the panels into the power grid, and then be able to draw upon the power grid, in other words, sort of getting credits for that. Is that a realistic technology? Anybody can answer.

Mr. DICKERMAN. Well, I think that is. What we were saying to complement storage and wind is that you simply are taking it from something where you can't be sure when it is available, and you are storing it an making it available on peak, which clearly has a value. It sounds like that is exactly what they are talking about doing with the solar, and so it is the same value proportions. Simply making sure that it is available and dispatchable resource on peak when needed most.

Mr. MCCAUL. Mr. Key.

Mr. KEY. The point that we will use the electric grid to buy and sell and trade solar and wind energy is critical. As I described in my testimony, we are limited, I think, in doing that, especially as we take our regulation-type generation, natural gas, and we try to move toward more nuclear and clean coal, and we add wind, and then it is going to be more difficult to do this trading and keep this system in balance. So I think it is a correct statement, but it is a matter of how long we can continue to do that as these renewable resources come into play.

Mr. MCCAUL. And Ms. Hoffman, as I recall, in your testimony, you are not aware of any thermal storage research and development programs at the Department of Energy.

Ms. HOFFMAN. Congressman, I was actually thinking of ice storage and some of those technologies when we were talking about thermal storage. We do have a concentrating solar power program that is tied with thermal storage, but I shall have to get back, for the record, on details of that program.

HYBRID ELECTRIC DEVELOPMENT TIME

Mr. MCCAUL. One more, I have limited time. The hybrid plug-ins, you know, we have hybrid vehicles, we have batteries, why—just explain to me—I am not a scientist—why it takes so long to get a hybrid plug-in vehicle that could be available to the average consumer, if anybody knows the answer to that one.

Ms. HOFFMAN. The next panel may be able to address that with——

Mr. MCCAUL. Ms. Hoffman, you would probably be the best person to try to venture at that. I won't be around for the next panel.

Ms. HOFFMAN. From the Department's perspective, in developing a vehicle, there is a development cycle that the manufacturers have to put plans for future vehicles, and I understand that cycle is somewhere around eight years to ten years, and so they are looking now for technologies that they will introduce in the marketplace at a later time. For the record, I can find more on the cycle development for introducing new technologies into vehicle application.

Mr. MCCAUL. I know we sponsored legislations for tax credits for that. It just seems to me that should be more in the short-term than in the long-term.

THE PROPOSED LEGISLATION

And finally, Ms. Hoffman, have you had a chance to look at the proposed legislation here before us? There are two sections, section 6 and 7, that deal with demonstration projects at the Department of Energy. Can you comment on these two sections and also whether there is any duplication between these two programs?

Ms. HOFFMAN. From a technical perspective on the content of that, I think it is very synergistic to where the Department is heading, where the states are heading, and where other research programs are going for this type of demonstration project. So for an area of completeness, I think the bill does capture both of those aspects.

Mr. MCCAUL. So you see them as complementing and not duplicating. Is that fair?

Ms. HOFFMAN. Yes, sir.

Mr. MCCAUL. And then, finally, intellectual property is going to be a real issue if advanced technologies are discovered through these joint activities. Do you have anything in place to protect intellectual property?

Ms. HOFFMAN. The Department does, and I would have to get back to you for the record on that one.

[The information follows:]

INFORMATION FOR THE RECORD

Protecting intellectual property rights (IP) is a matter of high priority for DOE. The policy and procedures for protecting IP in DOE's Research, Development and Demonstration Program is well developed and in accord with applicable statutes and the practices followed by all government agencies. First, a private partner's preexisting IP is respected and under the terms of any award, the preexisting private partner's IP remains owned by the private partner. Next, while the government retains some rights to new inventions that are created through DOE awards, such as a government use license, the *Bayh-Dole Act* (35 U.S.C. 200 *et seq.*) permits small business and nonprofit organizations to retain ownership of their new inventions. Pursuant to a statutory procedure, other organizations can petition DOE to retain ownership of their new inventions and such petitions are usually granted subject to the government obtaining some rights. Finally, while technical data first produced under an award is normally required to be publicly disseminated, in appropriate circumstances DOE may grant up to five years of protection from public release of some data from a research award at the discretion of the DOE program office.

Mr. MCCAUL. Okay, that will be fine. Thank you, Mr. Chairman.

Chairman LAMPSON. Mr. Akin, I recognize you for five minutes.

STATUS OF BATTERY TECHNOLOGY

Mr. AKIN. Thank you, Mr. Chairman. Just—I didn't know of the different witnesses, do we have anybody that is on top of where we are in terms of battery technology and that developmental process? My background is in engineering. My sense is that maybe one of the shortest paths to solving some of the dependence on foreign oil is using the off-peak power from the—whether it is coal or nuclear generation, and being able to put that right into a car. It also has the added benefit of not paying any fuel tax, which I like. But anyway, what is the status of battery technology? I understand, basically, the answer to my friend's question is that it is too expensive. The batteries are too expensive. They don't last too long, and just, economically, it is cheaper to burn gas. But the question is where is that technology, because certainly, it has come a long way in ten years. I mean I remember when they came out with that first electric-powered, you know, screw gun or drill, and the thing was not much power. Now, they have got, you know, these big hammer-drills are running on batteries. Is that continuing to move or not?

Mr. ROBERTS. Congressman, unfortunately, in the afternoon session, there is a battery manufacturer that is here that could address that probably a little better, but there is a lot of activity and research and development of advanced batteries, particularly for vehicle application, going on in this country right now, and——

Mr. AKIN. But that is not your expertise, particularly.

Mr. ROBERTS. No.

Mr. AKIN. Well, that is all I had for questions. Thank you, Mr. Chairman.

Chairman LAMPSON. You are welcome. I think everyone has had an opportunity to ask questions, and we do have a second panel. We want to thank you very much for coming. I shall, in closing, ask are any of you aware of anything that has to do with wireless transmission of energy, and if so, I would like to talk with you. And again, I thank you all for coming. We will take a short break. We shall be in recess before our next panel comes up.

[Recess].

Chairman LAMPSON. Come back to order, and we will now hear from our second panel. That includes Ms. Lynda Ziegler who is the senior vice president for customer services at Southern California Edison; Ms. Denise Gray, who is the director for hybrid energy storage systems at General Motors; Mary Ann Wright is the vice president and general manager for Hybrid Systems Power Solutions at Johnson Controls. You will each have five minutes for your spoken testimony. Your written testimony will be included in the record for the hearing, and when all three of you have completed your testimony, we will begin with questions. Each Member will have five minutes to question the panel.

Ms. Zeigler, we will begin with you.

Panel II:

STATEMENT OF MS. LYNDA L. ZIEGLER, SENIOR VICE PRESIDENT, CUSTOMER SERVICE, SOUTHERN CALIFORNIA EDISON

Ms. ZEIGLER. At Southern California Edison, we are the largest purchaser of wind. We purchase over 2,700 megawatts, and we also purchase 90 percent of the solar generation in the country. My company has been committed to the electrification of transportation for 20 years. We operate the Nation's largest and most successful fleet of electric vehicles, a fleet that has traveled nearly 15 million miles on electric power. Our Electrical Vehicle Technical Center, unique in the utility industry is one of only several facilities recognized by the Department of Energy to evaluate all form of electrodrive technology. We have ongoing research collaborations with major automakers, battery suppliers and both the Federal and State governments. We believe that with continued engineering advances and appropriate public-policy support, the widespread use of advanced batteries in plug-in vehicles and in stationary storage will become one of the Nation's most effective strategies in the broader effort to address energy security, reduce greenhouse gas emission, and reduce air pollutant.

In fact, the Electric Power Research Institute, which we heard form earlier, and the Natural Resources Defense Council recently partnered to publish one of the most comprehensive studies to date on Plug-in Hybrid Electric Vehicles. One key finding was that widespread adoption of plug-in hybrids could reduce annual emissions of greenhouse gases by more than 450 million metric tons by 2050, or the equivalent of removing 82 million passenger cars form the road. That kind of reduction is obviously a long way off, but it provides all the more incentive for us to begin today.

Electricity is virtually petroleum free, is about 25 to 50 percent of the cost of a gasoline equivalent and is the only alternative transportation fuel today with a national infrastructure already in place. A recent study by the U.S. Department of Energy estimates that a little over 70 percent of the light-duty cars and trucks on the road today could be fueled by the excess off-peak capacity that exists in the electricity system, without building a single new power plant.

For utilities such as Southern California Edison, the challenge and the opportunity is to integrate electric transportation and their advanced batteries into a total energy system.

In the near-term, the advanced high-energy battery in a plug-in vehicle could serve as a source of temporary energy power for the home, or to occasionally help customers avoid high electricity costs during peak pricing time. We call this vehicle-to-home. These same advanced high-energy batteries could also be used in stationary applications. Home owners could fill a home energy battery at night using lower cost electricity and then draw from it during the high-cost part of the day to help lower the monthly utility bill.

In the mid-term, as plug-in vehicles increase in volume, using the grid's off-peak capacity at night to charge these vehicles may actually help lower customer's rates by increasing the utilization of our generating plants. In effect, utilities would spread their fixed costs over more kilowatt-hour sales.

We evaluate new business models on these and other applications. Edison recently launched a partnership with Ford Motor Company to demonstrate and evaluate purpose built plug-in hybrid Ford Escapes. Our goal is to explore the future customer values believed through plug-in vehicles and stationary energy storage.

At the same time as the emergence of plug-in vehicles and home energy storage is the advance of advanced utility meters. Over the next five years, Southern California Edison will install five million next-generation advanced meters called Edison SmartConnect in the home of every customer in our service territory. These meters will offer our customers better information and enhanced control over their electricity usage. Our Electric Vehicle Technical Center is working with industry stakeholders to integrate the vehicles and the home and the advanced meter.

Finally, in the long-term, we can imagine the potential of so-called vehicle-to-grid systems, or the ability to move stored energy from many plug-in vehicles back to the grid. The potential, however, for vehicle-to-grid is many years away and will depend on the development of all new control technologies as par of the smart grid of the future.

Is that anything I should worry about?

Now, let me conclude with our view on the important role the Federal Government can play to bring the promise of electric transportation closer to reality. In our opinion, large-scale domestic manufacturing capacity for high energy advanced batteries is crucial to the expansion of plug-in hybrid vehicle application and complementary stationary energy storage uses. There currently exists no such capacity on a significant scale in the United States today. The Federal Government should provide near-term incentives to help nurture U.S. production of this critical technology.

