FACILITATING THE TRANSITION TO A SMART ELECTRIC GRID

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND AIR QUALITY

OF THE

COMMITTEE ON ENERGY AND COMMERCE

HOUSE OF REPRESENTATIVES

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

MAY 3, 2007

Serial No. 110–41

Printed for the use of the Committee on Energy and Commerce

energycommerce.house.gov

U.S. GOVERNMENT PRINTING OFFICE

40–588 PDF WASHINGTON : 2008

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON ENERGY AND COMMERCE

JOHN D. DINGELL, Michigan, *Chairman*

HENRY A. WAXMAN, California
EDWARD J. MARKEY, Massachusetts
RICK BOUCHER, Virginia
EDOLPHUS TOWNS, New York
FRANK PALLONE, JR., New Jersey
BART GORDON, Tennessee
BOBBY L. RUSH, Illinois
ANNA G. ESHOO, California
BART STUPAK, Michigan
ELIOT L. ENGEL, New York
ALBERT R. WYNN, Maryland
GENE GREEN, Texas
DIANA DEGETTE, Colorado
Vice Chairman
LOIS CAPPS, California
MIKE DOYLE, Pennsylvania
JANE HARMAN, California
TOM ALLEN, Maine
JAN SCHAKOWSKY, Illinois
HILDA L. SOLIS, California
CHARLES A. GONZALEZ, Texas
JAY INSLEE, Washington
TAMMY BALDWIN, Wisconsin
MIKE ROSS, Arkansas
DARLENE HOOLEY, Oregon
ANTHONY D. WEINER, New York
JIM MATHESON, Utah
G.K. BUTTERFIELD, North Carolina
CHARLIE MELANCON, Louisiana
JOHN BARROW, Georgia
BARON P. HILL, Indiana

JOE BARTON, Texas
Ranking Member
RALPH M. HALL, Texas
J. DENNIS HASTERT, Illinois
FRED UPTON, Michigan
CLIFF STEARNS, Florida
NATHAN DEAL, Georgia
ED WHITFIELD, Kentucky
BARBARA CUBIN, Wyoming
JOHN SHIMKUS, Illinois
HEATHER WILSON, New Mexico
JOHN B. SHADEGG, Arizona
CHARLES W. "CHIP" PICKERING, Mississippi
VITO FOSSELLA, New York
STEVE BUYER, Indiana
GEORGE RADANOVICH, California
JOSEPH R. PITTS, Pennsylvania
MARY BONO, California
GREG WALDEN, Oregon
LEE TERRY, Nebraska
MIKE FERGUSON, New Jersey
MIKE ROGERS, Michigan
SUE WILKINS MYRICK, North Carolina
JOHN SULLIVAN, Oklahoma
TIM MURPHY, Pennsylvania
MICHAEL C. BURGESS, Texas
MARSHA BLACKBURN, Tennessee

PROFESSIONAL STAFF

DENNIS B. FITZGIBBONS, *Chief of Staff*
GREGG A. ROTHSCHILD, *Chief Counsel*
SHARON E. DAVIS, *Chief Clerk*
BUD ALBRIGHT, *Minority Staff Director*

SUBCOMMITTEE ON ENERGY AND AIR QUALITY

RICK BOUCHER, Virginia, *Chairman*

G.K. BUTTERFIELD, North Carolina, *Vice Chairman*
CHARLIE MELANCON, Louisiana
JOHN BARROW, Georgia
HENRY A. WAXMAN, California
EDWARD J. MARKEY, Massachusetts
ALBERT R. WYNN, Maryland
MIKE DOYLE, Pennsylvania
JANE HARMAN, California
TOM ALLEN, Maine
CHARLES A. GONZALEZ, Texas
JAY INSLEE, Washington
TAMMY BALDWIN, Wisconsin
MIKE ROSS, Arkansas
DARLENE HOOLEY, Oregon
ANTHONY D. WEINER, New York
JIM MATHESON, Utah
JOHN D. DINGELL, Michigan *(ex officio)*

J. DENNIS HASTERT, Illinois, *Ranking Member*
RALPH M. HALL, Texas
FRED UPTON, Michigan
ED WHITFIELD, Kentucky
JOHN SHIMKUS, Illinois
JOHN B. SHADEGG, Arizona
CHARLES W. "CHIP" PICKERING, Mississippi
STEVE BUYER, Indiana
MARY BONO, California
GREG WALDEN, Oregon
MIKE ROGERS, Michigan
SUE WILKINS MYRICK, North Carolina
JOHN SULLIVAN, Oklahoma
MICHAEL C. BURGESS, Texas
JOE BARTON, Texas *(ex officio)*

PROFESSIONAL STAFF

SUE D. SHERIDAN, *Senior Counsel*
JOHN JIMISON, *Counsel*
MARGARET HORN, *Clerk*
DAVID MCCARTHY, *Counsel*

CONTENTS

WITNESSES

FACILITATING THE TRANSITION TO A SMART ELECTRIC GRID

THURSDAY, MAY 3, 2007

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND AIR QUALITY,
COMMITTEE ON ENERGY AND COMMERCE,
Washington, DC.

The subcommittee met, pursuant to call, at 10:10 a.m., in room 2123 of the Rayburn House Office Building, Hon. Rick Boucher (chairman) presiding.

Members present: Representatives Barrow, Markey, Wynn, Doyle, Harman, Inslee, Matheson, Dingell, Whitfield, Shimkus, Bono, Rogers, Burgess, and Barton.

Staff present: Sue Sheridan, John Jimison, Laura Vaught, Chris Treanor, Margaret Horn, David McCarthy, Kurt Bilas, Peter Kielty, Matthew Johnson, and Garrett Golding.

OPENING STATEMENT OF HON. RICK BOUCHER, A REPRESENTATIVE IN CONGRESS FROM THE COMMONWEALTH OF VIRGINIA

Mr. BOUCHER. The subcommittee will come to order.

This morning the subcommittee will examine the evolution of our electricity transmission and distribution network into a smart grid, a subject regarding which I personally have a longstanding interest. In the coming weeks this committee will produce legislation for House floor consideration this summer, having the overall objective of promoting greater national energy self-sufficiency. It is my hope that today's hearing will yield useful legislative suggestions for smart grid development that we can then incorporate in the larger bill that this committee will soon assemble, and I would encourage our witnesses this morning to make legislative recommendations to us.

Given the number of witnesses who are testifying before the subcommittee both on this opening panel and also on the second panel, I intend to defer any further opening statement on my part and use the time allotted to me to ask questions of these outstanding witnesses. I would simply note that our first panel of witnesses is comprised of individuals who are well positioned to offer a vision of how a smart grid would be configured, how it would operate, what benefits it would confer upon utilities, upon consumers and upon society generally, what barriers exist to its development and what role government can play in overcoming those hurdles. Our second panel of government representatives can then respond to the suggestions made by witnesses on the first panel and of course offer their own recommendations.

I want to welcome today's witnesses and say that I very much look forward to their testimony, and I thank each of you for taking time to join us and share your views with us.

I will now recognize for an opening statement of 5 minutes the gentleman from Kentucky, Mr. Whitfield.

Mr. WHITFIELD. Mr. Chairman, thank you very much and I certainly look forward to the hearing this morning and I am going to waive my opening statement and look forward to the testimony of our witnesses and welcome them.

Mr. BOUCHER. Thank you very much, Mr. Whitfield.

The gentleman from Maryland, Mr. Wynn.

Mr. WYNN. Thank you, Mr. Chairman. I will also waive.

Mr. BOUCHER. Thank you, Mr. Wynn. And the gentle lady from California, Ms. Harman.

Ms. HARMAN. Mr. Chairman, if I don't waive, have I created some kind of national crisis?

Mr. BOUCHER. Ms. Harman, we are always delighted to hear from you. You would be welcome.

OPENING STATEMENT OF HON. JANE HARMAN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Ms. HARMAN. In that case, very briefly and succinctly, I would like to welcome our witnesses and especially an old good friend, John Bryson of California. I want everyone to know that John was an environmentalist before he was a captain of industry, but the good news is, he is still an environmentalist while he is a captain of industry and I think that his testimony, and I assume the testimony of others, will show us a way forward that I think is enormously promising.

If we do one thing in this subcommittee, Mr. Chairman, and I hope we are going to do many more than one thing, I think focusing on a smart electric grid is it because that is the way we really can get our arms around how we use energy and how we can conserve energy and I just want to note that my house in Venice, California, has solar panels on the roof, and when I expanded my house I added more solar panels. I got a rebate from the city of Los Angeles but I thought it was important to invest in solar power. The problem is that there really is not a way for me to sell excess energy back to the utility the way I think I should be able to do, and until I can do it, I know my neighbors aren't going to be that excited about putting solar panels on their roof.

So this testimony will tell us more than we presently know or at least tell me about real-time metering, smart appliances and a two-way system for buying and selling electricity and the benefits that that can have. Information technology should be a weapon against the climate challenge and our dependence on foreign oil. If everyone up here including old Grandma can learn to use a Black Berry and a fancy cell phone, I think I could even maybe understand what advantages could come from facilitating a transition to a smart electric grid.

I just want to finally add that this also has advantages not just for homes and appliances but for cars and trucks and we have been talking about the tough issues around pushing transportation in the right direction. A smart grid could lay the groundwork for plug-in electric hybrid vehicles that would help cut our oil imports and it could also help us use effectively the new battery technologies that are being developed, for example, by Toyota and Honda in my congressional district and could help people who drive cars and trucks with those technologies know how to store energy, for example, when energy prices are sky high. So it just seems to me this is the key to understanding a way forward on climate change and I think we have the right panels, and I have abused all the members here so that I could tell my little story, and I appreciate you yielding me the time.

Mr. BOUCHER. Thank you very much, Ms. Harman, and we appreciate that opening statement.

The gentleman from Texas, Mr. Burgess, is recognized for 3 minutes.

Mr. BURGESS. Thank you, Mr. Chairman. Because we have got so much to get through today, I will just insert my comments into the record. I would like to welcome Mr. Brad Gammons here from my home State of Texas. It is good to see you, sir, on the panel and I look forward to the testimony. Thank you.

[The prepared statement of Mr. Burgess follows:]

PREPARED STATEMENT OF HON. MICHAEL C. BURGESS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TEXAS

Thank you, Mr. Chairman.

I look forward to hearing from our witnesses today about smart grid technology.

The forces of supply and demand have long governed prices in a free enterprise system. Unfortunately, that is not the case with the electricity market.

Consumers pay the same rate per kilowatt during the day, when demand is high, as they are in the middle of the night, when demand is low.

This disguises the true costs of electricity and prevents consumers from adjusting their demand to the actual cost of electricity.

The Smart Grid technology that we will learn more about today has the capacity to bring the power of the market to electric consumers at the retail level by providing them with real-time prices. This will allow them to make rational decisions about demanding electricity and if it costs more to wash a load of towels during the day than it does in the evening, I may wait until 8 p.m. to do my laundry.

If a whole lot of other people make that same decision, we may be able to move enough electricity load to off-peak times to avoid building a new power plant or substation.

That's real energy savings.

Mr. Chairman, conservation and efficiency must play an important role in our strategy to wean ourselves from our dependence on foreign energy, so I thank you for holding this hearing today.

Mr. BOUCHER. Thank you, Mr. Burgess.

The gentleman from Georgia, Mr. Barrow, is recognized for 3 minutes.

Mr. BARROW. Thank you, Mr. Chairman.

OPENING STATEMENT OF HON. JOHN BARROW, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF GEORGIA

Mr. BARROW. In the interest of time, I would like to state an area of concern up front that I hope the witnesses will address as they are able in the course of their presentations. Advanced metering is one of the key things we can do to involve consumers in the management of their demand for energy and yet there is a marked difference in terms of the penetration in the market for advanced metering technology. The FERC has done a survey and they show that in the electric co-op sector we have got 13 percent of the folks. It has been 13 percent penetration for advanced metering in the electric co-op market. The investor-owned utility field, it is only about 6 percent. It is less than half of what they are doing in the electric co-op. So what I would like you all to do is address what we can do to try and get the investor-owned utility community to be more like the electrical co-op community in terms of implementing advanced metering technology and involving the consumers.

Thank you.

Mr. BOUCHER. Thank you very much, Mr. Barrow.

We will turn to our witnesses momentarily, and we are awaiting the arrival of one other Member who has indicated interest in taking part in our hearing this morning, and he is just arriving, and it gives me pleasure at this time to recognize the chairman of the full Energy and Commerce Committee, the gentleman from Michigan, Mr. Dingell, for a 5-minute opening statement.

OPENING STATEMENT OF HON. JOHN D. DINGELL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MICHIGAN

Chairman DINGELL. Mr. Chairman, I thank you. I will try and be more brief in this matter than your generosity would permit.

First of all, Mr. Chairman, thank you for holding the hearing. Second of all, I commend for the outstanding leadership that you are giving this committee in its consideration of energy matters. The committee and the country owe you a great thanks.

The Nation stands in a position where we could reap significant benefits from new technologies which will maximize the efficiency of our electric power delivery system. These benefits include greater reliability, lower cost to consumers, improved ability of the industry to operate proactively, and alternatives for improving the Nation's energy infrastructure, which is unfortunately aging. The shorthand term for these new technologies is smart grid. Our focus today is on public policies that will facilitate the rapid deployment and adoption of these technologies without disruptions or increased costs. There are a number of challenging requirements created by these opportunities and I know under your leadership that we will address them.