And earlier this year, H.R. 670, the *DRIVE Act,* included important measures to support research, development, and demonstration of advanced batteries in plug-in hybrids, battery EVs and stationary applications, as well as R&D for other aspects of electric drive technology. This language was then improved this summer by battery makers, automakers and other stakeholders and now passed the Senate as H.R. 6, and part of the *DRIVE Act* have passed the House as H.R. 3221.

We support this language and look forward to working with your committee to explore other effective national manufacturing and consumer incentives to set the stage for the breakthrough of plug-in vehicles and energy storage in the U.S. marketplace.

Mr. Chairman and Members of the Committee, we stand committed to partnering with all automakers, battery suppliers, stakeholders and government to help realize the vision I have laid out for you today. Thank you very much.

[The prepared statement of Ms. Ziegler follows:]

PREPARED STATEMENT OF LYNDA L. ZIEGLER

Thank you Mr. Chairman (Lampson) and Ranking Member Inglis.

My name is Lynda Ziegler and I am Senior Vice President of Customer Service at Southern California Edison. Thank you for the opportunity to lend our support today to your important efforts to promote advanced battery technology.

My company has been committed to the electrification of transportation for twenty years. We operate the Nation's largest and most successful fleet of electric vehicles, a fleet that has traveled nearly 15 million miles on electric power. Our Electric Vehicle Technical Center, unique in the utility industry, is one of only several facilities recognized by the Department of Energy to evaluate all forms of electro-drive technology. We have ongoing research collaborations with major auto makers, battery suppliers, and both the Federal and State governments.

We believe that with continued engineering advances and appropriate public policy support, the widespread use of advanced batteries in plug-in vehicles and in stationary storage applications will become one of the Nation's most effective strategies in the broader effort to address energy security, reduce greenhouse gas emissions and reduce air pollutants.

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For utilities such as Southern California Edison, the challenge and the opportunity is to integrate electric transportation and their advanced batteries into a total energy system.

Near-term

In the near-term, the advanced high-energy battery in a plug-in vehicle could serve as a source of temporary emergency power for the home, or to occasionally help customers avoid high electricity costs during peak pricing times. We call this "vehicle-to-home."

These same advanced high-energy batteries could also be used in stationary applications. Home owners could fill a home energy battery at night using low-cost electricity and then draw from it during the high-cost part of the day to help lower their monthly utility bill.

Mid-term

In the mid-term as plug-in vehicles increase in volume, using the grid's off-peak capacity at night to charge these vehicles may actually help lower customer rates by increasing the utilization of our generating plants—in effect utilities would spread their fixed costs over more kilowatt hour sales.

To evaluate new business models on these and other applications, Edison recently launched a partnership with Ford Motor Company to demonstrate and evaluate "purpose built" plug-in-hybrid Ford Escapes. Our goal is to explore the future customer values delivered through plug-in vehicles and stationary energy storage.

At the same time as the emergence of plug-in vehicles and home energy storage is the advent of advanced utility meters. Over the next five years SCE will install five million "next generation" advanced meters called Edison SmartConnect in the home of every customer in our service territory. These meters will offer our customers better information and enhanced control over their electricity usage. Our Electric Vehicle Technical Center is working with industry stakeholders to integrate the vehicle and the home and the advanced meter.

Long-term

Finally, in the long-term we can imagine the potential of so-called "vehicle-to-grid" systems or the ability to move stored energy from many plug-in vehicles back up to the grid. The potential however of vehicle-to-grid is many years away and will depend on the development of all-new control technologies as part of the "smart grid" of the future.

The Role of the Federal Government

Now let me conclude with our view on the important role the Federal Government can play to bring the promise of electric transportation closer to reality.

In our opinion, large-scale domestic manufacturing capacity for high-energy advanced batteries is critical to the expansion of plug-in hybrid vehicle applications and complementary stationary energy storage uses. There currently exists no such capacity on a significant scale in the United States today. The Federal Government should provide near-term incentives to help nurture U.S. production of this critical technology.

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Thank You.

BIOGRAPHY FOR LYNDA L. ZIEGLER

Lynda Ziegler is Senior Vice President of the Customer Service business unit of Southern California Edison (SCE), one of the Nation's largest investor-owned electric utilities. She is responsible for customer services to SCE's 4.7 million customers, including customer experience, industry-leading demand-side management programs and advanced metering, as well as customer-facing operations, phone center activities, field services, account management, and local public affairs. She was elected to the position on March 1, 2006.

Ziegler began her career at SCE in 1981 as a conservation-planning consultant. She held a variety of positions including service planner and manager of energy efficiency, customer service and major accounts. She was most recently the Director of the Customer Programs and Services Division until she was elected as Vice President of Customer Service on May 1, 2005.

Ziegler is a member of the EEI Customer and Energy Services Executives Advisory Committee, and is a member of the Marketing Executives Conference. Ziegler also serves on the board of directors of Leadership California, an organization dedicated to educating high-level women on the issues in California and encouraging women's leadership in policy and public office. She also serves as Secretary on the board of Partners in Care Foundation, an organization dedicated to improving health care policy through demonstrating success.

She received her M.B.A. at California State University, Fullerton, and her Bachelor of Science degree in marketing from California State University, Long Beach. In addition, she has participated in two special management development programs at Southern California Edison.

Chairman LAMPSON. You are welcome and thank you. For those of you who don't know, those were our equivalent in the Science Committee for bells for votes, so we will have votes in just a few minutes. We shall proceed on until we have to leave, and we will be watching the number of people for those votes.

So at this time, we will call on Ms. Gray for five minutes.

STATEMENT OF MS. DENISE GRAY, DIRECTOR, HYBRID ENERGY STORAGE SYSTEMS, GENERAL MOTORS CORPORATION

Ms. GRAY. Mr. Chairman and Members of the Committee, thank you for the opportunity to testify today on behalf of General Motors. I am Denise Gray, director of the Hybrid Energy Storage Systems Department. I direct the development and the production of energy storage systems for GM, with a focus on developing and qualifying new battery-technology solutions.

For 100 years, the global automotive industry has run almost exclusively on oil. Tomorrow's industry will not. The solution: alternative sources of energy, along with new technology to allow automobiles to run on tomorrow's fuels. But what fuels? And what technology?

At GM, we believe that no one solution is right for part of the world, or even every consumer in any given market, so our approach is simple: offer as many choices to as many consumers as possible everywhere we do business, while offering the best possible fuel economy for whatever type of vehicles our customers choose.

Our vision moving forward is to reduce petroleum dependency and greenhouse gas emissions by displacing oil with biofuels and electricity as well as enhancing vehicle efficiencies. And we have developed a comprehensive advance-prolusion strategy to meet these challenges. We are continuing to make incremental improvements in the efficiency of conventional vehicles. We are continuing to expand the portfolio of flex-fuel vehicles, ramping up to 50 percent by 2012, provided the fuel infrastructure and supplies are available.

We are continuing to expand the portfolio of hybrids we offer with five hybrid offers available this year, and more coming next year.

Most relevant to this hearing, we have started a plug-in program for our Saturn VUE Greenline two-mode hybrid, followed by the introduction of our Chevrolet Volt concept vehicle.

And finally, we are continuing to develop hydrogen-powered fuel-cell vehicles and the infrastructure needed to support such vehicles with the largest market test of fuel-cell vehicles today, beginning later this month.

As I mentioned earlier, this year brought the announcement of a game-changing Chevy Volt, our first demonstration of an innovative new GM propulsion system called E–Flex. The "E" stands for electric because all of the E–Flex vehicles will run on electricity. The "Flex" in E–Flex is flexible because the electricity can come from many different sources. GM E–Flex system is simpler than hybrids, because it is purely electrically driven. Electricity is stored in the battery pack, and used with electric motors to drive the car, with the electricity from the battery obtained in two different ways. First, you can plug in your vehicle in your common electrical outlet to recharge the battery. This allows the vehicle to operate as a battery-electric vehicle. Second, once the battery charge from the electric utility grid is depleted, the battery can also be recharged by a simple engine generator set or fuel cells. This allows you to extend your vehicle's electric driving range to several hundred miles.

Let me turn to our battery technologies. There are really two types of batteries that we require. The one most people are familiar with is charge depletion. Think of this as a flashlight that depletes its energy when used. And then you can either dispose of it, or you can recharge it. It is the rechargeable version of this battery that we are most interested in for plug-in hybrids. This is a new area of focus for the U.S. Advanced Battery Consortia (USABC).

The other type of battery is known as charge sustaining. These batteries are designed to accept and deliver power while maintaining a constant state of charge. They never deplete. Charge sustaining batteries are used in hybrids on the roads today, such as our Saturn Aura hybrid. They store up energy captured during breaking and reapply it to help the vehicle accelerate. Charge sustaining batteries have progressed to the point where many OEMs are able to offer these hybrid vehicles. We owe much of this success to the work of DOE and USABC with the supplier community.

For plug-in vehicles, what we really need are high-energy charge-depletion batteries that also have power, so we are looking for both of those attributes. To bring these new hybrid batteries to market, GM is using a multi-phase process that starts with qualifying these lithium ion cells. Then we develop these, and we go through a number of different tests as a battery pack, with performance attributes such as life, durability, reliability, and finally we work through our vehicle integration process to make sure that these batteries can live in our vehicles.

Again, I must make sure that with these points in mind, we have to follow the various concepts, if you will, that are outlined in our various plans. Again, with this, I stop and look forward to your questions. Thank you so very much.

[The prepared statement of Ms. Gray follows:]

PREPARED STATEMENT OF DENISE GRAY

Mr. Chairman and Members of the Committee, thank you for the opportunity to testify today on behalf of General Motors. I am Denise Gray, director of Hybrid Energy Storage Systems. I direct Development of Hybrid Energy Storage Systems for GM with a focus on developing and qualifying new battery technology solutions. It's a daunting task for our team (and all of us as an industry) to develop and produce vehicles with these advanced battery systems in a robust and timely manner.

For 100 years, the global auto industry has run almost exclusively on oil. Tomorrow's industry will not. The solution: alternative sources of energy, along with new technology to allow automobiles to run on tomorrow's fuels. But what fuels? And what technology?

At GM, we believe that no one solution is right for every part of the world, or even every consumer in any given market. So our approach is simple: offer as many choices as possible, to as many consumers as possible, everywhere we do business. And regardless of the fuel, regardless of the technology, our goal remains the same—the best possible fuel economy for whatever type of vehicle our customers choose. That's why we offer more cars that get 30 mpg highway than any other automaker.

Our vision moving forward is to reduce petroleum dependency and greenhouse gas emissions by displacing oil with biofuels and electricity, as well as enhancing vehicle efficiencies. Over time, the goal is to reduce vehicle emissions to zero and make personal mobility truly sustainable, but it will take a variety of powertrain and fuel technologies to get there. And we have developed a comprehensive advanced propulsion strategy to meet these challenges.

First, we're continuing to make incremental improvements in the conventional vehicles that we produce (e.g., six-speed transmissions, active fuel management). Currently, we have over two and one-half million flex fuel vehicles "FFVs" on the road today with 16 FFV offerings in the 2007 model year. We're continuing to expand the portfolio of FFVs, ramping up to over two million vehicles a year by 2012—provided the fuel infrastructure and supplies are available.

Second, we're continuing to expand the portfolio of hybrid vehicles that we offer. For 2007, GM hybrids include: the Saturn VUE Green Line, and Saturn Aura Green Line and beginning next month, the Chevy Malibu, the Chevrolet Tahoe and GMC Yukon will offer hybrid models using our advanced two-mode system. For 2008, the two-mode hybrid system will be added to the Chevrolet Silverado and GMC Sierra pickup trucks and to the Cadillac Escalade. The Saturn Vue Green Line will also get the advanced two-mode hybrid system.

And third, beginning with the Los Angeles and Detroit auto shows, we created quite a stir with the announcement that we have started a plug-in program for the Saturn VUE Green Line two-mode Hybrid, followed by the introduction of the Chevrolet Volt concept car.

We're also continuing to develop the fuel cell capabilities needed to produce hydrogen powered fuel cell vehicles and the infrastructure needed to support such vehicles. Later this month, we will roll out the first of a fleet of 100 Chevy Equinoxes for Project Driveway, the largest market test of fuel cell vehicles to date.

The E–Flex Architecture

The Volt is our first demonstration of an innovative new GM propulsion system called "E–Flex." The "E" stands for "electric," because all E–Flex vehicles will run on electricity. And E–Flex is "flexible" because the electricity can come from many different sources. The Volt is designed as a flex fuel vehicle capable of running on gasoline or E–85 ethanol. In Shanghai, we showed the fuel cell variant of E–Flex in a fuel cell Volt. And most recently, in Frankfurt, we showed the bio-diesel variant of E–Flex in the new "Flextreme" concept car. By offering a system that drives vehicles with any of these fuels, E–Flex will provide our customers around the globe with a single elegant solution to tomorrow's energy future.

E–Flex consists of a common drivetrain that uses electricity created and stored on board the vehicle in a variety of ways. This includes creating electricity with a simple engine and generator, creating electricity from a hydrogen fuel cell, and storing electricity in an advanced battery by plugging the car into the electric utility grid. E–Flex enables energy diversity because electricity and hydrogen can be generated from a wide range of energy sources.

GM's E–Flex system is simpler than a hybrid because it is purely electrically driven. Electricity is stored in a battery pack and used with electric motors to drive the car, with the electricity for the battery obtained in two ways. First, you can plug the car into a common electrical outlet to recharge the battery. This allows the vehicle to operate as a battery-electric vehicle. Second, once the battery charge from the electric utility grid is depleted, the battery can also be recharged by a simple engine/generator set. This allows you to extend your vehicle's electric driving range to several hundred miles.

Battery Technology

There are really two types of batteries that we require. The one most people are familiar with is called "charge depletion." Think of this as a flashlight battery that depletes it energy with use, and then is either disposed of or recharged. It is the rechargeable version of this battery that we are interested in for plug-in hybrids. This is a new area of focus for USABC.

In addition to charge depletion, there is another type of battery known as "charge sustaining." These batteries are designed to accept and delivery power while maintaining a constant state of charge—they never deplete. These charge sustaining batteries are in use in hybrid vehicles on the road today, such as our Chevy Malibu and Saturn Aura hybrids. They store up the high power energy captured during braking and reapply that energy to help the vehicle accelerate. Although charge sustaining batteries have not yet met their cost and durability targets as defined by USABC, they have progressed to the point where many OEMs are able to offer a limited number of hybrid vehicles. We owe much of this success to the work of DOE and USABC with the supplier community.

For the future, what we really need are high energy "charge depletion" batteries necessary for plug-ins that also have the "power" of charge sustaining batteries to handle the re-generative braking and other high power situations of conventional hybrid vehicles.

To bring these new energy hybrid batteries to market GM is using a multi-phase process which starts at qualifying Lithium Ion cells, proving out key performance cycle life, power, calendar life, and then developing and testing battery packs to evaluate system performance attributes. Finally we work through important integration issues at the vehicle level such as thermal, interaction with hybrid controls, and durability.

All this work is necessary as a precursor to declaring a solution "implementation ready" and planning it into a production program. While this is a sequential process with some overlap it can take up to five years. Currently, our challenge is to parallel path key work streams to develop the battery solutions and vehicle in a faster timeframe.

In a traditional hybrid, the battery provides electric vehicle operation at low speeds, recharges only while driving, and is designed for very limited electric only drive. A plug in version of a traditional hybrid, such as our design for the Saturn VUE two-mode hybrid would need to provide over 10 miles all electric drive, charges while driving and when plugged in. In our design for the Volt Range Extended Electric Vehicle, the battery would provide at least 40 miles in city driving. It would be charged through and on-board generator, regenerative braking and when plugged in. Each of these carries a very challenging goal of being "life of vehicle" solutions.

For example, the discharge power for two-mode plug in hybrid is marginally higher than for a traditional hybrid. However, the Volt would require roughly three times more than traditional hybrids. In terms of energy, the difference is even more drastic. Range Extended Electric Vehicles like the Volt require significantly more energy than traditional hybrids.

Currently, NiMH batteries typically provide about 70 whrs/kg. Lithium-ion batteries represent a significant improvement over NiMH in terms of both power and energy. Energy formulations of Lith-Ion can provide higher specific energy, but lower power. Range Extended EVs, like the Volt, would need a more optimized balance of power and energy. Big challenges also remain in terms of thermal management & life.

GM has awarded advanced battery development contracts to two suppliers to design and test lithium-ion batteries for use in the VUE plug-in hybrid: the first to Johnson Controls and Saft Advanced Power Solutions, and a second to Cobasys and A123Systems. Both teams are being challenged to prove the durability, reliability and potential cost at mass volumes of their technology. The two test batteries will be evaluated in the prototype VUE plug-in hybrid beginning later this year.

In developing advanced batteries, OEMs and component suppliers have many similar objectives and needs. Auto OEMs need to determine which technologies and pack solutions are most promising. We need to develop strategies that maximize bill of materials reuse and move toward more plug and play solutions. As technology evolves, suppliers are looking for revenue stream quickly, reducing the amount of OEM specific work and not have to burden the entire risk of introducing new battery technology in the market. Both OEMs and suppliers should focus on the things they are good at and leverage others for things they are not.

Qualification of design solutions is the first big hurdle to enable both charge sustaining and charge depleting hybrids with Lithium Ion batteries. Once these solutions have met "design readiness" we need to quickly and in parallel, move toward high reliability and high volume battery "manufacturing readiness" as a parallel path that needs significant focus and funding support. Many of the leading battery suppliers have shared that it takes up to two years to ramp up high volume production once the high volume manufacturing process and equipment have been developed.

As an automotive industry, we are reliant on these rapid advancements in order to consider scaling to high volume the vehicle solutions that will use these batteries.

Legislation

As we assess pending legislation, we believe that as a general matter Congress should support initiatives that will accelerate the process and industrialization needed to ramp to high volume Lithium Ion battery manufacturing and subsequent access to these developed products that will help us together bring to life the sustainable mobility vision for our industry and for our nation. The additional funding for energy battery development that Congress has provided DOE and USABC is a good start. It will help our suppliers develop near-term battery chemistries required if we are going to be commercially successful in the next few years. However, as an industry, we also recommend last November in response to a White House request that Congress provide funding support for manufacturing and facilities development for potential U.S. suppliers. This will be essential if these new battery chemistries are to be manufactured in the U.S. at a cost and reliability level that will enable more than just niche market success sooner than would others be possible.

We also recommended that more funding be provide for long-term research into new, novel approaches to batteries. The potential of lithium-ion appears to be limited to plug-ins and other short all-battery operation mode vehicles. We will need all new batteries approaches if we want to extend the range of vehicles to the point where an internal combustion engine or fuel cell generator would not be required.

With these points in mind, we have the following comments on the Discussion Draft you provided us for review. First, we support the overall authorization levels for both basis and applied research into energy storage. If fully funded at these levels, the proposed research program could materially speed up the development of advanced batteries. Second, the direction to conduct demonstrations of advanced energy storage systems could make a valuable addition to the development of plug in vehicles, although funding is not specified in the bill.

One issue that is not clear from the draft is the relationship between this research program and ongoing DOE battery research programs, and the roles of USCAR and USABC in the new program. In general, we believe new legislation should build on the existing DOE structure and not seek to create a parallel research program.

Another issue is the scale of any demonstration programs. We believe that in the 2009–2014 timeframe, demonstration programs should be of limited size. As with fuel cells, we learn most of what we need to know with relatively few vehicles involved—placing thousands of vehicles in a demonstration program yields limited marginal returns. Within this time window, we look beyond demonstration programs to early purchase programs where federal procurement of early vehicles—realizing that they will be more expensive than today's vehicle technology.

We suggest that the Committee consider transitioning from demonstration programs to buy-down programs to reduce the cost of cutting edge technologies to federal and State agencies. Sections 782 and 783 of the *Energy Policy Act of 2005,* dealing with early federal and state purchases of fuel cells, may offer a model for plug-in vehicles.

Thank you.

Biography for Denise Gray

Employed by General Motors since September 1980.

Current assignment is Director Hybrid Energy Storage Systems. Position responsibility consists of advance development, design, release, validation of battery system solutions for GM Hybrid and Range Extender vehicles.

Previous assignments include the following.

Director of Transmission Controls. Responsible for design and release of Transmission Algorithms and Calibrations, Electromechanical devices, and Torque Converters for four-speed, five-speed, and six-speed transmissions. These transmissions are integrated into GM conventional powertrains as well as hybrid powertrains.

Director of Engine and Transmission Controller Systems Integration and Director of Engine and Transmission Software Engineering. Both positions engineered controller hardware and algorithm/software solutions into GM vehicles worldwide. The job elements contained design, development, and verification of complex engine and transmission controls systems to meet worldwide emissions and safety standards while meeting customer driveability requirements.