First, the electric grid must continue to balance and constantly do so between ever-shifting demand and supply. That is a very difficult task for a product that moves, as we know, at the speed of light and offers no effective means of storage. Second, the product, electricity, must also be exceptionally reliable. In today's computerized, high-tech society, even a momentary interruption of power can create dramatic, costly losses to the economy and to the society. Third, the ever-growing demands of our aging electric infrastructure are a serious concern. Projections show the demand for power increasing significantly in the coming years. Absent some extraordinary innovation, we would need to invest tremendous resources to increase capacity and ensure greater reliability.

Fortunately, smart technologies appear to address these challenges and with substantial benefits to both the electricity sector as well as to the consumer. These new technologies, by working smarter, not harder, promise electric generation and delivery that is more efficient, economic and environmentally responsive. It is expected that at some point smart grid technology will ultimately provide for our transportation sector's energy needs through plug-in hybrid vehicles such as plug-in hybrids that provide valuable electricity storage back to the grid.

While this transition will not quick or easy, the move towards smart grid technology is coming and your leadership, Mr. Chairman, is extremely valuable. Again, I want to thank you for holding this hearing which will enable us all to learn about the issues associated with the transition, and I want to thank our witnesses who are here today and I know that their contribution to this process will be valued.

Thank you, Mr. Chairman.

Mr. BOUCHER. Thank you very much, Chairman Dingell.

The gentleman from Pennsylvania, Mr. Doyle, is recognized for 3 minutes.

Mr. DOYLE. Mr. Chairman, I will waive my opening remarks. I just want to welcome the panelists, especially Ms. Zibelman from PJM.

Mr. BOUCHER. Thank you very much, Mr. Doyle.

Any other statements for the record will be accepted at this time.

[The prepared statements of Messrs. Hastert and Barton follow:]

PREPARED STATEMENT OF HON. J. DENNIS HASTERT, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ILLINOIS

Thank you, Mr. Chairman, for holding this hearing today. Smart grid technologies hold much promise for the United States. Deployment of these technologies will help reduce our electricity use, keep energy costs down, provide jobs for Americans, and increase our energy security. This is something I think we all can support.

When I first started my career in public office I wrote the Illinois Public Utilities Act. A lot has changed in providing electricity since then.

Smart grid technology will allow for the more efficient operation of the electric grid. It does this in a number of ways: better communication, distributed generation, appliances that can "talk" to the grid and if needed, help support the grid. It can also lead to distributed storage of electricity through batteries and other devices, and facilitate the deployment of new generation of vehicles such as plug-in hybrids.

These technologies also have the ability to reduce peak demand on the electric system. This helps everyone by reducing the need for new generation and transmission facilities saving consumers money.

It also reduces peak period fuel use, which is usually natural gas. This reduces price pressure on natural gas, freeing it up for industrial and residential use. Ultimately keeping jobs in America from moving overseas.

Furthermore, reduced electricity demand and the related reduced fuel demand means emissions of pollutants and greenhouse gases such as CO^2 are lessened. As I have said before, good energy policy is good environmental policy. Smart grid technology does both.

Using our energy resources wisely and more efficiently is always a good idea. The better we use our domestic resources to generate electricity, and power the next generation of vehicles, such as plug-in hybrid vehicles, the less we will depend on unstable foreign sources of energy. Improving our energy security now and into the future must be our priority. I am confident we can do that leaving a stronger and cleaner Nation for generations to come. And new technology will lead the way.

Many of our best and brightest are involved in developing smart grid technology.

I am particularly pleased to see Dean Kamen here today before the committee to testify. I have had the pleasure of knowing Dean for some years now and he is probably known best as the inventor of the Segway. However, his work in developing technology that generates electricity and clean water could be further reaching. Dean is developing a device that continuously outputs a kilowatt of electricity, enough to light 70 energy efficient light bulbs, all on abundant sources of fuel like cow manure. In developing countries with populations that have never had electricity this is life changes technology.

It is technology and innovation from companies like Dean's that will lead energy needs and efficiencies into the future not only in this country but around the world.

As work on smart grids comes to maturity, it should be utilized in developing nations, so they too will have the ability to manage growing electricity and energy demands and improve their environment. Improvements in emissions in places like China and India benefit everyone around the globe.

I look forward to our witnesses' testimony today, I want to wish them the best in developing these new technologies that will make such a difference in so many peoples' lives.

Thank you, Chairman Boucher, and I yield back the remainder of my time.

PREPARED STATEMENT OF HON. JOE BARTON, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TEXAS

Thank you, Chairman Boucher, for holding this hearing today on smart grid technologies. I also want to thank our witnesses here today. This is an exciting area and I look forward to your testimony.

Smart grid technologies combine advanced communications technologies, electric distribution technologies and end-use electric technologies in order to create a more efficient electric system. Just as advancing computer and communications technologies over the last 25 years have transformed our everyday lives with Black Berries, e-mail, cell phones, and broadband Internet, so too will smart grid technologies transform the way utilities and consumers use the electric system. And the resulting system will be better.

I have always supported a market-based approach to the electric utility system. The market requires three things: suppliers, consumers, and a distribution method. Congress has done a great deal to increase the number of competitive suppliers, starting with the Public Utilities Regulatory Policy Act of 1978 and extending through the Energy Policy Act of 2005. Competition at the wholesale level for electricity supply has brought benefits to consumers. The Federal Regulatory Energy Commission and many States have reformed their regulations and laws to bring the benefits of competition to consumers.

What has been missing in this system is the ability for the consumer to respond to price signals. Just like in any market, as prices rise, consumers use less of the product. Except electricity, which doesn't come with a price tag. Consequently, almost no one has the ability to actually know the price of power as they buy it. When prices rise, it takes a month for the bad news to show up in your mailbox. Price competition doesn't work when the producer won't or can't tell the customer the price, and this has been a fatal flaw in many deregulated markets starting in California in 2000.

I can't think of much else that I would buy without knowing the price, and it looks like smart grid technologies may finally be able to fill in this last hole in the market by allowing me and other consumers to know the price and act accordingly. A true electricity market may be on the horizon.

But there are benefits beyond the creation of a true competitive market. Smart grid technologies can help the utility distribute electricity more efficiently. This may mean fewer new transmission lines, substations and generating units. And this means lower costs for consumers.

These technologies can help consumers use electricity more efficiently reducing demand and consumer costs. Greater efficiency in the distribution and use of electricity can also result in less pollution and a cleaner environment. It also improves our energy security. There is a lot to look forward to as a result of these technologies.

I am sure though, that like any new technology and its penetration into the American market, there will be bumps along the road. There may be significant up-front coats before the results are apparent. Some of the technologies may not perform as promised. But the bottom line is that these technologies will be our future and we on this Committee should do everything we can to see that Americans reap the benefits of these new technologies.

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

Mr. BOUCHER. We now turn to our panel of witnesses, and I will simply say a brief word of introduction concerning each.

Mr. Michael Howard is the senior vice president for Research and Development Group for the Electric Power Research Institute. Mr. Kurt Yeager is the executive director of the nonprofit Galvin Electricity Initiative. Mr. Dean Kamen is the president of DEKA Research and Development Corporation. Mr. Kamen is also the inventor of the Segway, known to most in this country, and many other innovative products. Mr. Brad Gammons is vice president of IBM Global Energy and Utilities Industry of the IBM Corporation. Mr. Dan Delurey is the executive director of the Demand Response and Advanced Metering Coalition. Mr. John Bryson is the chief executive officer and president of Edison International, the parent company of the utility, Southern California Edison. And Ms. Audrey Zibelman is the chief operating officer and executive vice president of the PJM Regional Transmission Organization. We are pleased to have each of our witnesses with us today.

Your prepared opening statements will be made a part of the record and we would welcome your oral summaries of approximately 5 minutes.

Mr. Howard, we will be pleased to begin with you.

STATEMENT OF MICHAEL W. HOWARD, SENIOR VICE PRESIDENT, RESEARCH & DEVELOPMENT, ELECTRIC POWER RESEARCH INSTITUTE, PALO ALTO, CA

Mr. HOWARD. Thank you, Mr. Chairman, Ranking Member Hastert and members of the committee. I am Michael Howard, senior vice president of the Research and Development Group for the Electric Power Research Institute, a nonprofit, collaborative research and development organization with major offices in Palo Alto, California, Charlotte, North Carolina, and Knoxville, Tennessee. My comments today reflect the work of the talented scientists and engineers who work across our institute on the many issues associated with an electric power delivery system.

EPRI's purpose is to work collaboratively with the electric utility industry to develop the technologies that will ensure our existing grid infrastructure continues to work reliably and safely while at the same time facilitate the transition to an intelligent grid that supports both the changing generation mix in a carbon-constrained world and a more effective and efficient participation by consumers in managing their use of electricity.

During the last 5 years, we have been helping the electric utility industry develop and deploy the concept of an intelligent grid through the implementation of our IntelliGrid initiative. The IntelliGrid initiative is developing the methodology, tools and integrating technologies that will help the industry and equipment manufacturers start transitioning the electric grid of the future.

We believe the grid of the future will include six important features. It will be a dynamic system that is interactive with consumers and markets. It will be self-healing and adaptive. It will be self-optimized to make best use of resources and equipment. The grid of the future will be predictive rather than reactive and it will be able to store large amounts of energy and able to accommodate a variety of generation options including renewable energy.

Achieving these objectives will require a power system that incorporates millions of sensors all connected through an advanced communication and data acquisition system. A distributed computing system will analyze in real time the information from the millions of sensors to enable predictive rather than reactive response to a blink-of-the-eye disruption.

I mentioned that one of the six important grid of the future features is a dynamic system that is interactive with the consumers and markets. An example of a dynamic system that is interactive with consumers and markets is what we refer to as "Prices to Devices." An example is an intelligent air conditioning unit with embedded software and hardware capable of two-way interaction with the power system. The intelligent air conditioning unit will receive day-ahead and hourly electricity prices and day-ahead weather forecast through the Internet. The system will learn the rate of building cool-down and heat-up based on factors such as occupant habits, outside temperature and time of ear, and finally the air conditioning unit will self-optimize to minimize energy costs.

The potential energy efficiency savings from the intelligent air conditioner and similar devices remains a matter of ongoing analysis. A peer-reviewed analysis of 11 studies in 2004 by EPRI indicated an achievable savings of 24 percent of the total U.S. electricity demand, although there was substantial variation among the studies that we reviewed.

Another benefit of the grid of the future is improved reliability and power equality. The total estimated annual cost for the U.S. economy from power outages and power quality disturbances, what I refer to as blink-of-the-eye disruptions, is over $100 billion. By implementing the six important grid of the future features outlined in this testimony, we will enable a robust, interactive and efficient power delivery system that is more energy efficient, more reliable, more immune to power quality disturbances and better able to support a vigorous and growing national economy.

It is a pleasure being here today, Mr. Chairman, and I appreciate the opportunity to provide testimony to the committee on facilitating the transition to a smart electric grid. Thank you.

[The prepared statement of Mr. Howard follows:]

ELECTRIC POWER RESEARCH INSTITUTE

Testimony

Facilitating the Transition to a Smart Electric Grid

Michael W. Howard, Ph.D., P.E.
Senior Vice President, R&D Group
Electric Power Research Institute

May 3, 2007

Thank you, Mr. Chairman, Ranking Member Hastert, and Members of the Committee. I am Michael Howard, Vice President of the R&D Group for the Electric Power Research Institute (EPRI), a non-profit, collaborative R&D organization with major offices in Palo Alto, California; Charlotte, North Carolina; and Knoxville, Tennessee. EPRI appreciates the opportunity to provide testimony to the Committee on "Facilitating the Transition to a Smart Electric Grid." My comments today reflect the work of the talented scientists and engineers who work across our Institute on the many issues associated with electric power delivery system.

The electric power delivery system is a very complex network of over 450,000 miles of transmission, 5 million miles of distribution, and 22,000 substations that tie everything together.

At EPRI, we focus on developing the technology that ensures our existing grid infrastructure is working reliably and safely, while at the same time facilitating the transition of the power delivery system to an intelligent grid that supports both a changing generation mix in a carbon constrained world, and a more effective and efficient participation by consumers in managing their use of electricity.

During the last five years, we have been helping the industry develop and deploy the concept of an intelligent grid through the implementation of our IntelliGrid initiative. The IntelliGrid initiative is developing the methodology, tools and integrating technologies that will help the industry and equipment manufacturers start implementing the electrical grid of the future.

We believe the grid of the future will include six important features:

1. A dynamic system that is interactive with consumers and markets,

2. Self-healing and adaptive,

3. Self optimize to make best use of resources and equipment,

4. Predictive rather than reactive,

5. Able to temporary store large amounts of energy, and

6. Able to accommodate a variety of generation options including renewable generation.

Achieving these objectives will require a much greater reliance on intelligent systems. This includes a power system that can incorporate millions of sensors all connected through an advanced communication and data acquisition system. This system will provide real-time analysis by a distributed computing system that will enable predictive rather than reactive responses to blink-of-the-eye disruptions.

The grid of the future will require an order of magnitude greater number of touch points compared to today's system. For example, where today an electric utility company might monitor and control hundreds of grid devices, in the future it will monitor and control thousands to millions of devices, all designed to provide information on the power systems' performance.

This increased number and scale of touch points will force utility companies to fundamentally change how they think of and approach the grid of the future. The result will be a flexible and secure intelligent power delivery infrastructure that can meet both today's needs as well as tomorrow's consumers' needs for information to better manage their day-to-day energy demands.

As an analogy, consider the airplane. The basic design of today's airplane is the same as 40 years ago; however, today's airplane is controlled very differently. For example, we can now fly and land an airplane without intervention of the pilot. To do so, requires a tremendous number of sensors, communications, and intelligent use of an enormous amount of data about the airplane's aerodynamics, mechanical performance, and surrounding environment. This same analogy can be applied to the electrical power delivery system. While the basic design of tomorrow's power delivery system will be the same, there will be many changes. The most significant will be the number of sensors, communication and controls resulting in a highly automated power delivery system. The challenge is to implement tomorrow's power delivery system while continuing to "fly today's grid."