GM Vehicle Engineering experiences include electrical systems development and validation. Some of the electrical systems include instrument clusters, entertainment systems, lighting systems, and anti-lock braking systems. Assignment locations also included GM's manufacturing and assembly facilities.

Educational accomplishments include BS Electrical Engineering from Kettering University (formally GMI) in 1986 and MS Engineering Science—Management of Technology from Rensselaer Polytechnic Institute in 2000.

Proud wife and mother of two sons.

Chairman LAMPSON. Thank you, Ms. Gray. Ms. Wright, you are recognized for five minutes, and at the conclusion of that, we do have three votes, and we will be in recess long enough for us to make those votes, probably half an hour.

STATEMENT OF MS. MARY ANN WRIGHT, VICE PRESIDENT AND GENERAL MANAGER, HYBRID SYSTEMS FOR JOHNSON CONTROLS; LEADER, JOHNSON CONTROLS–SAFT ADVANCED POWER SOLUTIONS JOINT VENTURE

Ms. WRIGHT. Very good. Thank you, Mr. Chairman and Members of the Subcommittee. It is a pleasure to be here. And my hope is when we all walk out of this room for you to go vote that you will have a better understanding of what the state of play is for battery technology and how we are applying that battery technology into the various hybrid applications.

Before joining Johnson Controls, I was with Ford most of my career, where I was the chief engineer of the Escape Hybrid. And Mr. Inglis, I was also the chief engineer for the fuel cell program and the hydrogen internal combustion program. So I am going to do two things today. One is what is the state of play of hybrid battery technology, and what is going on relative to putting that technology into the vehicle.

As Denise said, on the road today, we have a lot of hybrids. They are powered by nickel-metal hydride batteries. And I have to tell you that in the industry we have done a really good job of creating acceptance and confidence in the technology. They are reliable. They perform well. They are safe, and they deliver really good fuel economy and lower emissions. But like anybody's technology, your iPod or anything else, technology continues to move forward.

Now, what we are doing is you are seeing this journey go on from nickel-metal hydride to lithium ion. And it is the right step: they are smaller; they are more powerful; they are lighter; they are equally safe. And the exception, obviously, is the economic benefits are going to come along with them as well, and along with those benefits, you get better fuel economy, better emissions performance because they are lighter. Weight is the evil in a vehicle for fuel economy.

Now, not all hybrids are alike. At the break, we had an interesting discussion, and one of the things I want everybody to understand is there are several different types of hybrids. We have hybrids that are on the road today, readily available for all of us to purchase and drive. Mr. Bartlett drives his Prius. I have an Escape. Starting with the stuff that is here today, we have micro-hybrids. Those are basic start-stop function hybrids. They are widely available in Europe. In fact, Johnson control will put over 400,000 of these batteries in vehicles this year over in Europe. And they have a pretty good efficiency rating of about 10 percent fuel economy and CO_2 reduction benefits.

Moving up the spectrum, we have mild hybrids. That you would probably think of as a Honda Accord. It delivers about 30 percent improved fuel economy and emissions and provides a bit more functionality, as Denise said, regenerative capability.

And then, finally, we have the full hybrid, and an Escape hybrid and a Toyota Prius are a full hybrid. You can power the vehicle on electric power alone, which clearly would provide increased economy relative to fuel consumption, as well as reducing CO_2 emissions.

All of these are on the road and available today. In fact, Johnson Controls, next year, will be putting our first lithium ion batteries in the Mercedes S–Class, which will go on sale in the United States in 2009. And they are also ready to go into the full hybrid.

If you take the journey a bit further, now we are talking about plug-ins and pure EVs and there is an awful lot of, deservedly so, excitement about the opportunity with plug-ins. They are very promising, significant improved fuel economy and emissions. I mean literally, you can have zero emissions and a very, very high fuel economy rating. Lithium ion, clearly, is the enabler, just because of the physics of the battery—they are smaller and lighter—because of all of the energy that is going to be required to be able to propel these vehicles.

Just as the lithium ion is the enabler, it is also the biggest technical challenge that we have on the table, and it is working with my customers, such as Denise, to try and overcome these challenges as an industry. Now, in Johnson Controls, we have a lot of partnerships in play right now, with GM on the Saturn VUE, with Southern Cal, with Ford Motor Company on a plug-in fleet, and clearly all of the great work that is going on with USABC as well as the Chrysler Sprinter Vans that are going on sale next year.

We are going to solve these technical problems. I am absolutely convinced of that because I sat in this seat about four years ago, talking about hybrids and just getting them on the road. But then, what you are faced with is what are you going to do about the cost and the economics? We have got to get this scale up. We have to get standard. We have to put a recycling infrastructure in place. We need domestic manufacturing capability. We have to establish a diverse supply base outside of Asia.

So in conclusion, we are confident we are going to be able to get to commercialization by solving the technology and working towards these cost drives. But it is going to take Federal Government assistance. We are going to need to continue to fund research, and not for just the stuff we are doing today. Clearly, we need that, and we need demonstration fleets. We also need to fund the next great breakthrough, because just like lithium ion was a breakthrough, next is going to be something else. The consumer and manufacturing incentives are sure enablers to help us with this. Funding manufacturing investment and infrastructure and supply-base development, we have to facilitate collaboration between the industry, our government labs, the automakers and the utilities to see this all come to fruition in a way that we can see mass commercialization.

So in summary, recognizing that you all need to go and vote, thank you very much, and I look forward to answering your questions.

[The prepared statement of Ms. Wright follows:]

PREPARED STATEMENT OF MARY ANN WRIGHT

Mr. Chairman and Members of the Subcommittee, my name is Mary Ann Wright. I am the Vice President and General Manager of the Hybrid Battery Systems business at Johnson Controls, headquartered in Milwaukee, WI. I also serve as the Chief Executive Officer of the Johnson-Controls Saft Advanced Power Solutions (JCS) joint venture. JCS was formed in January of 2006 specifically to address our customers' needs for advanced battery systems for hybrid vehicles, plug-in hybrid vehicles, and electric vehicles. In addition, I serve on the Board of Directors of the Electric Drive Transportation Association (EDTA).

I greatly appreciate the opportunity to discuss with you today the options and challenges that America faces as it moves down the road towards the goal of a sustainable transportation future. I am honored that you have asked me to speak before you today on a topic so critical to the security, economic vitality, and environmental stability of our country and planet.

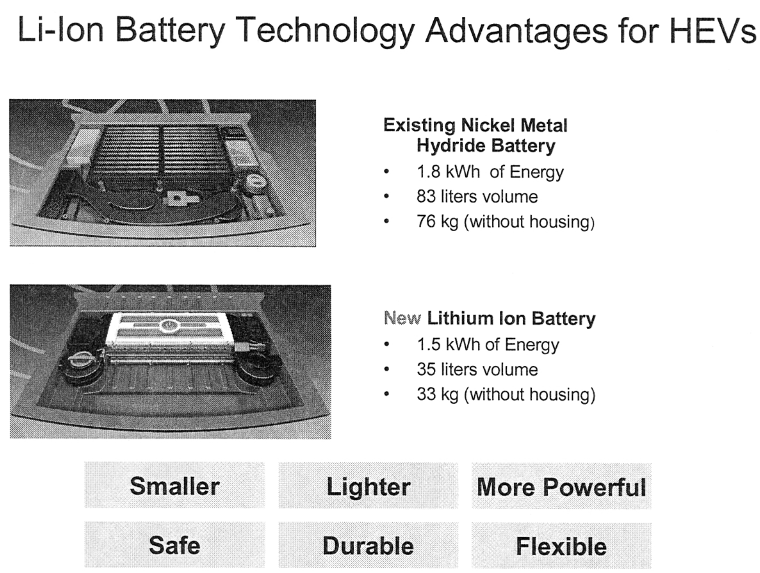
Electrification of Vehicles

Clearly, the United States is at a crossroads. We face a double-edge sword: the world's supply of crude oil is approaching maximum output while the specter of an environmental future compromised by green house gas-induced global warming continues to grow. As President Bush stated in his 2006 State of the Union speech we must change the way we power our buildings, homes, and vehicles. Today, I would like to discuss specifically what can be done on the vehicle side of the ledger.

The focus of my discussion will be vehicles with electrified drivetrains, powered by advanced battery systems. A key to this discussion will be differentiating hybrid battery applications in the range of micro to full hybrids, that have been proven using NiMH chemistry and are in the final validation phase using Li-Ion, from battery applications which have not yet been fully validated for functional performance and life; plug-in hybrids and pure electric vehicles. However, first I would like to comment on other credible powertrain technologies that can help us transform the way we power our automobiles, trucks, and buses. Given the continuing upward trend in vehicle miles driven annually in the United States, incremental increases in spark (gasoline/ethanol) and compression (diesel) ignition engine efficiency, while desirable and attainable, will not be sufficient to substantially reduce America's dependence on crude oil. Increased production and use of *biomass derived motor fuels (e.g., ethanol)* are important from an energy security standpoint, and have the potential to significantly advance progress towards the President's 20 in 10 goal. Affordable Fuel Cell (H_2) vehicles and an infrastructure to produce and distribute hydrogen are many years away from commercial viability.

I passionately believe that *electrification of the vehicle powertrain* in part or in whole can make a dominant contribution to America's energy security and transportation sustainability. Electric powertrains by nature are incredibly more efficient than their internal combustions counterparts. This efficiency prowess is the foundation of the *hybrid advantage.* The additional benefit of electrified powertrains is that they can be used as complementary technology to internal combustion engine drivetrains or as stand-alone technology, e.g., pure electric vehicles. Despite the proven benefits in terms of fuel economy and emissions, we face substantial challenges to widespread adoption of hybrid vehicles in the United States. Currently, neither the domestic market-pull nor the domestic manufacturing technology-push is sufficient to drive a sustainable electrified powertrain vehicle industry. Contrary to a popular notion, battery performance is NOT the barrier to widespread adoption of standard hybrid vehicles. In fact, Johnson Controls is the leading supplier of advanced lead-acid battery technology, called AGM, for use in micro hybrid automobiles as well as hybrid transit buses. Next year Johnson Controls will launch its first production Li-Ion battery system for the Mercedes-Benz S–Class *mild hybrid.* You may be familiar with Nickel-metal hydride (NiMH) batteries. NiMH battery technology is a proven, mature technology that to date has captured nearly 100 percent of the HEV battery market. Yet Li-Ion, due to its lower mass, reduced volume, higher power and energy, faster recharging, and lower cost potential is expected to overtake NiMH as the battery technology of choice by 2012. From 1988 to 2005, I worked for Ford Motor Company. I was the Chief Engineer for the Escape Hybrid SUV, the first domestic hybrid which was successfully launched in 2004. Since then total global sales for the hybrid Escape and it sister vehicle, the Mercury Mariner hybrid, have exceeded 59,000 units. The Escape hybrid utilizes NiMH battery technology. I also led the team that launched the first hydrogen fuel cell demonstration fleet. These vehicles also use the same NiMH battery technology as in the Ford Escape. Please see Figure 1 on page four for a comparison of the NiMH and Li-Ion technologies.

Figure 1: Li-Ion versus NiMH Technology



Rather than battery technology, the major issues impeding broader acceptance of HEVs in the United States are:

1) Relative insensitivity to motor fuel prices on the part of the American consumer, thus inhibiting the desire to purchase a hybrid vehicle at a cost premium.
2) An underdeveloped domestic industry for manufacturing raw materials and key components necessary to produce hybrid powertrains.

To better understand the domestic factors currently suppressing hybrid vehicle sales, it is helpful to look at the hybrid advantage from a global perspective. In Europe, the vehicle manufacturers are aggressively pursuing the spectrum of near-term hybrid technologies—micro, mild, and full, while continuing to improve the diesel engine technology that has traditionally enjoyed tremendous popularity. Because of the high fuel prices and CO_2 reduction targets self-imposed by European OEMs, the incremental costs of hybrid technology is less daunting to would-be purchasers. In Asia, and particularly China, there is a tremendous amount of activity focused on the rapid development of hybrid and fuel cell vehicles. In the People's Republic of China, the government has set very aggressive goals for the introduction and proliferation of ultra-efficient and clean vehicle technologies.

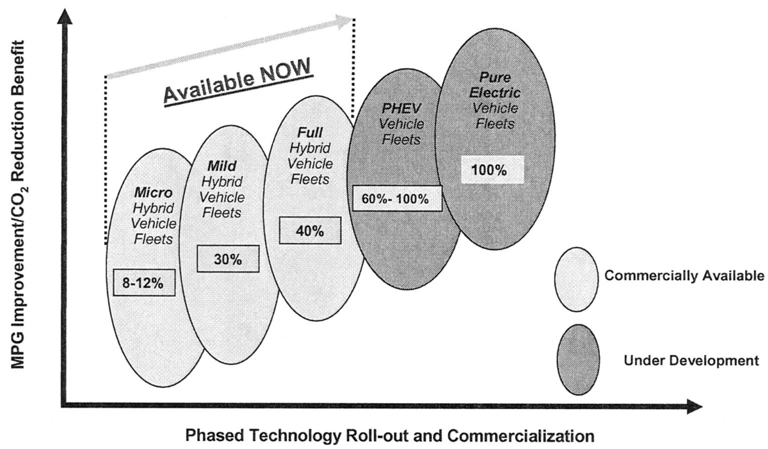
The United States is somewhat unique in that our relatively low motor fuel prices and current lack of CO_2 emissions reduction mandates also contribute to stunted demand for high efficiency vehicles such as hybrids. Fortunately, there is a remedy, but it will require a phased-technology plan and government assistance at the federal and perhaps State and local levels as well.

Phased Technology—A Journey

I see the development of a strong hybrid vehicle industry and market in the U.S. as a journey, not just a destination. As is the case with most journeys there are key achievements points or milestones along the way. Figure 2 illustrates the *Hybrid Journey*—a technology evolution that builds on hybrid technologies available today—*yes, today.* I urge the Congress to implement policies that accelerate the commercialization of micro, mild and full hybrid vehicles in the United States.

Figure 2

The Journey to Plug-In Hybrids



The plug-in hybrid concept has garnered substantial attention over the last 18 months and deservedly so. Congress has heard testimony extolling the virtues of plug-ins and their promise to eradicate our energy and environmental problems. Without question, plug-in hybrids are a promising technology. The plug-in approach has the potential to double vehicle fuel economy while displacing imported oil with domestically produced electricity. The environmental benefits could be massive, particularly if recharging is done using predominantly renewable energy sources for electricity generation. Demonstration vehicles, like those being operated by Sacramento Municipal Utility District are registering fuel economy over 90 mpg. The key tasks needed to make PHEVs a reality are: 1) accelerated technology, particularly the Li-Ion battery development; and 2) further assessment of the commercial opportunities and issues by the public and private sectors. The assessment phase should include a plan for the development of a recharging infrastructure throughout the country to ensure that the benefits of PHEVs could be maximized. Also, because PHEVs by definition will at times be "on the grid," it is imperative that all stakeholders, but in particular, the vehicle OEMs, the supply base and the utility industry, engage in frank discussions about the cost/benefits that will be encountered. Unlike the case for micro, mild, and full hybrids, there are significant battery technology barriers to the commercialization of PHEVs. A strong partnership between the public and private sectors will be needed to tear down these barriers. A successful outcome from this endeavor would serve as a giant step forward in achieving the ultimate embodiment of highly efficient and environmentally responsible transportation—the pure electric vehicle.

Johnson Controls has a development contract with General Motors to furnish PHEV battery systems technology for the Saturn Vue Green Line vehicle. We are also partners with Southern California Edison and Ford to deliver PHEV demonstration fleets. Earlier this year, Johnson Controls announced a partnership with Daimler and Chrysler to provide Li-Ion batteries for Sprinter van demonstration fleets. In addition, the Department of Energy announced on September 25th that

Johnson Controls will be awarded a PHEV battery development contract for 10 mile and 40 mile electric range vehicles. We are proud to continue our mutually beneficial relationship with DOE and the United States Advanced Battery Consortium, and look forward to *accelerating* the development of *commercially feasible* technologies for PHEV battery systems. Next, I'd like to concentrate on two words from the previous sentence—*commercially feasible.*

Reducing the Cost of Battery Systems

During my stint as Chief Engineer for the Escape hybrid SUV my team had to focus on the same acceptance criteria demanded by purchasers of conventional automobiles: style, performance, comfort, convenience, reliability, quality, serviceability, safety, and last but not least, *cost.* There is certainly a place early in the product development cycle for demonstration vehicles produced with recognition that costs will be high, but the bottom line is this: A successful HEV (all types of HEVs) vehicle industry and market in the United States must be based on satisfying these required criteria. These requirements are demanded by our customers and/or mandated by the government and they must be delivered at an affordable cost and acceptable market price.

So, although the battery technology is in the final validation phase to drive forward the market for micro, mild, and full hybrid, other elements needed for marketplace success, notably cost, are in a very early stage of development. The resolution path to ensure a long-term economically successful HEV industry in the United States must elevate *cost reduction* to the highest priority. Johnson Controls is confident that there are no insurmountable technical issues prohibiting the eventual widespread use of Li-Ion battery technology as the heart of standard hybrid vehicle drivetrains. Other issues separating it from commercial viability are:

- insufficient field experience,
- lack of domestic manufacturing infrastructure
- adequate sales volume to achieve economies of scale
- supply base diversity beyond Asia
- technical standards to drive common architectures

These challenges can be overcome in a compressed timeframe with sufficient federal assistance. Specifically, we propose a partnership between the appropriate Federal Government agencies, the battery manufacturers, and the lower Tier supply chain companies to drive down costs by focusing on the three following elements: 1) Material and component manufacturing and supply base development, 2) Process development and recycling, and 3) Equipment development.

1. Material and Component Manufacturing and Supply Base

Currently, we obtain almost all of our critical battery materials and system components from Asia. We need to develop a North American supply base for:

- Cell materials
    - Oxides
    - Carbonaceous and graphitic additives
    - Separators
    - Electrolyte
    - Roll stock aluminum and copper

Although the battery system is central to this discussion, other HEV system components are of similar concern from the standpoint of an insufficient domestic manufacturing base including:

- Power electronics
- Drivetrain electromechanical devices
- A secure supply of strategic materials, e.g., lithium ore

2. Process Development and Recycling

Another cost reduction opportunity is in the processes used to convert the basic battery materials and components into finished products. For example, today the electrode manufacturing process is time intensive, energy intensive, and environmentally challenging. A new electrode manufacturing process can be developed that would be a lower cost process, which is more environmentally friendly, saves energy and could potentially enhance battery life. Also, significant economic and environmental advantages can be realized through recycling spent battery systems. This can involve both re-use of certain components and re-processing of components containing strategic materials; e.g., nickel and lithium. Currently, over 97 percent of all lead-acid automotive batteries are recovered for recycling. Although recycling processes exist today for NiMH and Li-Ion batteries, technology development programs aimed at cost-reductions goals should include recycling.

3. Manufacturing Equipment Development

To achieve an optimal balance between product cost and creation of a sustainable domestic manufacturing base we must also focus on the equipment needed to execute the advanced processes discussed above. We need to work with domestic equipment manufacturers to develop large, production-scale equipment with a high degree of automation capable of obtaining higher speeds compared to the smaller prototyping and development-scale equipment currently in use.

There is also a large cost savings potential in improving the design of the cell for manufacturing. Identifying a design change might save several steps in the manufacturing process, thereby saving time and cost. In addition to the electrochemical cells, the battery system requires additional components and subsystems to provide critical functions, such as thermal management. Domestic manufacturing of non-cell componentry should also be factored into policy-enabled mechanisms to advance the commercial viability of hybrid vehicle technologies. A high level listing of the barriers to sustainable commercialization of hybrids in the United States and proposed enabling countermeasures are shown below in Figure 3.