The IntelliGrid blueprint will improve energy efficiency by enabling "Prices to Devices^{SM}." One of the six important grid features of the future discussed earlier is "a dynamic system that is interactive with consumers and markets." A dynamic system, or "Prices to Devices" allows customers' equipment to respond to price signals provided by the electric utility thereby providing better control of homeowner's or business' electricity costs. This will also enhance peak load management which increases reliability and lowers overall costs to consumers.

As an example of "Prices to Devices" is an intelligent air conditioning unit with embedded software and hardware capable of two-way interacting with the power system. The intelligent air conditioning unit will provide the following features:

- Receive day-ahead and hourly electricity prices and day-ahead weather forecast through the Internet,

- Specify multiple target temperatures as a function of time of day,
- "Learn" the rate of house/building cool-down/heat-up based on factors such as occupant habits, outside temperature, and time of year,
- Optimize operation to minimize consumers' energy costs, and
- Measure and communicate hourly power consumption to energy service provider through the Internet.

The total potential energy efficiency savings from the intelligent air conditioner and similar devices remains a matter of ongoing discussion and analysis. A peer-reviewed analysis of 11 studies in 2004 indicated a median achievable economic potential of 24% of total U.S. electricity demand, although with substantial variation among the studies reviewed. For perspective, a 24% estimated savings potential would dramatically reduce the 40% growth in U.S. electricity use projected by the U.S. Energy Information Administration through 2030. Other analyses, based on the direct experience by utilities over the last 10 years, estimate the economic potential to be on the order of 5–10% at the low end of estimates to substantially higher levels as described above.

Another benefit of the grid of the future is improved reliability and power quality. The total estimated annual cost to the U.S. economy from power outages and power quality disturbances is over $100 billion.

By implementing the six objectives outlined in this testimony, we will enable a robust, interactive and efficient power delivery system that is more energy efficient, more reliable, more immune to power quality disturbances, and better able to support a vigorous and growing national economy.

For more information on the IntelliGrid and Energy Efficiency Initiative, please refer to the following URLs.

IntelliGrid
http://www.epri.com/portfolio/product.aspx?id=1991

Energy Efficiency
http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=CommunityPage&parentid=1&in_hi_userid=39735&control=SetCommunity&CommunityID=302&PageID=-302

As part of this testimony, I would like to submit for the record a background paper EPRI prepared last summer for our 2006 EPRI Summer Seminar titled Advancing the Efficiency of Electricity Utilization: "*Prices to Devices*[SM]"

The background paper begins with several assumptions:

- End-use energy efficiency remains a critically underutilized resource in the United States.

- This resource will become strategically more important as carbon constraints and affordability of energy create greater economic challenges to energy companies and consumers.

- The potential size of the energy efficiency resource is a matter of ongoing debate and analysis; estimates range from 10–25% of total U.S. electricity consumption.

- The upward bound on this potential is likely to grow as technology advances and as regulators and policy makers elevate its strategic priority.

The background paper discusses the efficiency of electricity utilization in three broad categories:

- "Energy efficiency" consists of ongoing technology development and programs in energy efficiency driven by economic and policy drivers. In this sense, these drivers result in a built-in improvement in energy efficiency that is occurring on an ongoing basis. This area has a large and direct bearing on CO2 reduction as well as reduced electricity consumption.

- "Demand response" represents shifting the pattern of the load. This area has a small impact on energy reduction but a large role in enhancing system economics and reliability. It may or may not result in reduced CO2.

- "Dynamic systems" represents the future of networked, smart, end-use devices interacting with the marketplace for electricity and other consumer-based services. Market interaction includes sending direct "Prices to Devices℠." This area may have substantial impacts on system reliability, customer value, modest energy savings, and CO2 reductions.

The central hypothesis of the background paper is that a set of four building blocks is needed to create the environment for dynamic systems to take root and flourish. Together, the building blocks leverage the rapid advances in communication and microprocessor technology to create the ability for consumers to optimize cost while increasing load management capabilities for energy companies.

The following are the four building blocks:

- Communications Infrastructure – It would add new functionality to the electricity system and allow for prices, market data, and decisions to flow in two directions: between electricity supplier/devices and consumers.

- Innovative Rates and Regulation – Regulations are needed to provide adequate incentives for energy efficiency investments for electricity suppliers and consumers alike.

- Innovative Markets – Market design must ensure that energy efficiency measures instituted by regulation become self-sustaining in the marketplace.

- Smart End-use devices – Direct linkage of prices and other parameters to devices would allow dynamic energy management and coordination of networked devices, all on behalf of the customer and the energy company.

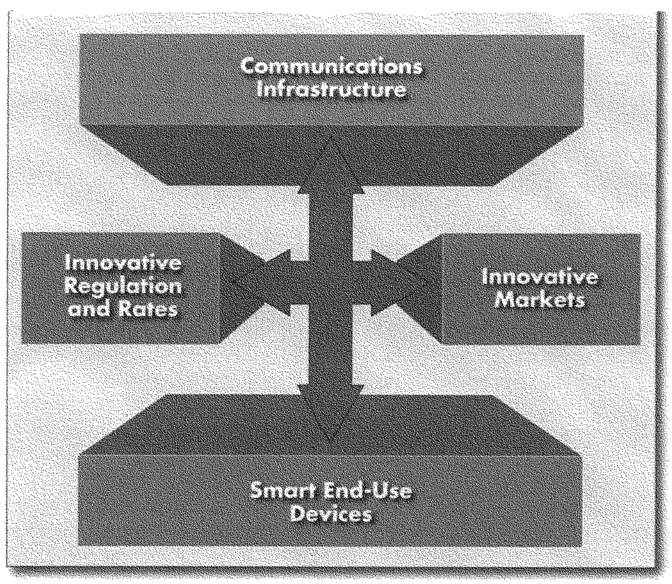
The background paper concludes by identifying the R&D needed to quantify the efficiency potential and to develop the technology infrastructure composed of the four building blocks envisioned in this background paper.

ELECTRIC POWER
RESEARCH INSTITUTE

2006 Summer Seminar

Advancing the Efficiency of Electricity Utilization: "Prices to Devices[SM]"

Background Paper
2006 EPRI Summer Seminar



Prepared by the EPRI Energy Technology Assessment Center

TABLE OF CONTENTS

1 INTRODUCTION

The purpose of this background paper is to help frame the issues and stimulate discussion at the EPRI Summer Seminar, August 7–8, 2006, on the subject of "Advancing Energy Efficiency and End-Use Technologies." This paper asserts that increased efficiency of electricity utilization is an essential element of any strategy seeking to meet national goals to conserve scarce energy resources, minimize air pollution, control global carbon emissions, protect and enhance economic growth, and move toward a more sustainable long-term energy supply. We offer a vision of an "infrastructure" of advanced technologies and supporting policies that we believe is necessary to fully realize the benefits of energy efficiency for both consumers and utilities.

Despite its multiple benefits, energy efficiency remains critically underutilized in the U.S. energy portfolio. This is largely due to the dominance of supply-oriented economic incentives, the legacy of regulatory policies, and the underutilization of advanced technology for customer interactions. With so many aspects in play, there is little agreement on the full potential of cost-effective energy savings, but most observers support the view that the potential is very large.

The potential for energy efficiency remains a matter of ongoing discussion and analysis. A peer-reviewed analysis of 11 studies in 2004[1] indicated a median achievable economic potential of 24% of total U.S. electricity demand, although with substantial variation among the studies reviewed. For perspective, this 24% estimated savings potential would dramatically reduce the 40% growth in U.S. electricity use projected by the U.S. Energy Information Administration through 2030[2]. Other analyses (including those presented in this paper), which have been based on the direct experience by utilities over the last 10 years, estimate the economic potential to be on the order of 5–10% at the low end of estimates to substantially higher levels described later in this paper.

[1] Nadel, Steven et al., "The Technical, Economic, and Achievable Potential for Energy Efficiency in the U.S. – A Meta-Analysis of Recent Studies," Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings.

[2] U.S. Energy Information Administration, "Annual Energy Outlook 2006 with Projections to 2030, February 2006. Energy Information Administration, DOE/EIA0383 (2006).

To facilitate discussion of the proposed vision, it is necessary to consider several aspects of the efficiency of electricity utilization: energy efficiency, demand response, and new strategies that enable access to the full range of benefits in these areas. This paper explores existing knowledge of these areas and how we might transition to the strategic vision discussed here.

2
FOUR BUILDING BLOCKS

The central hypothesis of this paper is that an interactive set of four building blocks constitutes an emerging "energy efficiency infrastructure" that will amplify the effectiveness of energy efficiency and demand response while creating the capability of widespread real-time continuous optimization. These four key building blocks are:

- Communications infrastructure
- Innovative rates and regulations
- Innovative markets
- Smart end-use devices

Understanding the interactions and integration of functions in these areas with the existing power system will be critical to meeting the national need for radical improvements in energy efficiency and demand response. Contemplating such an "energy efficiency infrastructure" leads to several challenges, including a number of research and development priorities.

3
STRATEGIC CONSIDERATIONS

A number of strategic challenges face the electricity industry:

- Increasing electricity production cost
- Steady growth in electricity demand
- Effective management of greenhouse gas emissions
- Pressures to control consumer energy costs
- National policies driving increasing energy independence

The value of a strategic approach to energy efficiency and demand response is that it can address these issues simultaneously. As a result, energy efficiency and demand response are being explored today with a new sense of urgency by policymakers and industry leaders alike. It's evident that although energy efficiency and demand response offer many cost-effective alternatives to adding new capacity, substantial potential remains untapped.

Economic growth has been accompanied by increasing electricity intensity. Total electricity demand has continued to steadily grow (as reflected in the Energy Information Agency's annual energy outlook studies), and total electricity sales are projected to increase 50% by 2030.[3] Concurrent with growing demand, fuel, production, and delivery costs have also risen, resulting in higher energy costs to consumers in all sectors (projected 7% increase by 2030, normalized to 2004 dollars.[4] These continuing trends, coupled with volatility and fuel cost increases in the oil and natural gas sectors, have created renewed political attention on ensuring continued affordability of energy and promoting national energy independence. The emergence of climate change and its multiple effects on the energy system introduces an important additional dimension to consider.

Climate Policy as a New Strategic Context for Energy Efficiency

If climate policy is to achieve the goal of stabilization of concentrations of greenhouse gases in the atmosphere, a near-complete transformation of the energy system will ultimately be required—from a global energy system that that is 85% CO_2-emitting today to one that is predominantly non-emitting. Electricity and an expanded set of electric end

[3] Figure 55, U.S. Energy Information Administration, "Annual Energy Outlook 2006 with Projections to 2030, February, 2006. Energy Information Administration, DOE/EIA0383 (2006).

[4] Ibid, Figure 66.

uses will play a critical role in this transformation, with electricity expected to play a greater role in the energy system the tighter the CO_2 constraint. In a carbon-constrained world, many direct uses of fossil fuels will likely be displaced by electric substitutes fueled by electric generation technologies that produce an ever increasing number of kWh per ton of CO_2 emissions.

The implications of these policies for energy efficiency, demand response, and dynamic systems will often be simple: for example, climate policy makes energy and electricity more expensive, thereby increasing the return on energy efficiency investments and driving consumers to use less energy. But, in other instances, the interactions are quite complex: for example, demand response programs that move load from peak to off-peak hours may actually increase CO_2 emissions in some regions if this demand is met with baseload coal (which has greater CO_2 emissions/kWh than gas-fired generation). Figure 1 illustrates one scenario representing a mix of generation technologies and energy efficiency strategies that could result in an atmospheric concentration of 550 ppm of CO_2 by 2100. "Zero carbon-emitting" refers to nuclear power and non-emitting renewables.

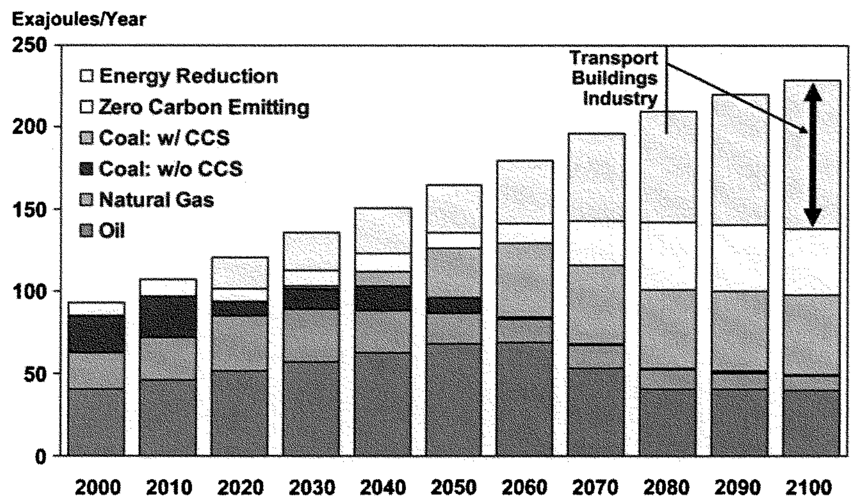


Figure 1
Reducing CO_2 Emissions Will Often Involve More Efficient End-Use Emissions[5]

Climate policy will increase the cost of energy for CO_2-emitting generation technologies, improving the economic attractiveness of individual energy efficiency investments. In the electric sector, natural gas-fired generation sets the electric price in many regions. A

[5] Clarke, Leon, James Edmonds, Henry Jacoby, Hugh Pitcher, John Reilly, and Richard Richels, "Climate Change Science Program Synthesis and Assessment Product 2.1, Part A: Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations. Draft for Public Comment." June 26, 2006.

$10/ton value assigned to CO_2 emissions could increase the cost of natural gas peaking equipment by $5–7/MWh, likely creating substantial increases in wholesale and retail electricity markets. In regulated markets, average generation costs could also rise significantly with this additional cost, depending upon the composition of the generation portfolio and details of the climate policy. State utility commissions would determine how these costs would be allocated across consumer groups and levels of electricity usage. In either regulated or unregulated markets, a CO_2 value can significantly improve the economics of individual energy efficiency projects.

Figure 2 schematically illustrates the potential effect of CO_2 emissions allowance prices on the relationship between end-use efficiency and generation capacity investments. Nominally, as prospective CO_2 emissions allowance prices rise, the net present value of CO_2-emitting generation investments goes down, while the net present value of avoided energy consumption and CO_2 emissions due to efficiency increases. Consequently, a characteristic "break-even" CO_2 emissions allowance price exists for a given combination of a specific generation technology and efficiency investment cost. The strategic value of investment in energy efficiency measures can be evaluated from this perspective relative to supply-side investment options. Other benefits(although more difficult to calculate) associated with demand response and dynamic systems measures would include reduced cycling of generation and T&D assets, reduced potential for transmission congestion, and shifting of load to lower cost forms of generation.

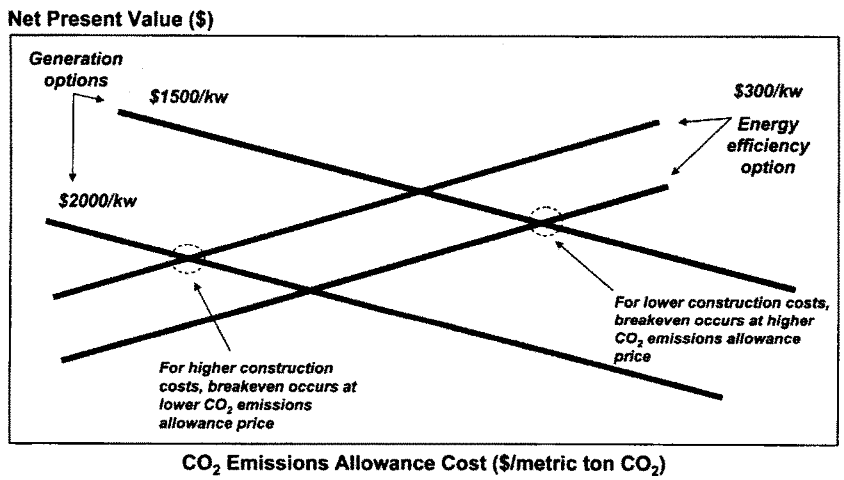


Figure 2
Net Present Value Comparison: Generation vs. Energy Efficiency

Energy Efficiency and Demand Response Segmentation

Management of energy and electricity consumption can be viewed in three segments:

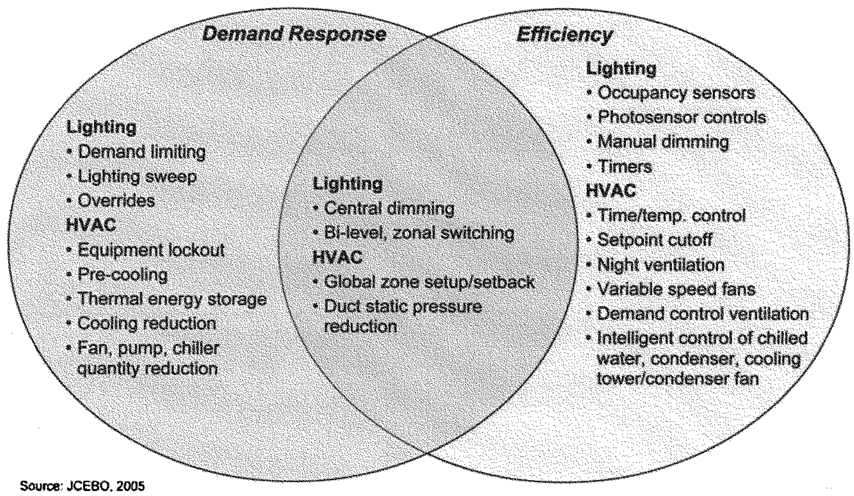
- Energy efficiency
- Demand response
- Dynamic systems

"Energy efficiency" refers here to technical improvements in energy efficiency of devices fueled by the continuous drive in all businesses to improve economic efficiency. The aggregate effect of this economically driven activity is commonly estimated to reduce the growth in electricity demand in the United States by as much as 1% per year. "Energy efficiency" as discussed here also encompasses state and federal measures designed to stimulate the development and deployment of energy efficiency programs, new appliance standards, and incentives for consumers to invest in new energy equipment or to change behavior. Because these improvements and actions driven by policy are ongoing, they represent a built-in energy efficiency effect.

"Demand response" provides time- and price-dependent variation in demand. It provides a measure of control over the shape of the electrical load, and the ability to reduce peak load in supply-constrained situations. Much of the research performed to date has focused on technologies enabling shifting of load from peak periods to other times of the day.

"Dynamic systems" represents the concept of networked devices automatically optimizing customer value based on multiple inputs (including price, weather, and other loads) within constraints imposed by electricity system operations. It can be used to reduce energy use and demand in conjunction with other services for home and building automation. "Dynamic systems" combines some of the tools developed in demand response programs with advanced communications, embedded intelligence, and emerging "smart" end-use device technologies. The integration of an advanced communications infrastructure with the dynamic systems described here will also enable the retail load-serving entity (LSE) to engage the retail consumer in the operation of the consumer's devices and processes. This will enable optimization of the LSE's system within the limits of the consumer's preferences. Both the LSE's desired optimization and the consumer's preferences will change through time, so that this engagement will require continual modification.

It will be possible to tackle multiple priorities with the same technologies in many cases. Figure 3 illustrates this, for lighting and heating, ventilating, and air conditioning (HVAC) applications. These functions are among the areas of highest electricity consumption in the residential and commercial sectors. More sophisticated algorithms for lighting and HVAC control are valuable for both energy efficiency and demand response.



Source: JCEBO, 2005

Figure 3
Overlap of Efficiency and Demand Response[6]

[6] Kiliccote, Sila and Mary Ann Piette. International Conference on Enhanced Building Operations (ICEBO). 2005 Conference Paper, September 1, 2005, "Advanced Control Technologies and Strategies Linking Demand Response and Energy Efficiency." Lawrence Berkeley National Laboratory, Berkeley, CA, LBNL #58179.

4

2020 VISION OF THE "EFFICIENCY INFRASTRUCTURE"

The vision underlying this paper is that of an infrastructure that fully integrates end-use energy efficiency and demand response measures and is primed to enable broader use of networked communications with smart end-use devices to achieve "dynamic systems" capabilities. Dynamic systems could, in principle, unleash the next wave of efficiency potential.

The advantage of dynamic systems is that they could optimize electricity supply and demand across multiple criteria, including economic, environmental, societal, and technical. System protection and power quality could be better managed. Broad societal objectives, from environmental protection to consumer protection, could be internalized, managed, and monitored more readily. Supplier services could become more diverse and put out into the marketplace for trial. Consumer choice could become more fine-grained as price signals are sent directly to decision-making appliances (prices to devices℠).

The strategic challenges facing electricity suppliers highlight the necessity to use all resources effectively to sustain an electricity system that supports economic growth within environmental objectives. Efficiency, demand response, and dynamic systems collectively represent a strategic option that should be considered in the same planning context as generation and transmission and distribution (T&D) asset development.

Realizing the expanding potential for efficiency requires an integrated combination of a communications infrastructure, policies and regulations, markets, and intelligent, adaptive devices. A fully integrated combination of these building blocks will enable the infrastructure envisioned in this paper.

Key Characteristics of the Infrastructure

This "efficiency infrastructure" would represent a significant step beyond current capabilities in two major ways: (1) aggregation and coordination of consumer data and (2) continuous optimization. First, an integrated infrastructure on the end-use side would feature automated self-management of loads at multiple levels: an individual device, a group of devices owned by the customer, or a group of loads for which aggregated treatment by the distribution operator is highly desirable. This infrastructure would permit the coordination and data exchange necessary for such flexibility as well as the means by which customer priorities and distribution operator priorities can be balanced or negotiated. Second, such an infrastructure would rapidly accelerate the development of software and hardware necessary for "self-learning." Thus multiple externalities—rate structures, meteorological conditions, changing economic drivers, or evolving customer behavior or processes–could be addressed on an ongoing basis while minimizing human intervention.

The efficiency infrastructure would have the following system characteristics:

- **Consumer portal –** Widespread use of advanced meters, serving as consumer portals (gateways to the consumer premises) facilitating the two-way flow of information, price signals, decisions, and network intelligence in and out of the customer's premises. The distributed intelligence built into appliances, tools, equipment, and processes could engage directly with the outside world or be subordinated to a larger energy management system governing all such transactions on behalf of the customer.
- **Two-way learning –** The ability of the on-site energy management systems to learn about the customer's preferences for comfort and convenience and to use that knowledge to optimize patterns of demand along with heating, cooling, lighting, ventilation, refrigeration, and so on. Similarly, the electricity supply system would also engage in continuous learning and adaptation to customer demand on multiple scales.
- **Distributed energy resources –** Standards and protocols, coupled with the communications and adaptive capabilities described above, would allow distributed generation and storage to be readily integrated into either the customer facility or the electricity distribution system in a "plug and play" fashion. Utilities would have the incentives and the means to dispatch significant portions of these distributed resources to enhance power reliability and quality and to meet critical needs.
- **Enhanced services –** The array of services available to consumers and to energy companies would expand, including options such as automated interface of multiple end-use devices with multiple rate structures or automated load management of a group of devices on multiple distribution feeders.

Four Building Blocks of an Efficiency Infrastructure

At EPRI, we believe that an integrated set of four building blocks—communications infrastructure, innovative rates and regulation, innovative markets, and smart end-use devices—constitutes an emerging energy efficiency infrastructure that will make the dynamic dimension of energy efficiency more robust over time, substantially expanding the potential for energy efficiency in the broadest sense (see Figure 4).

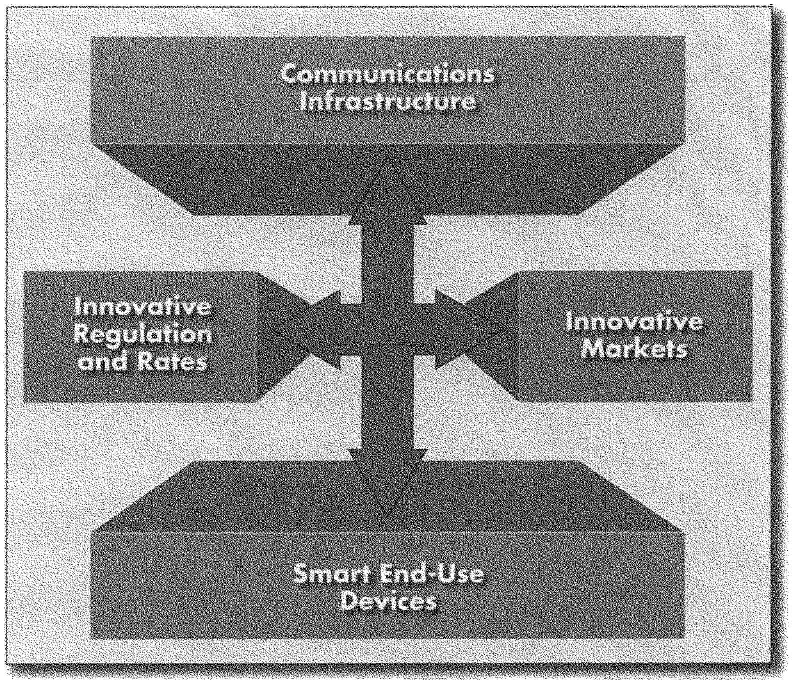


Figure 4
The Four Building Blocks of the Energy Efficiency Infrastructure

The integration of the four building blocks is necessary to realize the full potential of the energy efficiency infrastructure. In the future, effective communication of increasingly larger amounts of data will be required, and market rules and regulatory conditions must exist to incent and enable improved efficiency, demand response, and dynamic systems. Finally, a set of advanced end-use technologies with embedded intelligence will be required to implement the energy management necessary to achieve dynamic systems.

Figure 5 shows how the importance of these four elements might shift over time. In particular, regulatory innovation could decrease as market dynamics begin to take over the process, while the importance of both communications and smart end-use devices will increase substantially as the electricity supplier community begins to exploit the full and growing potential of the digital age.

In contrast, poorly designed rates and regulations in the early phases could hinder the development of markets as well as the innovative end-use technologies needed to support markets.