Figure 3: Commercialization Barriers and Enabling Countermeasures

Barrier/Challenge	Key Enabling Countermeasure
Insufficient market pull	Consumer purchase tax incentives
Underdeveloped manufacturing technology	Funding for advanced manufacturing development Loan guarantee programs for capital investment
Relatively low motor fuel prices	Carbon content based fuel economy or CO_2 emissions mandates
Supply base development	Lower tier supplier access to federal programs
Technical Standards development	Government enabled collaboration between OEMs, suppliers & standards organizations
Insufficient pace of technology development	Government support for demonstration programs
Accelerate application of innovative technologies	Direct collaboration between battery manufacturers and the federal laboratory network
Battery functional/life performance for PHEVs/EVs	Sustained DOE funding for battery storage R&D programs
Infrastructure for broad market penetration by PHEVs	Collaboration between OEMs, supply base and utilities to develop the value proposition

We would urge Congress to consider legislation to stimulate advanced battery development, including the following detailed provisions:

- Research and development programs to maintain our nation's competitive advantage in the basic and applied areas of energy storage R&D
- Demonstration programs to accelerate the development of batteries and battery systems
- Demonstration programs to accelerate the development of advanced manufacturing technologies to reduce production costs
- Loan guarantees for capital investment
- Battery industry and supply chain programs to secure a low cost economically competitive industrial base in the United States
- Strategies to secure long-term critical material supplies
- Fleet programs to prove-out advanced technologies
- Tax incentives for micro, mild, and full hybrids
  - Automotive manufacturer incentives to drive domestic production and supply of hybrid systems
  - Consumer purchase incentives
- Carbon-based fuel efficiency regulations (miles per carbon content rather than liquid volume)
- Increased role of the battery manufacturers in determining the goals and technical direction for development programs including more direct interaction with national laboratories and institutions of higher learning

- Integrated activities involving all stakeholders:
    - OEMs
    - Battery manufacturers
    - Federal Government agencies
    - Consumers
    - Electric Power industry
    - Fuels industry
    - Labs
    - Academia

In closing, I would like express my gratitude to this committee for taking the time to hear my testimony. I hope that you consider my comments in the spirit of cooperation guided by the goal to secure the economic and environmental future of the United States.

Johnson Controls looks forward to taking the hybrid journey with Congress. We are energized and ready to go.

Thank you for your time and attention.

Biography for Mary Ann Wright

Mary Ann Wright is the Vice President and General Manager, Hybrid Systems for Johnson Controls, and also leads the Johnson Controls–Saft Advanced Power Solutions joint venture. Wright joined the company in March 2007.

Wright is responsible for accelerating the growth and executing the launch of hybrid, plug-in hybrid and electric vehicle battery programs with emphasis on state of the art technology, manufacturing and electronics integration.

Prior to joining the company, Wright most recently served as Executive Vice President Engineering, Product Development, Commercial and Program Management for Collins & Aikman Corporation since February 2006. Prior to joining Collins & Aikman, she served as Director, Sustainable Mobility Technologies and Hybrid Vehicle Programs at Ford Motor Company. In this capacity she was responsible for all hybrid, fuel cell and alternative fuel technology development. Wright also served as Chief Engineer of the 2005 Ford Escape Hybrid, the industry's first full hybrid SUV. She began her career at Ford in 1988, holding a variety of positions in finance, product and business planning, and engineering. She also played a major role in the launch of multiple vehicles at Ford including the initial Mercury Villager and Nissan Quest, and successive versions of the Ford Taurus and Mercury Sable.

Wright has been recognized by Automotive News as one of the "Leading 100 Women in the Automotive Industry."

She earned a Bachelor's degree in Economics and International Business from the University of Michigan, a Master of Science degree in Engineering from the University of Michigan and a Master of Business Administration degree from Wayne State University.

Chairman LAMPSON. Thank you very much. We shall stand in recess for our votes. See you shortly.

[Recess].

Discussion

Government Accelerating Industrialization

Chairman LAMPSON. The automobile industry practically invented high-volume manufacturing. Why is the Federal Government needed to accelerate industrialization in this area, and what can DOE do that the industry cannot do? Either of you?

Ms. WRIGHT. Well, actually, I came with a whole list of specific projects that I would go and talk to my friends at DOE about relative to high volume manufacturing. We are presently completing the construction of our first lithium ion facility in Nersac, France. I wish I could say it was Nersac, Maryland or something. And one of the things that we are learning is that we have good capability to produce good quality hybrid cells, but it is not at the level that we need to be producing them in the qualities and at the cost levels that you do for cell phones and for laptop computers. We know very well the kind of help that we need, that we need help from the government labs, DOE and other federal resources, and I would be delighted to share those specific projects with you that would, indeed, enable us, here in the United States, to be able to get a leg up on the high-volume manufacturing at affordable costs.

GOVERNMENT AND BATTERY MANUFACTURER PARTNERSHIPS

Chairman LAMPSON. To drive down costs and to spur development of advanced batteries in the U.S., you propose a partnership, Ms. Wright, between federal agencies and the battery manufacturer's lower tier suppliers. Let me ask you three questions. Do these partnerships not already exist in the forms like the U.S. Advanced Battery Coalition? Does the DOE partner directly with the battery manufacturers and lower-tier suppliers in R&D projects, or is it mostly conducted through partnerships with automobile manufacturers? Or is there a need for diversifying the pool of participants in federal vehicle-related R&D?

Ms. WRIGHT. You know, clearly we do have partnerships that are established, and they are good partnerships. Through DOE funding, USABC freedom card—those are all great forums. But I would suggest to you that what we need now is to really look at it in two pieces in terms of improving our partnership.

One is being able to take the technology that is ready to go forward and be commercialized in high volumes at affordable costs and support that as an industry with the automotive manufacturers, the battery suppliers, and the Federal Government, including the labs, who can help us with the intellectual-property generation, and get those into demonstration fleets to absolutely build the confidence and the capability to do it on a high volume.

The second piece—and this is where I don't think that we have the emphasis that we need—that is the what comes next. We tend to focus too much on getting through a specific project rather than we will solve this, but what is going to come after that? Because I assure you everybody else in the world is already thinking about that. And I think, in terms of—the partnerships really are through the USABC in terms of our day-to-day interaction, so the direct work really comes through the USABC at the direction of DOE. I would encourage more direct interaction between DOE, the automotive manufacturer, the industry, as well as the suppliers.

And then, finally, I think you had a question on diversification of who should be involved?

PARTICIPANTS IN VEHICLE-RELATED R&D

Chairman LAMPSON. Who are the participants in vehicle-related R&D?

Ms. WRIGHT. I think, you know, we are actually in fairly good shape relative to who is participating, you know, in these established forums, and I think, clearly, if you take a look at how the automotive manufacturers are partnering up, they are taking advantage of everything that is available to them. Unfortunately, there are only a few of us that are based, here, in the United States.

Ms. GRAY. If I could add in that area as well, I think USABC and DOE have done an excellent job, thus far, to getting us to where we are. But our product is still high cost. Our product still doesn't have a quality it needs to go. We need to take a step change in allowing us to understand more, apparently, how these applications are going to work, learning cycles. We can stay in the research, we can stay in the what-if kind of mode for awhile, but in order to really get to a commercialization of where this has to go, you have got to have demonstrations. You have got to manufacture the production, and you have got to have exercising activities from a learning perspective. And the cost of these energy storage systems, these batteries, are high in the beginning, and you have got to have means by which you get some quick learning cycles, and then you have go to have a means for the customer to be able to buy these kinds of things. So they've got to have some incentives to bring it down so the customers don't assume all of the cost, but then, rapidly, at the same very time, you have got to build up your manufacturing capacity in the States in order to continue and sustain that cost curve, because if you don't do that, you will end up having one system that works, and all of a sudden, it is gone away, and technology has passed you up.

Chairman LAMPSON. I shall call on Mr. Inglis, and then I shall come back and ask a second.

CHEVY VOLT

Mr. INGLIS. Thank you, Mr. Chairman. We are here at the Science Committee, and you know, we are very excited about science. It is also true it can be a science project until the market sort of drives things along. And so the goal being to break our dependence on foreign oil, the goal being to create jobs by inventing new technologies, and the goal being to clean up the air, I think it is very helpful testimony you are giving because it is about the market. And so, Ms. Gray, maybe you could talk a little bit about General Motors hope of either—is it hydrogen or is it volt? Or is it, it doesn't matter, either one works for General Motors? As a manufacturer here, what do you see as the market's acceptance of those? And help us move from a science project into something that is really going to transform the fleet.

Ms. GRAY. You know, when we put out the Chevy Volt earlier this year, I think that was a means to bring these kinds of things together, because number one, we have got a battery, a high-voltage storage device, that allows you to mate that up with an internal-combustion engine so that when the battery gets depleted, you can use the internal-combustion engine in order to replenish the battery, but you can also use a fuel cell in that same configuration, if you will, in order to provide power, if you will, energy for that battery to store and to use appropriately.

It really was a way that we pulled all of these technologies together, so it is not an either-or, but an and, in order to allow us to have diversification, if you will, from petroleum. So really there is a place for both us them, depending upon the needs and the use and the accessibility of the various energy devices.

GM ALLOCATION OF RESOURCES

Mr. INGLIS. That said, capital is generally limited. In other words, you have got to allocate resources within a company, so you think you will be allocating them—where do you think you will be allocating them? Don't tell me anything you have got to shoot me after you tell me or anything or call the SCU lawyers if you have got to before you answer, but I guess it is a public forum so you can probably tell me.

Ms. GRAY. Allocation of resources have been applied for both areas, quite frankly, and for all of the areas. I was telling one of the constituents a little while ago, back in the early '90s, I worked on ethanol. Currently, I am working on energy storage devices in fuel cells, and I am coming up with requirements for fuel cell vehicles with an energy storage device, and I am also coming up with requirements for an internal-combustion engine, again, to replenish the battery when needed, so we have resources allocated in all of those areas. I was also trying to advertise that we are still hiring, because for some reason, people think that we are not adding resources in these particular areas, but that is so, so incorrect. We have been hiring over the last ten years in areas that allow us to increase our fuel economy through regular, conventional vehicle efficiencies as well as diversification.

If you looked at where GM has been hiring, if you will, over the last ten years, it has been in those areas so that we can meet the need of where we have to go, so the answer is all of the above.

ENERGY STORAGE DEVICES

Mr. INGLIS. Ms. Wright, do you got a prediction about which one is going to win?

Ms. WRIGHT. Well, I was going to ask you if I could make a comment if you didn't invite me. I think it is really important for everybody to understand that one is a journey so you are going to learn and we are going to increase hybridization, increase electrification, and there is going to come a point where it is not going to matter what is actually providing the fuel. You will always, always, always have an energy storage device. So I am employable for a long time, because you are always going to need an energy storage device.

Now, what shape and form it takes, what the chemistry is, who knows? What is really exciting about that, though, is we've done—and it used to be called a science project at Ford with the hybrids and with the fuel cells. We are now seeing the convergence, and exactly what GM is doing, and that is regardless of what the power plant that Denise is told to provide an energy storage for, she doesn't care. She is going to be able to provide an energy storage device that will fuel anything. And so as we get better and smarter with ethanol and internal combustion engines and diesels and fuel cells and pure electrification, it is all a journey that we are going to drive standards, drive the cost down, and eventually, we will have a whole portfolio of stuff that we will be able to.

So I didn't answer your question. I would be a good politician, wouldn't I? I don't think there is winner. I think the winner is the battery, clearly.