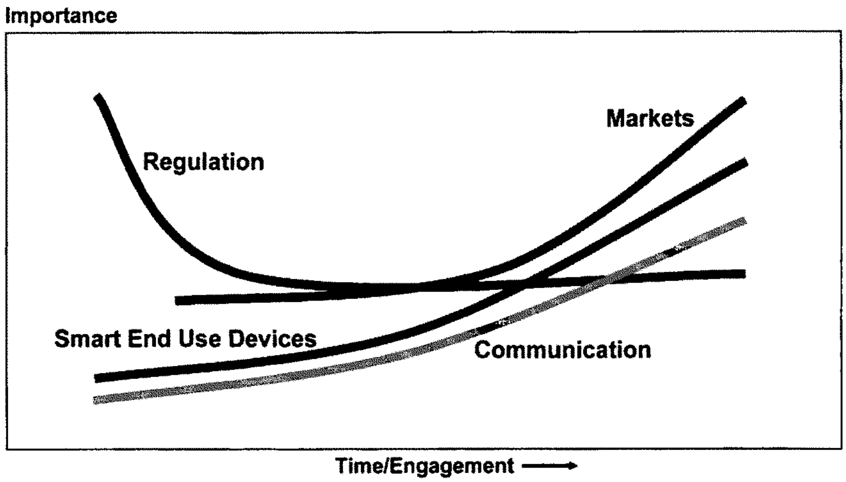


Figure 5
Importance and Value of Building Blocks vs. Time and Engagement

Communications Infrastructure

The communications infrastructure links the other building blocks because the energy efficiency and demand response strategies are predicated on measurement and exchange of data with other devices and systems. New functionality built into the existing electricity system should allow electricity providers to fully utilize the new technical capabilities, ranging from smart appliances in the home to the high-tech industrial processes. For example, the ability for two-way communications between electricity suppliers and consumers' devices would enable price information to influence electricity usage. Information would be exchanged directly with smart end-use devices, so consumers do not have to make hourly or daily energy choices. This "prices to devices^{SM}" approach would allow the device itself to optimize its operation to meet predetermined costs or conditions. Multiple devices on consumer premises, for example, could coordinate among themselves not to exceed an aggregate demand limit set by the consumer.

Some types of advanced meters with two-way communications capability exist and have been deployed at some utilities. Communications protocols are typically based on a signal communicated through the power line or wirelessly to an Internet access point (similar to a wireless computer network in a home). A number of U.S. utilities have conducted trials of limited numbers of smart meters and associated communications. Europe is also active in this area. One of the most ambitious and significant deployments of such meters with advanced communications capabilities is in Italy by ENEL: more than 27 million meters have been installed. These have limited two-way communications capability and are currently addressing automatic transmittal of time-of-use rates to the meter and transmission of consumption data back to the utility. Similarly, Electricité de France is considering installation of 34 million meters. Several other European utilities have installed several hundred thousand meters.[7] Programs in the United States are not as extensive, but it is significant that the California experiment described next indicates that customers will respond to time-varying prices when the user is provided with enabling technology that gives them an element of control over their energy expenditures.[8]

EPRI's IntelliGrid Consortium has developed an advanced communications architecture that includes the delivery system/load interface. EPRI is working with several of the key U.S. and international standards bodies focusing on developing communications standards that will enable the added functionality necessary for smart metering and demand response capabilities. Figure 6 outlines the applications options of the communications infrastructure underlying a strategic dynamic systems capability.

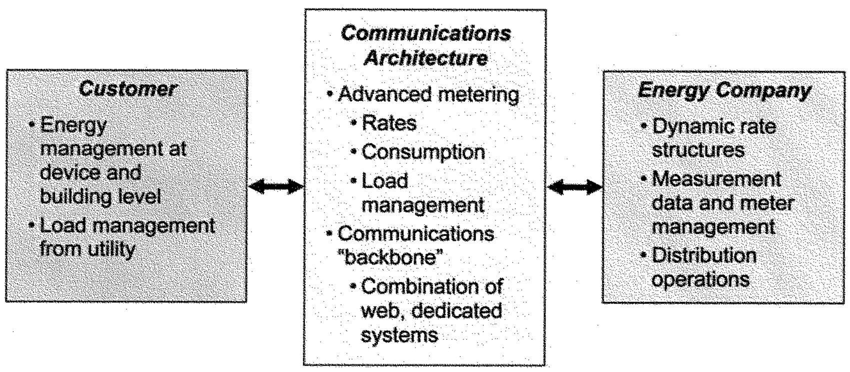


Figure 6
Key Communication Applications

Finally, the need to ensure the security and reliability of the power system will place additional demands on the communications infrastructure. Security requirements span the physical assets of the power system—power plants, T&D facilities, substations, and control rooms—as well as the cybersecurity elements of the system. With respect to the latter, it's important to note that many of the changes to the communication infrastructure undertaken to improve overall system reliability should also improve cybersecurity.

As shown in Figure 7, multiple two-way networks can be used to address the varying needs of the different elements of the communications infrastructure. Consumer interactions with the utility or load-serving entity could be handled by the Internet (or

---

[7] Jouaire, J. and Richard Schomberg, Electricité de France, presentation at Metering America, April 24, 2006, Atlanta, Georgia.

[8] Faruqui, Ahmad and Robert Earle, "Demand Response and Advanced Metering," Regulation, Spring 2006.

Internet successor). The Internet could be used for information exchange only; ideally, control functions and connection to the grid would be limited to secure networks. Local area networks may provide links between the meter (the service measuring system) and the consumer. This function will require handling large amounts of business-sensitive information. Security and privacy issues will need to be addressed and are best handled by the hardware and software.

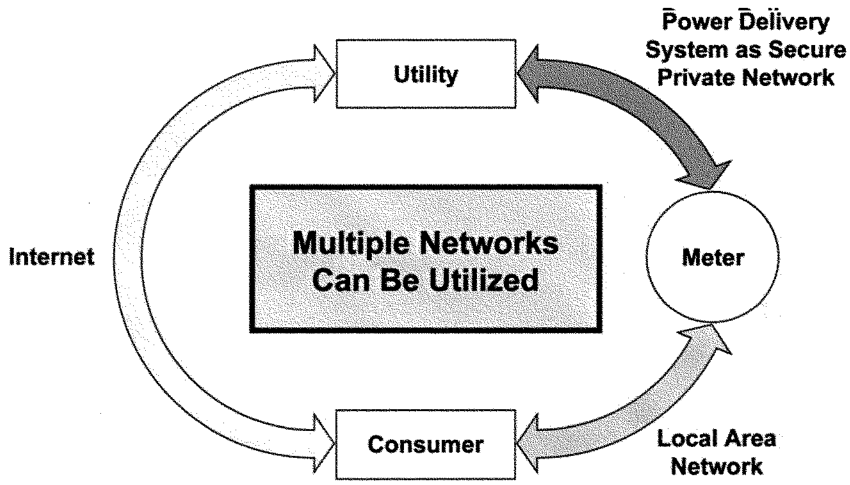


Figure 7
Use of Multiple Networks for Communications

Innovative Rates and Regulation

Traditional ratemaking approaches have linked a utility's financial health to the volume of electricity sold, thus providing a disincentive to investment in energy efficiency, demand response, and ultimately, the consideration of demand-side resources on the same playing field as generation resources. However, over the last two decades, many state regulatory bodies have experimented with various approaches to energy efficiency and demand response, providing a rich field of experience for today's regulators to draw upon for future innovations in regulation.

For regulators, energy efficiency and demand response can be viewed as tools to help expand the portfolio of options, create new capabilities and functionality in the power system, and establish more of a dynamic "partnership" between utilities and their customers. Going forward, it will require a renewed business model that goes beyond that of strictly selling electricity. Viable business models are needed to place energy efficiency resources on a competitive platform with new generation.

Regulation should:

- o Remove the disincentive of lost revenues so that the utility does not lose money by selling less electricity
- o Allow recovery of investment costs in infrastructure
- o Provide incentives for utilities to achieve energy efficiency and demand response goals

Prior experience has shown that these business models must be designed carefully to avoid unintended effects detrimental to utilities and consumers.[9]

In the United States, significant legislative and regulatory experience associated with programs designed to foster energy efficiency and demand response exists and includes this: since passage of the 1980 Pacific Northwest Electric Power Planning and Conservation Act authorizing the states of Idaho, Montana, Oregon, and Washington to form the Council as an "interstate compact" agency, the Northwest Power and Conservation Council has been studying energy efficiency and demand response.[10] For the past five years, the Council has issued its annual Northwest Electric Power and Conservation Plan, which systematically relies on energy efficiency and demand response as part of the regional integrated resource planning process.

Note that the following data from the United States[11] are illustrative of programs in place as of the end of 2003:

- o New Mexico's legislature has declared energy efficiency the primary resource for meeting demand growth, followed by renewables, distributed generation, and fossil generation, in that order.
- o California and Hawaii have been some of the leaders in regulatory innovation by decoupling electric utility profits from sales volume, positioning energy efficiency as the state's most important electricity-based resource, and adjusting the loading order accordingly for new electric resources.
- o Pennsylvania and Connecticut now include energy efficiency as an integral part of their resource portfolios.
- o The Independent System Operator (ISO) New England put out a request for proposal for an energy efficiency resource that could address a growing reliability problem. The winning bid was a 5-MW commercial office lighting project.
- o Minnesota, Iowa, and Massachusetts provide utilities with lost revenue adjustments for energy efficiency.

---

[9] EEI/NRDC Letter to NARUC Commissioners, "Electric Resource Portfolio Management," November 18, 2003.

[10] Northwest Power and Conservation Council, "Fifth Northwest Electric Power and Conservation Plan," 2005.

[11] *Revealing the Value of Demand Response: Regulatory and Market Options.* EPRI: Palo Alto, CA: 2003. 1001638.

- Massachusetts and Minnesota also use system benefit charges to set spending budgets for energy efficiency. The formula is 2.5 mills/kWh in Massachusetts, and 1.5% of gross operating in Minnesota. The New York commission has set the 2006 budget at $175 million.
- Performance incentives are used in several states, including Rhode Island, Massachusetts, Connecticut, and Nevada.

New programs incorporating other aspects of energy efficiency and demand response are under development across the country. A description of these programs is beyond the scope of this paper, but some specific examples are described next.

Innovative Markets

Market innovation in the context of this paper has two dimensions: innovations needed to stimulate the market for energy efficiency capital stock as well as energy efficiency programs and those innovations needed in the structure of wholesale and retail electricity markets to stimulate dynamic systems.

Retail Markets for Energy Efficiency

The technical potential for improving energy efficiency in appliances, equipment and processes is substantially greater than anything realized to date. The actual achievements are likely to remain suboptimal without concerted efforts to intervene in the marketplace for equipment. A key reason is that both consumers and suppliers are focused on a wide array of performance features, only one of which is energy consumption. Most often energy efficiency improvement is simply a by-product of overall performance improvement in equipment and appliances.

As mentioned in the discussion of regulation, the current primary intervention in the marketplace occurs through regulatory action, the establishment of appliance standards and building codes, and the creation of consumer incentives. In addition, electricity suppliers have used a number of measures over the last few decades to stimulate the marketplace, some with significant and lasting results.

Key measures include:

- **Trade ally cooperation**, including home builders and contractors, professional societies, and trade groups
- **Direct customer contact**, for example, by market service representatives, energy auditors, and equipment servicing
- **Energy Star Program**, a large national effort to publicize efficiency improvements possible through innovative technology
- **Direct incentives**, including cash grants, rebates, buyback programs, and low-interest loans
- **Alternative pricing**, including time-of-use rates, inverted rates, and seasonal rates.

Wholesale Electricity Markets

The four building blocks provide for "24/7" time- and price-dependent variation in demand. This will entail structural accommodation by wholesale and retail power markets and is very likely to have a substantial impact on the price behavior of power markets. This in turn will require accommodation by the energy generators, energy distributors, and consumers, with particular attention to changes in load patterns, price patterns, and financial risk management. Marketplace drivers to advance efficiency in equipment and processes combined with development of advanced communications and dynamic systems will create the technology backbone on which innovative value propositions can be built to include efficiency and demand response elements.

Markets to Stimulate Energy Efficiency and Demand Response

As mentioned in the discussion of the building blocks of energy efficiency, market systems emerge as a key enabler that can allow market participants and customers access to new levels of value. Coupled with technology advances discussed in the communications and smart-end use device building blocks and with creative rate structures, markets can provide a platform for creative new value offerings that benefit both energy consumers and energy providers.

Reliance on market features that allow participants to develop new value presumes that competition will drive innovation and will successfully attract capital willing to accept the risks. There is ample evidence from well-developed markets on the wholesale energy side that this type of innovation occurs. In a recent example, one major northeast utility is obligated to sell any excess energy (above its native load) at a market clearing price. This ensures maximum cost-effective utilization of the generation asset and encourages functional market processes, whether the market prices are lower or higher than contract prices.

In comparison, development of markets on the consumer side is much less advanced. Numerous possibilities can be envisioned in a well-developed retail market. With appropriate rate structures, some energy-intensive businesses will find it cost-effective to re-engineer their processes to optimize their energy usage or to achieve energy flexibility and profit from dynamic systems. Others might find it more profitable to not operate under certain conditions where they could be compensated for reducing load, essentially adding to the capacity margin. A niche for aggregated load management could emerge in which aggregators could make financial commitments to owners of different loads and offer aggregated load management services to utilities under certain conditions as a hedge against situations where the additional capacity is needed. Utilities could provide additional value-added products other than electricity, for example, appliance diagnostics.

Appropriate market features enabling new innovative value propositions are necessary to enable market participants to adequately differentiate themselves to consumers and thus compete. For example, simple peak-shaving capabilities, while valuable to utilities, are often of only moderate value to consumers since the energy cost reduction may not be significant (however, there are large benefits to the economy and society from avoiding power curtailments to maintain system reliability). Another critical issue that can be addressed by markets is balancing important priorities for consumers, society, and market participants. Markets increase the number of organizations looking to create solutions that respond to all priorities.

An interesting perspective on markets relative to the infrastructure concept discussed in this paper is that the emergence of the other three building blocks in many ways creates visibility and transparency on how value can be derived from investments in efficiency and demand response, thus incenting creation of markets where this value is accessible.