SIMPLIFYING HYBRID SYSTEMS

Mr. INGLIS. That is helpful. Now, I have heard from some people that hydrogen is the future—or a pure electric would be far more simple to manufacture than a hybrid. I have heard the objection to hybrids that they are actually very complicated systems. In fact, I have seen it laid out how many pieces are in a hybrid as opposed to how many pieces would be in a fuel cell vehicle, and it is really an interesting layout. And the idea being, you know, you put all of that complexity into a vehicle, and you drive it a couple of hundred thousand miles, a lot of those things are going to break, and so the simpler, the better, right?

So I agree, you have got to have a storage mechanism, but you want to get it as simple as possible, right, and cut out that—some part of that so you can get the simplicity?

Ms. WRIGHT. Well, I do agree with you, and if you take a look at the complexity of a hybrid system, you have essentially nine intelligence systems that are trying to play nicely in the sandbox, right, and operate as a cohesive system. But what you have to take—and this is where we get into Lynda's expertise—is you are right. Denise said EVs are inherently more simple, but then you have to take a look at the total picture, and that is how clean is the energy source from which you are driving that electric vehicle. So I mean we get outside of the fundamental technology of the vehicle, and then you have to start looking at it more globally, so I would suggest to you, yeah, we want to drive to electrification of vehicles and with or without a fuel cell. You know, we can debate that. But I do think, then, we have to examine and say how are we doing, to ensure that the energy sources aren't worse than the cure of those vehicles of which we are propelling them.

Mr. INGLIS. Ms. Ziegler.

Mr. ZIEGLER. Yes, I just did want to add the study that was done by EPRI and NRDC, when they look specifically at plug-in hybrids, in all scenarios, even with the current mix of generation, which doesn't include any, you know, coal gasification or anything like that, there was greenhouse gas benefits in all cases. And then if you look at, as the electricity industry moves to, you know, lower carbon generation, you get much more greenhouse gas savings. So even with—and this was studied on the plug-in hybrids, not pure electric vehicles. But in all cases, with the current mix of generation, there was benefits for greenhouse gas.

Ms. GRAY. The only comment that I would like to make, if I may, as we talked about simplicity, I agree that as we move towards our Chevy Volt for example, or E–Flex system, it does get more simple when it comes to the control system. But we need the technology breakthroughs in order to realize that simplicity, and that is why we have to keep focusing on ensuring that we have got that technology breakthrough in our advanced battery technology area. So I like the end-game, but we have got to make sure that we take the appropriate steps as we move forward, and providing some additional support in the advancement of batteries will allow us to get to that very more simplistic end-game.

Southern California Edison Partnerships

Chairman LAMPSON. Ms. Ziegler, Southern California Edison is leading the charge to develop plug-in hybrid vehicles, and you signed some employment partnerships in this area with companies like Ford and Johnson Controls. What are the next steps in using these partnerships to advanced technologies?

Ms. ZIEGLER. I think what we will get out of these partnerships is exactly what my two colleagues were talking about, which is getting vehicles tested with real people, out in real circumstances, so when we get the Ford vehicles delivered to us, we will put them in our fleet, we will put them out with some customers, and we will test them in real circumstances, looking at the recharging cycles and the discharge.

So the benefit of that is getting cars in the fleet, getting them tested. The other things that we are working on, and you have heard talk to day of this smart grid of the future—it is looking at what are the kind of standards and controls that you are going to want to have. When we talk about that the electricity grid can charge most of these vehicles, you need to charge them off peak. We have excess capacity on the grid for California that is typically at night. So what you want to have is the intelligence, either in the car, in the smart meter, or in the grid, that can tell the car that you only want it to charge at night. So another benefit of these partnerships is really looking at what are the kinds of standards and controls that we need to develop between all of the industries to make that happen and use the electric grid to the benefit, as opposed more on big load by charging the vehicles.

Chairman LAMPSON. What is the timeline to do so?

Ms. ZIEGLER. The timeline for the first, which is the demonstration, we will get some vehicles next year and begin demonstrating those. I hesitate to speculate on the timeline for the smart grid. I think we are experimenting now with one circuit, which we call our Avante circuit, which is a test of a smart grid, and so we need to test that and see the results, and then you are looking at a huge infrastructure across the United States. So to replace that infrastructure with a smart grid technology is at least a couple of decades, I would think, if not more, to really replace all of the electric grid with the smart-grid capability.

Domestic Manufacturing of Batteries

Chairman LAMPSON. All of you to comment on, we talked about the importance of building up a domestic manufacturing base for an advanced-battery industry, but what does this really mean for your respective sectors and the United States as a whole? Why should domestic auto-manufacturers not outsource part of the industry to Asia and buy cheap components from an established battery sector?

Ms. GRAY. If I could start?

Chairman LAMPSON. Please.

Ms. GRAY. Every single program that we have, we made up with a supplier, and there is learning that happened. And that learning on how does the customer use their vehicle—and as every one of us is in here, there are those many different means by which a person drives a vehicle. And that learning loop is so important, and how we characterize it, how we standardize those driving operations, and then give that to a supplier to make your system, they are learning from you. And every time they do that, they are getting better and better at doing that. If we do that with all of our non-domestic companies, they become smart. They will stay smart, and we will continue to send information that way.

I think it is very important that we establish within our own country that learning opportunity, the learning opportunity to make energy storage devices, the technology to build the manufacturing tools. There are toolmakers out there that are all outside of the United States. There are chemists. There are companies that make all kinds of powers and things like that for energy storage devices. And they are all outside of the United States. If we don't retain that knowledge here, every single vehicle that we build, all of the knowledge on how we operate and how we advanced that technology goes away and does not stay here in the United States. So I think it is extremely important that we establish that capability, that competence, here in the States, so that we can retain that knowledge, so that we can have jobs here for our folks, instead of sending information or sending parts the other way.

So it is extremely important that we, as OEMs, partner up with companies and have the ability to have that knowledge here, and we can only get it by increasing our focus on manufacturing of energy storage devices, high-tech systems here in the States, because it is an art, and it is also a science.

Ms. WRIGHT. In terms of—and let us talk about hybrids first. The market is and is going to continue to stay here in the United States. We are the largest consumers of hybrid vehicles in the world, and it is projected that we are going to continue to be doing that. So if you start with that premise, it seems to make sense that you want to make the jobs here, where you are going to be assembling them. We can assemble them here; we can manufacture them here; and we can sell them here.

I would also let you know that hybrid vehicle technology originated here in the United States, and if you take look at what happened, we are absolutely getting decimated in the marketplace with technology that we invented here. And I am not going to repeat what Denise said, but I think she summed it up exactly right. We have an opportunity here to take advantage of a market that wants hybrids and will accept them, with some help from the government, of course. We can create jobs. We can create the infrastructure. We can pull, through our universities, and through our schools, a desire and a sexiness for kids to embrace science and technology instead of becoming day traders. We can then become exactly what we are seeing happen everywhere else in the world where we have to go and export. And from a purely practical standpoint, every time we do a hybrid vehicle right now, we have to go to Japan, China, or Europe to get all of our components. It takes a lot longer for us to get a vehicle on the road if we are traveling all over the world to get these components, you know, engineered and manufacture——

Chairman LAMPSON. Well, what is the state of the development of a domestic supply chain for the battery——

Ms. WRIGHT. We don't have one.

Chairman LAMPSON. Period?

Ms. WRIGHT. We don't have one, and I would—I don't think you know this, but this facility that I have in Milwaukee, the Johnson Control facility, is the only facility outside of Japan that has complete capability to do cell research, cell prototype manufacturing and systems engineering. It is the only one outside of Asia. That is a real commentary on what has happened to our ability to not only have the basic science, but the capability to produce. We do not have a single supplier here in the United States.

Chairman LAMPSON. Ms. Ziegler, would you like to comment?

Ms. ZIEGLER. I would just add one thing. I think, as we talked about earlier, we are looking at plug-in hybrids and this technology to really get ourselves off of imported oil, so doesn't it make sense to try to use United States manufactures to make the replacement for imported oil. And I would really preach, as well, we as the United States really need to have good jobs for our people that provide good wages, and I think being able to manufacture technology in the United States is critically important.

Chairman LAMPSON. What are other countries doing to increase their own capabilities that as we, perhaps, develop that, they will stay competitive. What kind of comment would you have on that?

Ms. WRIGHT. Well, I think it starts first in the structure of the society. If you take a look anywhere but in the United States, they encourage science and technology in the school systems. They are supportive from a government level, the industries as well as the universities, to advance their technology. So I think there is just a fundamental infrastructure inside of these countries that we just don't have here to encourage the building up that capability.

And if you take a look at what is happening—let us just use Europe as an example. They have a plethora of activity going on, not only in diesels, but in hybrids, because they know for the 2012 Kyoto protocol, diesels, alone, are not going to get them to the levels they need to be at. So what they are going to do—and we will produce the batteries—sell the vehicles over here. We shall make sure that it is accepted, and we will get the technology, and they are going to take it back over there. And that is what is happening in the world right now.

Ms. GRAY. Just to add another comment, I think we need a more focused effort between government and industry here in the United States in order to advance that technology. You are absolutely right. We have efforts in place, DOE, USABC. We have been doing some thing thus far, but if we are going to stay in this league, we are going to have to make a step change in our efforts, in our funding efforts, in our focus efforts.

As we, industry, come together—and it's amazing how GM has a collaboration with Ford and Chrysler. We also have collaborations with BMW as well as DCX because the answer is everybody sees this is what we have to do. We have to advance the technology in this area, and collaborations are occurring. I think, from a government perspective, we need to step up our game in that area as well. Japan has a huge step up in this where they have combined, very effectively, their government, their industry, as well as their universities in development, not just nickel-metal hydride, but also lithium and the next generation lithium, because the answer isn't just with one. You have got to have that business plan to allow you to continue to sustain that to understand what the next one is and the next one is in order to bring the cost down, because if you stay in the startup mode, which I feel we are in at this point. We are still at that infancy of being able to bring advanced-battery technology to fruition. If we just stay there, the cost will never be there, and we will be left behind.

And then, again, the cost is going to be high in the beginning, and collectively, with government, we are going to have to lower that so that we can get more product out there in the real consumers' hands so that we can learn more and then bring those costs down.

Chairman LAMPSON. Mr. Inglis, I have well overstayed my welcome.

PURCHASING PLUG-IN HYBRIDS

Mr. INGLIS. Thank you, Mr. Chairman. I don't know that I shall use all of the five minutes, but here is the—if I wanted to go from here to buy a plug-in hybrid, can I get one? Who would I call?

Ms. GRAY. You can't get one from an OEM today that has been completely integrated, that has been completely tested, that will last the expectation, ten years, you won't have to service it. We are not ready yet. There is still a lot of work to get done.

You can buy demonstration kinds of things where it is in there; it won't last forever; but yet it allows you to have some demonstration opportunity.

Ms. INGLIS. So I could get a kit, right, for a Prius? I guess I could buy that? I could go online and find a kit——

Ms. GRAY. Well, I am not advertising——

Ms. WRIGHT. I shall take care of that one Denise. Yes, there are what we call garage-conversions. I would just caution you, however, if you are personally thinking about that, one, you invalidate your automotive warranty, and number two, Denise is absolutely right, the standard and the validation that we have to undergo as an industry are beyond anything anybody, except for if you are in that industry, understands. And so these conversions do not or are not intended to meet those validations, useful life, reliability, and potentially unintended consequences. So I would just encourage you to wait because she is going to be out very soon with one.

Mr. INGLIS. So it will be soon?

Ms. GRAY. Yeah, we are currently working on a plug-in hybrid, right now, for Saturn VUE. Johnson Controls staff is one of the advanced technology suppliers that we are working collectively on, but we have got to make sure that under all kinds of conditions, this vehicle is safe, in a crash condition, that the occupant is not hurt.

We have got to make sure that it lives and lasts. You don't want to go and replace your battery every 600 miles because we have failed. So we are working towards coming up a with a real, certified plug-in vehicle that will allow us to, again, sell it to the customer, and it meets your needs.

Mr. INGLIS. And when is the projected delivery?

Mr. GRAY. We haven't put a production date on that we can announce to the public, although internally, I got a production date that I have to make sure that I line everything up and work as hard as I possibly can to uncover and to deal with all of those engineering issues in order to make this program feasible.

PLUG-IN HYBRIDS FOR CONSUMERS

Mr. INGLIS. You encourage me that it is that, it is engineering of standards. It is not the price of gasoline. Is that right? Or is it also some concern about whether the price of gasoline goes down, and then when it goes down, do I really want to buy one, or do I just decide I shall keep on driving what I got?

Ms. GRAY. As an OEM, I wish I could predict which vehicles you will buy and at what price you will buy them. I can't do that, but my obligation is to get the technology out there, certified, so that you can have the opportunity in order to accomplish that.

Ms. WRIGHT. And you know what we have to do is, in absence of mandates, we have to drive the market pull. And I think Denise said it very well that it is going to be a collaboration. We have to have continued and continued improved collaboration with government. The vision is, at some point, hopefully in the next couple of years, you are going to go to the dealership, and when you choose whether you want leather or your recyclable seats, you can then check off a plug-in option or another hybrid option, and it will be some reasonable incremental cost, that you see the value being there and that Denise's and my industry can have a profitable growth plan.

That is what we are working towards, but we can't do it at the volumes that we are at now, the lack of standards, and the lack of real collaboration in terms of driving scale and infrastructure here in the United States.

Mr. INGLIS. So if we really wanted to drive this, mandates may be a good idea? In other words, fuel efficiency standards might be a good idea?

Ms. WRIGHT. You can address it in a number of ways. It could be fuel efficiency, or I would—certainly the shift in discussion to carbon mandates.

HYBRID EMISSIONS

Mr. INGLIS. Which is helpful in your chart that you had both of those, either carbon kind of systems or a fuel efficiency standard. I mean it is a good argument that perhaps that might really get us going?

Ms. WRIGHT. Without a doubt, and what you saw in that chart represented CO_2. When you add in all of the other forms of greenhouse gasses, it only gets better as you increase your level of hybridization. So just to refresh your memory, I would very much encourage that we continue to exploit the technology that we have available today that we can put on the road today, but we are not in the volumes, as well as continue to invest in what is hopefully going to be near-term plug-in capability and eventually EV.

RAW MATERIAL SUPPLIES FOR BATTERIES

Mr. INGLIS. And one last question: the—I have used all of the time, Mr. Chairman. We have got enough raw materials to do these batteries, right? It is not like there are made out of platinum, and there is only so much in the world, and that means that we really can't use these or—it is not a resource problem, right?

Ms. WRIGHT. That is correct.

Mr. INGLIS. There is enough Lithium there is enough——

Ms. WRIGHT. We can't divulge the recipes because that is our intellectual property, but clearly the materials are always a concern, but as Denise said, when you look at nickel-metal hydride versus a lithium ion, first because it is 50 percent lighter, you are using—consuming less materials. And one of the areas that I would encourage additional research beyond where we are today is alternate materials that take all of the variability in terms of market spikes as well as availability. And they are there. They are on the horizon, and we are working with them. So we are going to continue to experiment with our recipes to ensure that we meet all of the requirements from our automotive manufactures, but I think there are a lot of opportunities for us to continue to take that volatility out and still deliver all of the performance.

Mr. INGLIS. All right, thank you. Thank you, Mr. Chairman.

Chairman LAMPSON. You are welcome. I would like to go another 20 minutes. It is fascinating, and you all have been great. Thank you very, very much. We appreciate you appearing before our subcommittee, and under the rules of this committee, the record will be held open for two weeks for Members to submit additional statements and any additional question that they might have for the witnesses. We shall send them to you. This hearing is now adjourned. Thank you.

[Whereupon, at 1:20 p.m., the Subcommittee was adjourned.]

Appendix:

ADDITIONAL MATERIAL FOR THE RECORD

[DISCUSSION DRAFT]

OCTOBER 1, 2007

110TH CONGRESS
1ST SESSION

H. R. ____

To provide for a research, development, and demonstration program by the Secretary of Energy to support the ability of the United States to remain globally competitive in energy storage systems for transportation and electricity transmission and distribution.

IN THE HOUSE OF REPRESENTATIVES

M . introduced the following bill; which was referred to the Committee on

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A BILL

To provide for a research, development, and demonstration program by the Secretary of Energy to support the ability of the United States to remain globally competitive in energy storage systems for transportation and electricity transmission and distribution.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the ''Energy Storage Technology Advancement Act of 2007''.

SEC. 2. DEFINITIONS.

For purposes of this Act—

(1) the term "Department" means the Department of Energy; and

(2) the term "Secretary" means the Secretary of Energy.

SEC. 3. ENERGY STORAGE SYSTEM PROGRAM.

The Secretary shall carry out a research, development, and demonstration program to support the ability of the United States to remain globally competitive in energy storage systems for transportation and electricity transmission and distribution.

SEC. 4. BASIC RESEARCH PROGRAM.

(a) IN GENERAL.—The Secretary shall conduct a basic research program to support the development of energy storage systems for transportation and electricity transmission and distribution, including research on—

(1) materials design;

(2) materials synthesis and characterization;

(3) electrolytes, including bioelectrolytes;

(4) surface and interface dynamics;

(5) modeling and simulation; and

(6) thermal behavior and life degradation mechanisms.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary for carrying out this section $50,000,000 for each of the fiscal years 2009 through 2014.

SEC. 5. APPLIED RESEARCH PROGRAM.

(a) IN GENERAL.—The Secretary shall conduct an applied research program on energy storage systems to support transportation and electricity transmission and distribution technologies, including research on—

(1) ultracapacitors;

(2) flywheels;

(3) batteries and battery systems (including flow batteries);

(4) compressed air energy systems;

(5) power conditioning electronics;

(6) manufacturing technologies for energy storage systems; and

(7) thermal management systems.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary for carrying out this section $80,000,000 for each of the fiscal years 2009 through 2014.

SEC. 6. ENERGY STORAGE SYSTEMS DEMONSTRATIONS.

(a) IN GENERAL.—The Secretary shall carry out 6 new demonstrations of energy storage systems. These demonstrations shall be regionally diversified and shall expand on the Department's existing demonstration program. These demonstrations should include the participation of a range of stakeholders, including rural electric cooperatives, investor owned utilities, municipally owned electric utilities, energy storage systems manufacturers, auto manufacturers, the renewable energy production industry, State or local energy offices, the fuel cell industry, and universities. Each of the following objectives shall be included in at least one of the demonstrations:

(1) Energy storage to improve the feasibility of ''micro-grids'' or ''islanding'', or the transmission and distribution capability to improve reliability in rural areas.

(2) Integration of an energy storage system with self-healing circuits.

(3) Use of energy storage to improve security to emergency response infrastructure.

(4) Small storage units that could be used in homes and cars to provide emergency backup or other services at homes and businesses.

(5) Integration with a renewable energy production source, either at the source or away from the source.

(6) Use of energy storage to provide ancillary services, such as frequency response or spinning reserve services, for grid management.

(7) Advancement of power conversion systems to make them smarter, more efficient, able to communicate with other inverters, and able to control voltage.

(8) Use of energy storage to optimize transmission and distribution operation and power quality, which could address overloaded lines and maintenance of transformers and substations.

(9) Use of energy storage for peak shaving of homes, businesses, or grid.

(10) Use of energy storage devices such as plug-in hybrid vehicles to fill up the night time valley for electricity demand to make better use of existing grid assets.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary for carrying out this section $____________ for each of the fiscal years 2009 through 2014.

SEC. 7. TRANSPORTATION ENERGY STORAGE DEMONSTRATION.

(a) IN GENERAL.—The Secretary shall carry out a program to demonstrate energy storage technologies and associated systems for transportation applications. These demonstrations shall be conducted through consortia, which may include energy storage systems manufacturers and their suppliers, vehicle manufacturers, rural electric cooperatives, investor owned utilities, municipal and rural electric utilities, State and local governments, metropolitan transportation authorities, and universities. The program shall demonstrate one or more of the following:

(1) High capacity, high efficiency energy storage, charging, and control systems, along with the collection of data on performance characteristics such as battery life, energy storage capacity, and power delivery capacity.

(2) Onboard energy management systems, efficient cooling systems, and technologies to reduce emissions.

(3) Integration of such systems on a vehicular platform, along with the collection of data on performance of the systems under a range of driving conditions.

(4) Technologies and processes that reduce manufacturing costs, associated wastes, and hazardous materials in the supply chain and increase the availability of raw materials and components in the supply chain.

(5) Integration of transportation technologies with electricity distribution system and smart metering technology.

(b) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary for carrying out this section $______________ for each of the fiscal years 2009 through 2014.

SEC. 8. COST SHARING.

The Secretary shall carry out the programs under sections 6 and 7 in compliance with section 988 (a) through (d) and section 989 of the Energy Policy Act of 2005 (42 U.S.C. 16352(a) through (d) and 16353).