Several aspects of value become apparent:

- Deferral of investment in generation and/or T&D assets. Such deferral has a significant value because the present value associated with the principal and interest for the deferral period is permanently avoided.
- Capital and ensuing operations and maintenance investments in low-capacity factor peaking plants could be reduced. The marginal cost of peaking generation is very high and usually least profitable for investors.
- Uncertainty on potential profitability of generation investments associated with potential CO_2 emissions allowance costs could be hedged in part by strategies including efficiency, demand response, and dynamic systems measures. In essence, some of the "risk premium" associated with investment in generation potentially affected by CO_2 policies could be partially mitigated.
- A robust market in which multiple providers of "negawatts" exist would increase competition and reduce "peakiness" in spot energy prices because those "negawatts" could then be offered in other markets.

The design of new markets and contracts will require a flexible regulatory approach and proactive commitments on the part of all market participants to address the challenges of implementing the new structures. The advances discussed in the other building blocks composing the energy efficiency infrastructure will permit delivery of value to all stakeholders at a scale that will drive market development.

Smart End-Use Devices and Strategies

Many end-use technologies are beginning to evolve through advances in distributed intelligence, from static devices to those with much more dynamic capabilities. Southern California Edison (SCE), for example, has proposed a pilot program that will use Westinghouse's two-way, wireless, dimmable energy efficiency T-5 fluorescent lighting as a retrofit for existing T-12 lamps in commercial, educational, and industrial facilities.

SCE will be able to dispatch these lighting systems using wireless technology and reduce lighting load at those facilities by as much as 50%.[12]

Similarly, air conditioner efficiency could be made more dynamic. An example of the substantial impact of intelligent devices can be seen in terms of space cooling. Embedded software and hardware in either a residential air condition system or a commercial HVAC system could provide the following capabilities:

- Ability to receive day-ahead and hourly electricity prices and day-ahead weather forecast through the Internet
- Ability to specify multiple target temperatures as a function of time of day
- Ability to "learn" the rate of house/building cool-down/heat-up based on factors such as occupant habits, outside temperature, and time of year
- Optimized operation to minimize consumers' energy costs
- Ability to measure and communicate hourly power consumption to energy service provider through the Internet

An example of potential savings comes from one of three pricing experiments in California. Each experiment informed customers of future electricity prices. One pricing experiment was day ahead, another four hours ahead, and one featured enabling technologies in the form of smart thermostats that were price sensitive and designed to increase air conditioner settings when electricity prices increased. As reported by Ahmad Faruqui and Robert Earle of CRA International in the article, "Demand Response and Advanced Metering," "the experiment revealed that customers did respond to time-varying prices. On average, residential customers reduced peak loads on critical days by 13.1 percent...Customers equipped with enabling technologies (automatic price-sensitive thermostats) delivered a response that was twice as high as those customers who did not have enabling technology."[13]

In the longer term, networked intelligence will dominate. EPRI conducted significant research in smart appliances and networked homes in the 1990s and developed products to capitalize on the availability of information to monitor load at the device, for example, Non-Intrusive Appliance Load Monitoring System (NIALMS). But when deregulation changed EPRI's customers' business model, research in this area slowed. Similarly, companies like Cisco dropped their consumer business group focused on networked devices for the home.[14] These efforts were ahead of their time. Today, networked devices are a commonplace topic to suppliers of consumer electronics, software, and networks. There are now conferences and web sites that concentrate on home and building automation, machine-to-machine communications, and networking technology.

---

[12] Southern California Edison Design and Engineering Services, Lighting Technology Center, Remote-Controlled Dimmable Lighting.
http://www.sce.com/RebatesandSavings/DesignandEngineering/SoCalLightingCenter/RemoteControlledLighting.htm

[13] See note 8.

[14] "Cisco Plans Its Home Invasion," *Newsweek.* March 20, 2006.

Major hardware and software suppliers such as Intel and Microsoft now envision that every consumer device that **can** be networked **will** be networked. Cisco's CEO John Chambers has a grand vision of the Home in the 21^{st} century based on a "digital lifestyle."[15] Consumers will use these networked appliances in the home for entertainment, convenience, healthcare, and energy management. Building management systems will use networked appliances for lighting, comfort, and energy management.

Standards are in development to ensure that products can work together on networks. Open architecture to enable interoperability appears to be accepted, although it has taken years to achieve that. Virginia Williams, Director, Engineering & Standards, Technology and Standards, Consumer Electronics Association, said, "our own members...want a proprietary network. People don't buy networks; they buy components, and they expect to be able to mix and match them, and they want competition on any given product. So the idea of a single-brand network...set back the industry maybe a decade."[16]

With the home and commercial network in place to meet consumer demands such as entertainment, comfort, and energy management, adding the capability to receive electricity information will simply be another function. Managing device operations to respond to electricity price signals, for example, will be another added functionality. Consumers will be able to select their energy management scheme to operate automatically. Energy management schemes can take many forms, for example, to meet a desired comfort level at the minimum cost. Eventually, all electronic devices will have these capabilities, and the energy efficiency capabilities will be intrinsic to the devices and the networks.

Descriptions of other innovative end-use technologies are provided in Appendix A.[17]

---

[15] Ibid.

[16] Williams, Virginia, "Consumer Electronics Association," *Electronic Engineering Times*. January 2006.

[17] World Energy Council, *Energy End-Use Technologies for the 21^{st} Century*. London, England (2004).

5
VALUING THE VISION

Can the priorities and investments implied by this national energy efficiency vision be justified by its benefits to utilities, consumers, and the society at large? We believe that they can, and as the potential energy savings grow over time, as technology advances, and as regulators and policy makers embrace energy efficiency as a major alternative to energy supply, these benefits will certainly grow.

Numerous energy efficiency programs by states and individual utilities have been in place for several decades, with mixed results. Utility restructuring that began in the 1990s set some of these programs back, while others withered away. Some regions have continued to aggressively pursue energy efficiency and demand response in integrated resource planning; the annual Electric Power and Conservation Plans developed by the Northwest Power and Conservation Council, a compact of Washington, Idaho, Montana, and Oregon, are examples.[18] Nevertheless, there is a consensus that the nation has achieved only a small fraction of what is possible in this broad area. For example, there is very high potential for improving energy efficiency in four major areas of electricity consumption:

- Residential and commercial lighting
- Efficient appliances
- Industrial process improvements
- Air conditioning and refrigeration

The potential for energy efficiency remains a lively topic for discussion and ongoing analysis. A variety of studies have been conducted in various states and regions on the "achievable potential" efficiency improvement (a subset of technical and economic potential), using a variety of measures, assumptions, and approaches. Details of these studies are included in Appendix B and summarized in Figure 8 and Table 1.

Figure 8 captures in conceptual form the general findings of low, medium, and high estimates of energy savings, at roughly 10%, 20%, and 30% of total U.S. electricity consumption. The lower figure represents the most conservative approach, using bottom-up analysis of actual implementation experience by electric utilities, current policy, regulations, and incentives.

[18] See note 10.

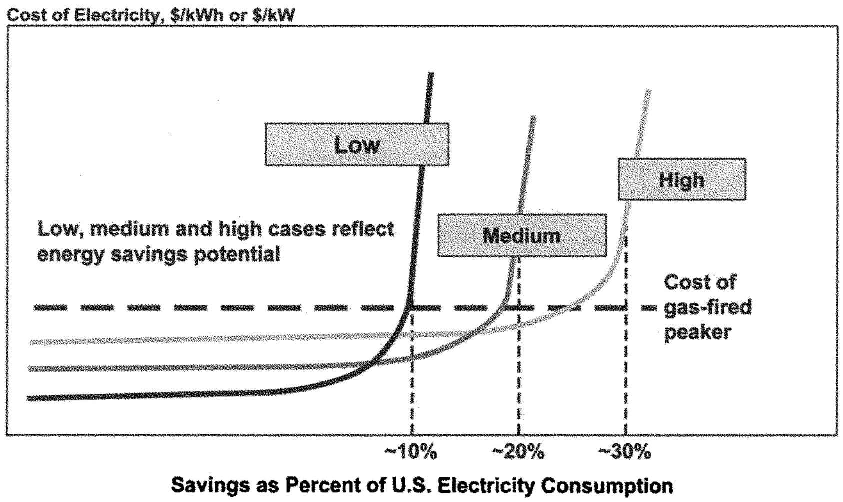


Figure 8
Achievable Potential Energy Savings

The medium curve in Figure 8 is representative of those that show up in many analyses based upon top-down assumptions of what is possible by pursuing aggressive deployment strategies, optimizing regulation, and providing sufficient incentives. It certainly reflects the thinking in California, where in January of 2006, utilities kicked off the most aggressive energy efficiency program in the country that provides $2 billion in funding from rates over the next three years.

The higher curve represents estimates from a few top-down studies that make generous and optimistic assumptions about regulation, incentives, and future technology. Although it appears to be a stretch for today's reality, EPRI believes that the emerging energy efficiency infrastructure and the capability of dynamic systems of services for customers and utilities of the future put this higher figure as a viable target for the future. The Annual Energy Outlook from the Energy Information Agency projects (assuming implementation of best-available technology today) potential energy efficiency savings of 29% across all three consumption sectors.[19]

Certainly as energy costs rise, the attractiveness of various energy efficiency options will increase. This in turn will push the upper bound of achievable potential energy savings.

Table 1 summarizes several major sources of studies on efficiency potential. Steve Nadel and his team at the American Council for an Energy-Efficient Economy (ACEEE) have undertaken a meta-analysis of 11 studies and found the U.S. median of achievable energy savings at 24% of U.S. electricity consumption.[20] The Best Practices Working Group of

[19] Figures 38, 42, and 48. U.S. Energy Information Administration, "Annual Energy Outlook 2006 with Projections to 2030," February 2006. Energy Information Administration, DOE/EIA0383 (2006).

[20] See note 1.

the National Action Plan for Energy Efficiency surveyed a set of analyses indicating achievable potential in the range of 10% for demand savings and 12% for energy savings.[21] The details and sources of the studies are included in Appendix B. It is important to recognize that three types of potential are traditionally defined in these studies. "Technical" refers what is possible based solely on technical feasibility. It is thus typically the highest estimate of potential. "Economic" represents a reduction to the technical potential considering requirements for cost effectiveness. "Achievable" further reduces the economic potential considering other factors that may limit the scope of implementation of energy efficiency and demand response measures. Thus, achievable potential is typically the lowest and most conservative estimate.

---

[21] "Energy Efficiency Program Best Practices," Best Practices Working Group of the National Action Plan for Energy Efficiency, June 2006.

Table 1
Achievable Potential Electricity Efficiency and Demand Response

State/Region	Demand Savings, %	Energy Savings, %	Data Source
Pacific NW	N/A	11	Northwest Council*
Puget	N/A	11	Nadel et al.**
Connecticut	10	14	Best Practices***
California	10	12	Best Practices***
California	N/A	10	Nadel et al.**
Georgia	7	10	Best Practices***
Idaho	8	3	Best Practices***
Southwest	N/A	33	Nadel et al.**
Vermont	N/A	31	Nadel et al.**
U.S. median	N/A	24	Nadel et al.**

* Northwest Council Fifth Plan.

** Nadel, Steven et al., "The Technical, Economic, and Achievable Potential for Energy Efficiency in the U.S. – A Meta-analysis of Recent Studies," Proceedings of the 2004 American Council for an Energy-Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Buildings.

*** "Energy Efficiency Program Best Practices," Best Practices Working Group of the National Action Plan for Energy Efficiency, June 2006.

Greg Wikler and his team at Global Energy Partners are completing a study of actual experience in implementation of a wide range of energy efficiency measures.[22] Figures 9 and 10 represent the results of this "bottom-up" analysis emerging from this study. Table 2 summarizes the data underlying the energy efficiency supply curve in Figure 9. Figure 9 shows levelized costs, in ascending order of cost per kWh, of an array of energy efficiency measures as a function of the amount of energy saved. Figure 10 shows levelized costs, in ascending order of cost/kW, of an array of demand reduction measures. These curves are informative in several respects. First, they depict the wide range of costs that exists at the many energy efficiency and demand response measures. Second, each of these curves allows another estimate of the potential energy or power savings, assuming that all measures up to the inflection point can be cost-effectively implemented.

[22] Wikler, Greg, "Assessment of U.S. Energy Efficiency Potential," Global Energy Partners, 2006.
Note: This document is the basis for the information contained in Figures 9 and 10 and Table 2.

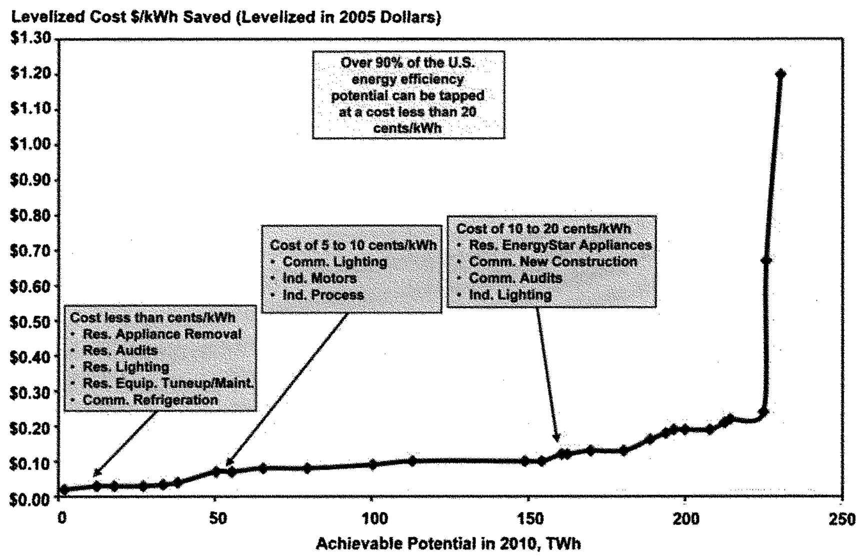


Figure 9
Example of a Bottom-Up Analysis of Achievable Energy Efficiency Potential

Table 2
Summary of the Data Underlying the Energy Efficiency Supply Curve Shown in Figure 9

Sector	Program Type	End Use	$/kWh	TWh 2010	Cumulative TWh
Res	EE-Appliance Removal	Refrigerators	$0.02	1.96	1.96
Res	EE-Audits/Weatherization	Building Shell	$0.03	10.26	12.22
Comm	EE-Prescriptive	Refrigeration	$0.03	5.60	17.82
Comm	EE-Customized	Refrigeration	$0.03	9.30	27.12
Res	EE-Equipment	Lighting	$0.03	6.31	33.43
Res	EE-Tuneup/Maintenance	HVAC	$0.04	4.73	38.16
Ind	EE-Customized	Other Process	$0.07	12.30	50.46
Ind	EE-Customized	Compressed Air	$0.07	5.00	55.46
Ind	EE-Prescriptive	Motors	$0.08	10.00	65.46
Ind	EE-Customized	Motors	$0.08	14.10	79.56
Comm	EE-Customized	Lighting	$0.09	20.90	100.46
Comm	EE-Prescriptive	Lighting	$0.10	12.60	113.06
Comm	EE-New Construction	All	$0.10	35.80	148.88
Comm	EE-Audit	All	$0.10	5.40	154.25
Res	EE-Equipment	Energy Star Appliances	$0.12	6.31	160.55
Comm	EE-Tuneup/Maintenance	All	$0.12	1.90	162.44
Ind	EE-Prescriptive	Lighting	$0.13	7.40	169.84
Ind	EE-Customized	Lighting	$0.13	10.50	180.34
Comm	EE-Customized	Cooling	$0.16	8.40	188.74
Comm	EE-Prescriptive	Cooling	$0.18	5.00	193.74
Ind	EE-Prescriptive	Cooling	$0.19	2.60	196.34
Ind	EE-Customized	Cooling	$0.19	3.60	199.94
Comm	EE-Customized	Equipment	$0.19	7.90	207.84
Comm	EE-Prescriptive	Equipment	$0.21	4.70	212.54
Res	EE-Equipment	Other	$0.22	1.80	214.35
Res	EE-New Construction	All	$0.24	10.59	224.94
Res	EE-Equipment	Fans	$0.67	0.90	225.84
Res	EE-Equipment	Air Conditioning	$1.20	4.51	230.34

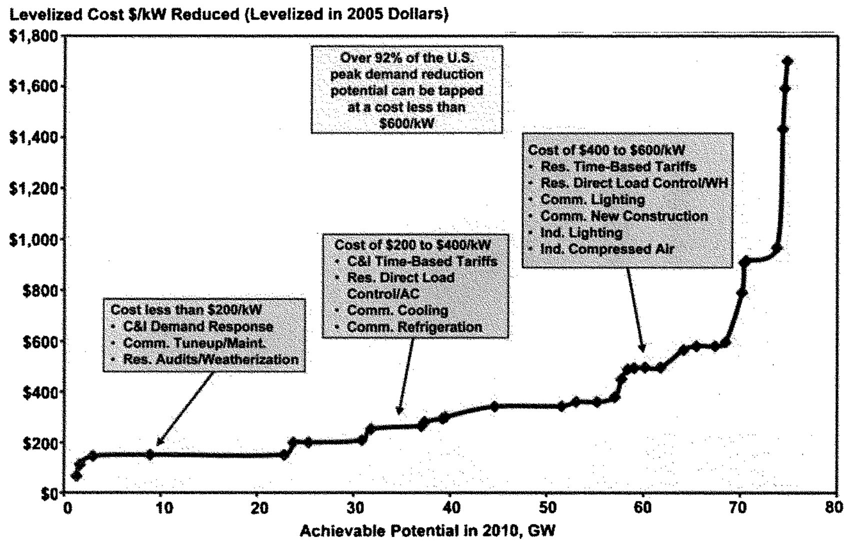


Figure 10
Example of a Bottom-Up Analysis of Achievable Demand Response

The perspectives and preceding data suggest that efficiency of electricity utilization in each of its dimensions holds substantial potential benefits that are strategically important. Beyond this potential, the optimization possible through an integrated approach to managing an "infrastructure" offers substantial additional value.

The Value of Dynamic Systems from the New Dynamic Infrastructure

The previous discussion (and its footnotes) indicates that although energy efficiency efforts are unlikely to single-handedly offset growth of all future electricity use and its carbon emissions, those efforts collectively represent a major role in a national strategy for energy, reduced dependence on foreign energy sources, net cost savings, and reductions in atmospheric CO_2 concentration. The dynamic systems of the envisioned strategy here should substantially extend the benefits of energy efficiency and demand response.

Multiple Dimensions of Value

The benefits of energy efficiency and demand response go well beyond energy savings, and attempts are being made in many states to look at the full array of societal benefits, including environmental protection and system reliability. Figure 11, adapted from a figure provided by M.A. Piette of Lawrence Berkeley Labs, attempts to capture the value framework for demand response (DR). This type of analysis is likely to grow in the policy arena in the years ahead. The result is that we are likely to place a higher value on energy efficiency and demand response than we do today.[23]

	The Customer Perspective	Customer Service Impact	Purpose of DR	Valuing DR
5	Full Outage	Total Loss of Service	System Protection	Full Outage Cost
4	Involuntary End-Use Curtailment	Loss of End-Use	Grid or System Protection	Expected Value Partial Outage Cost
3	Voluntary Partial End-Use Curtailment	Some Comfort Impacts	Reliability and Economics	
2	Shifting or Rescheduling	No Noticeable Impacts	Economics	kW
1	Basic Service	None	None	kWh

Figure 11
Schematic of the Sources of Value of Demand Response

Dynamic Systems – Future of the Energy Efficiency Infrastructure

Our discussion so far has focused on how the four building blocks of the energy efficiency infrastructure enhance the value of energy efficiency. However, optimization is possible on a system level when the dynamic interactions of energy efficiency, demand response, and dynamic systems are managed in an integrated fashion. Figure 12 illustrates this point by contrasting how energy efficiency, demand response, and dynamic systems play different roles in delivering value in several dimensions. As technology advances and the capabilities of the integrated efficiency infrastructure are more fully implemented, increased value in these dimensions is expected. Energy efficiency improvements can be gained throughout the entire energy chain—from fuel to electricity generation/delivery to end use. While the focus of this paper is end-use efficiency improvement, efficiency can also be gained in the electricity generation and delivery functions. Appendix C highlights some of the efficiency gains to be realized on the supply side.

[23] Piette, Mary Ann, PIER Demand Response Research Center, presentation to EPRI, May 2006.

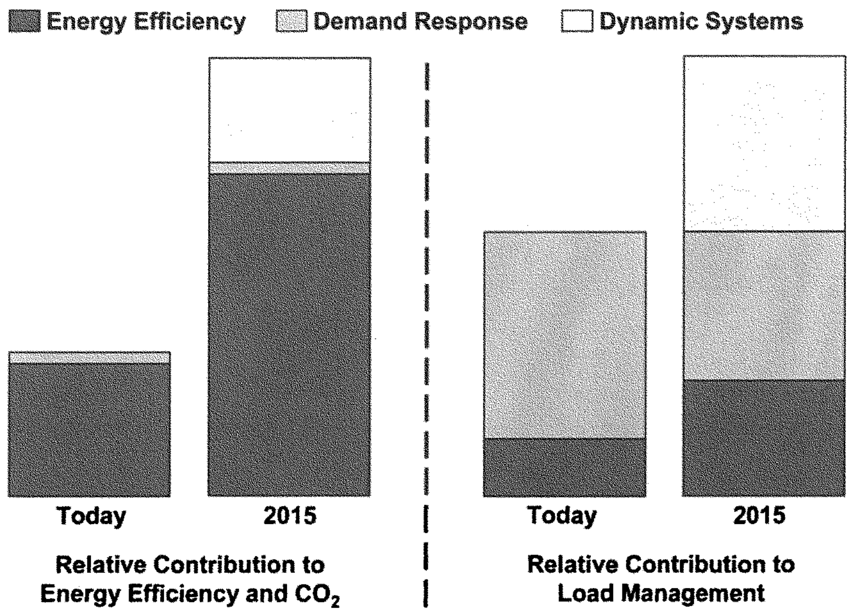


Figure 12
Potential Roles of Energy Efficiency, Demand Response, and Dynamic Efficiency

The value of dynamic systems is highest when customers are in a position to take advantage of new technologies that reduce the cost of efficiency improvement. This is conceptually illustrated in Figure 13, which implies that end-use technologies already in existence can take advantage of dynamic systems to create business models in which customer decisions are based on value. Facilitating dynamic systems is where research and development efforts are most needed. Based on experiences to date, it seems likely that network interactions will be the key toward development of new technology.

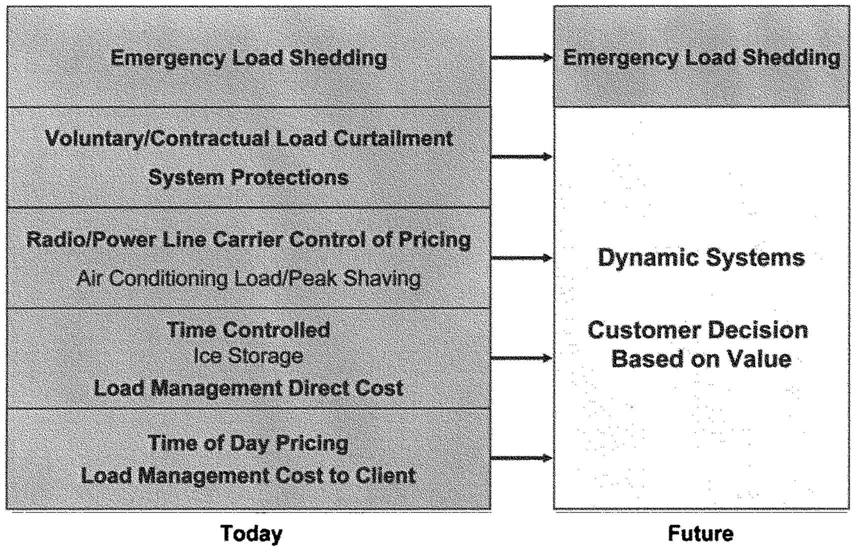


Figure 13
Technology Developments That Enable Dynamic Systems

6
CONCLUSIONS AND QUESTIONS FOR THE PARTICIPANTS

This paper is intended to stimulate discussion at the 2006 EPRI Summer Seminar. It provides an overview of the forces driving greater use of energy efficiency and demand response and explores the potential for both static and dynamic approaches. Some of its key observations are summarized next, followed by questions for the Seminar participants to consider.

Conclusions

- Energy efficiency and demand response can be cost-effective alternatives to adding new capacity.
- The programmatic approaches to energy efficiency and demand response have been successful, but substantial untapped potential remains in these two areas.
- There is a significant opportunity to utilize innovative technology, regulation, and markets to drive energy efficiency, demand response, and—through dynamic systems—even more effective electricity utilization than traditional approaches could offer.
- An interactive set of four building blocks—communications infrastructure, innovative rates and regulation, innovative markets, and smart end-use devices—constitutes an emerging "efficiency infrastructure" that will make the dynamic dimension of management of energy consumption more robust over time, substantially expanding the potential for energy efficiency.
- The potential for cost-effective energy efficiency, using today's technology, is at least 5–10% of total electricity demand.
- Europe has well-developed energy efficiency and demand response programs, is pursuing the advantages of dynamic systems, and could offer valuable lessons for the United States.
- The achievable potential associated with implementation of dynamic systems as discussed here has not been quantified, but combined with optimistic projections for achievable potential for existing energy efficiency and demand response technologies, integrated implementation of an efficiency infrastructure including dynamic systems should substantially exceed 30% of electricity consumption in the coming decades.
- The potential impact on demand management of the efficiency infrastructure envisioned here should also be substantial as it represents a continuous (rather than periodic) process capable of optimization at multiple scales.

Research and Development Agenda

It is clear from the previous discussion that several questions exist around the concept of an integrated "efficiency infrastructure": what is the potential inherent in such an approach, and what additional technologies are needed to realize this vision? New value propositions will have to be created for all stakeholders for the vision discussed here to be sustainable. Broadly, the research needs are present in three areas: hardware, software, and data and other items.

Based on the discussion in this paper and the research on which it is based, a number of R&D needs emerge; certainly others will emerge as the vision described in this paper is pursued. EPRI's focus will be on the technology challenges associated with the communications infrastructure and development and implementation of the dynamic systems described. The R&D needs below represent an initial assessment.

Hardware:

- Develop, test, and demonstrate network communications infrastructure, including security, protocols, and standards.
- Appliance manufacturers must develop microdevices that are Internet addressable for purposes of monitoring of device operation, diagnosis of impending operational problems, maintenance, and repairs.
- Smart technology is needed to respond to electricity price information (for example, day-ahead or hour-by-hour) and optimize electricity use continually. The optimization process would include efficiency improvement and demand response and would incorporate a "prices to devices" approach to manage system optimization.
- Develop, test, and demonstrate real-time two-way information exchange between energy service providers and energy-consuming devices.
- Advanced metering infrastructure is needed to integrate automated meter reading, grid management and operations, energy procurement, and customer services.
- CO_2 sensors for demand control of ventilation are needed. CO_2 concentration is a dynamic measure of indoor air quality. New sensor designs incorporate a carbon nanofiber sensor to replace the older infrared technology; energy savings are estimated at 10–30%.
- Switchable electrochromic window coatings are needed. Electrochromics are expected to dominate the worldwide coatings market. Trillions of square feet of existing glass and annual additions of hundreds of millions of square feet would benefit from addition of coatings that increase and optimize energy efficiency.
- Energy management in data centers is needed. Heat generation without efficient dissipation has become the largest impediment to the development of the next generation of high-speed computing devices. Improvements are needed in the efficient removal of heat from its source, especially at Internet data centers.
- Smart sensors and radio frequency identification systems are needed.

Software:

- o Adaptive software for integrated response to real-time rates, weather conditions, customer-specified energy management requirements, and utility-specified load management requirements is needed.
- o Adaptive software for aggregated load management of multiple consumer devices is needed.
- o Software for real-time data acquisition and analysis of energy efficiency, demand response, and dynamic systems data necessary to support adaptive software described above is needed.

Data and "other":

- o Need to develop a structure for studying and estimation the technical, economic, and achievable energy efficiency and demand response benefits associated with the efficiency infrastructure discussed here, including dynamic systems.
- o Better data regarding the potential, what's achievable, and what's economic for the advanced energy efficiency/DR infrastructure hypothesized in this paper

Key Questions for Participants

1. What are your perspectives of the vision of the future we have laid out? Where do you see value in this vision to society, consumers, and utilities?
2. Numerous activities are underway among suppliers of consumer electronics, software, and network components to automate and network buildings and homes. How can the electricity enterprise tap into that groundswell of activities?
3. What are avenues for implementing the energy communications infrastructure? How should it be accomplished, and who has what roles?
4. What are examples of innovative regulation to enable dynamic systems? What are avenues for creating and implementing innovative regulation?
5. What are opportunities for creating markets to encourage sustainable dynamic systems?
6. What role will smart devices play in energy efficiency? Demand response? Dynamic systems?
7. What are the key research needs to bring dynamic systems to a sustainable reality?
8. What roles are there for EPRI to further the dynamic systems concepts?

7
BIBLIOGRAPHY

Best Practices Working Group: "Energy Efficiency Program Best Practices," National Action Plan for Energy Efficiency, June 2006.

Bloom, Jeremy, "Program on Innovation: Opportunities for Advancing End-Use Energy Efficiency, Electric Power Research Institute, 2005.

California Energy Commission, "Is Efficiency Enough? Towards a New Framework for Carbon Savings in the California Residential Sector," Public Interest Energy Research (PIER) Program Final Project Report. Report Number CEC-500-2005-162, October 2005.

Electric Power Research Institute, *Electricity Technology Roadmap: 2003 Summary and Synthesis.* Palo Alto, CA: 2003.

Electric Power Research Institute, *Program on Technology Innovation: Opportunities for Advancing End-Use Energy Efficiency.* Palo Alto, CA: 2005. 1012003.

Electric Power Research Institute, *Principles and Practice of Demand-Side Management.* Palo Alto, CA: 1993. TR-102556.

Electric Power Research Institute, *Revealing the Value of Demand Response: Regulatory and Market Options.* Palo Alto, CA: 2003. 1001638.

Enerex Corporation, "Advanced Metering and Demand Responsive Infrastructure: A Summary of the PIER/CEC Reference Design, Related Research, and Key Findings," California Energy Commission, Consultant Report, June 2005.

European Communities, "Doing More with Less: Green Paper on Energy Efficiency," Office for Official Publications of the European Communities, Luxembourg, 2005.

Faruqui, Ahmad and Stephen George, "Pushing the Envelope on Rate Design," *The Electricity Journal.* March 2006.

Faruqui, Ahmad and Robert Earle, "Demand Response and Advanced Metering," *Regulation.* Spring 2006.

Gellings, Clark and Kelly Parmenter, "Demand-Side Management," Draft of CRC Handbook, 2005.

Global Environment Fund, "The Emerging Smart Grid: Investment and Entrepreneurial Potential in the Electric Power Grid of the Future," Center for Smart Energy, October 2005.

Jouaire, J. and Richard Schomberg, Electricité de France, presentation at Metering America, April 24, 2006, Atlanta, Georgia.

Keystone Dialog on Global Climate Change, Final Report May 2003. The Keystone Center, www.keystone.org.

Kiliccote, Sila and Mary Ann Piette, "Advanced Control Technologies and Strategies Linking Demand Response and Energy Efficiency," JCEBO 2005 Conference Paper, September 1, 2005. Lawrence Berkeley National Laboratory, Berkeley, CA, LBNL #58179.

Nadel, Steven et al., "The Technical, Economic, and Achievable Potential for Energy Efficiency in the U.S. – A Meta-Analysis of Recent Studies," Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings.

"Cisco Plans its Home Invasion," *Newsweek.* March 20, 2006.

Piette, Mary Ann, PIER Demand Response Research Center, presentation to EPRI, May 2006.

Rosenfeld, Arthur, "Air Pollution as Climate Forcing," East-West Center, Honolulu, HI, April 5, 2005.

Rosenfeld, Arthur, "Past and Current Efficiency Successes and Future Plans," ACEEE: Energy Efficiency as a Resource," Berkeley, CA, September 26, 2005.

U.S. Energy Information Administration, "Annual Energy Outlook 2006 with Projections to 2030, February 2006. Energy Information Administration, DOE/EIA0383 (2006).

United States Government Accountability Office, "Electricity Markets: Consumers Could Benefit from Demand Programs, but Challenges Remain," Report to the Chairman, Committee on Governmental Affairs, U.S. Senate, August 2004.

Wikler, Greg, "Assessment of U.S. Energy Efficiency Potential," Global Energy Partners, 2006.

Williams, Virginia, "Consumer Electronics Association," *Electronic Engineering Times.* January 2006.

World Energy Council, "Energy End-Use Technologies for the 21st Century," London, England, 2004.

A
ADDITIONAL TECHNOLOGY OPPORTUNITIES FOR IMPROVING END-USE EFFICIENCY

Leading the drive to higher end-use efficiency is a set of technologies that not only improve energy efficiency, but also improve productivity and add functionality to existing processes. Although much of the progress in developing these technologies focuses on communications and information technology, there are also many opportunities for improving efficiency in the process and manufacturing industries as well as buildings. This appendix gives several examples of improving efficiency in various industries, as well as in the commercial and residential sectors, that exhibit some of the ways in which integration of technologies provides a particularly rich set of capabilities.

Iron and Steel

A study by Lawrence Berkeley National Laboratory (LBNL) surveyed the trends in reducing the energy intensity of steel production in the United States, France, Germany, Japan, Korea, and Poland between 1970 and 1994. Energy intensity in the United States declined by over 20% during this period, driven in part by the growth in electric steelmaking. In addition, the authors investigated more than 45 specific energy saving improvements, which yielded an average energy improvement of about 18% below previously identified best practices.

In addition, the US DOE is funding a direct steel-making demonstration combining microwave, electric arc, and exothermal heating. The process is expected to save up to 25% of the energy consumed in conventional steelmaking by replacing the blast furnaces and basic oxygen furnaces with more efficient, electricity-based technologies. Moreover, the quality of the steel is higher.

Food, Chemicals, and Waste

Industrial and commercial electrotechnologies offer several examples of high end-use efficiencies. In the food processing industries, freeze concentration (for example) can be used for separation of solids and liquids, efficiently replacing distillation processes in water desalination. In the chemical industry, microwave processes for synthesis of ethylene are now available that reduce the energy requirement to about 10% of current processes. In the waste processing industries, membranes for purifying natural gas from landfills and anaerobic digesters could provide enough pure methane to replace 1% of all conventional fuels used to generate electricity.

In a variety of industries, advanced oxidation processes such as dielectric barrier discharge, corona discharge, and flow-stabilized discharge have the ability to destroy several categories of air pollutants simultaneously.

Other examples of commercial sector efficiency improvement are supermarket refrigeration and dehumidification systems, advanced lighting systems for offices, and initiatives in the healthcare industry.

Residential Buildings

Efficiency improvements in buildings address both the building envelope and the equipment and appliances that populate the building. These technologies interact. The space heating requirement, and hence the size of the furnace, is a function of window design, amount of insulation, and other factors. Today's technology is capable of zero net energy for heating and cooling, and technologies such as incorporating solar cells into windows can substantially reduce the space heating load.

Although the technologies for zero net energy homes are well in hand, some questions remain. These questions focus on factors such as cost, whether the indoor climate would be acceptable to residents, and whether a "sealed" house would meet future consumer preferences and air quality.

Opportunities for improving efficiency can be found throughout the house. Many of these electronic systems are either "on" or in a standby mode throughout the day and night. The Danish Energy Agency estimates that 10% of electricity use in private homes is "wasted" on standby.

The situation is exacerbated in offices and commercial buildings where computers and office equipment, as well as lights, are operated outside of normal business hours. While the computer equipment is normally operated nearly continuously, the office space is typically lit even though only a few people may be using the building after hours. In both residences and commercial buildings, there is room for substantial optimization of standby electricity consumption.

B
HISTORIC RESULTS AND FUTURE POTENTIAL

Historic Perspective on Energy Efficiency

The California Energy Commission (CEC) has estimated that the savings due to the application of energy efficiency programs and standards in California between 1976 and 2003 are roughly 15% of annual electricity consumption (see Figure B-1). If this is a harbinger of future investments throughout the United States, the potential savings due to energy efficiency could be quite large.

CEC estimated the average cost of efficiency measures for the period 2000–2004 to be approximately of $0.03/kWh saved. Similarly, the National Action Plan for Energy Efficiency cites a common rule of thumb that "many energy efficiency programs have an average lifecycle cost of $0.03/kWh saved, which is 50–75% of the typical cost of new power sources."

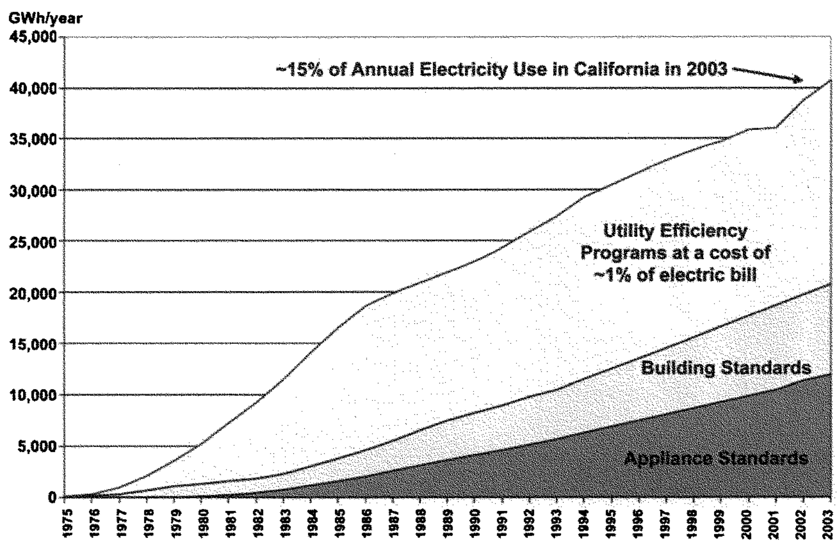


Figure B-1
Annual Energy Savings from California Efficiency Programs and Standards[24]

[24] Rosenfeld, Arthur: "Past and Current Efficiency Successes and Future Plans," ACEEE: Energy Efficiency as a Resource, Berkeley, CA, September 26, 2005.

Other studies by the CEC show the dramatic effect of appliance standards on the efficiency of refrigerators in the United States over the 30-year span from 1972 to 2002 (see Figure B-2). While the size of refrigerators has continued to grow, both energy use and price per unit have declined by nearly two-thirds.

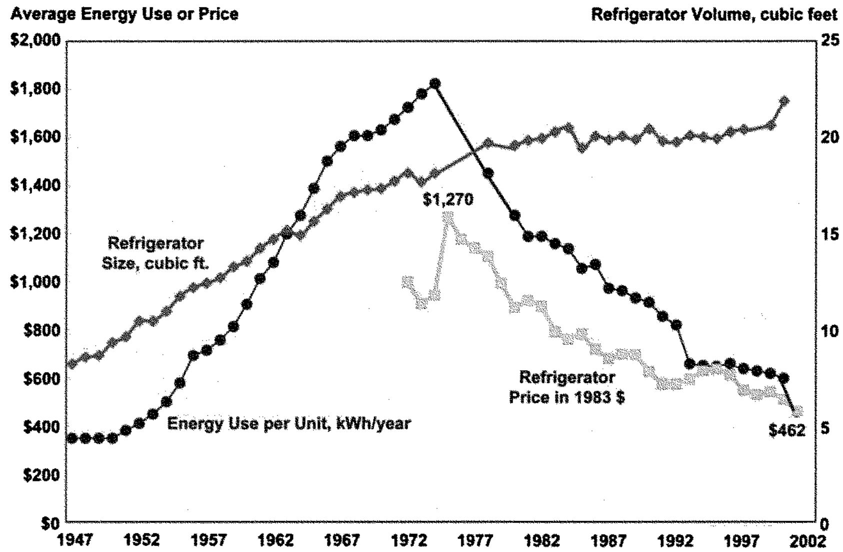


Figure B-2
United States Refrigerator Use vs. Time

One perspective from Europe, shown in Figure B-3, comes to a similar conclusion of large scale savings over the last 35 years. The figure indicates that the European Union considers "negajoules" as a viable element in the portfolio of strategies to respond to anticipated demand growth. By extrapolation, the "negajoules" shown in the graph, representing avoided consumption, are estimated to reach on the order of 13% of total consumption by 2020 if aggressive efficiency measures are implemented.

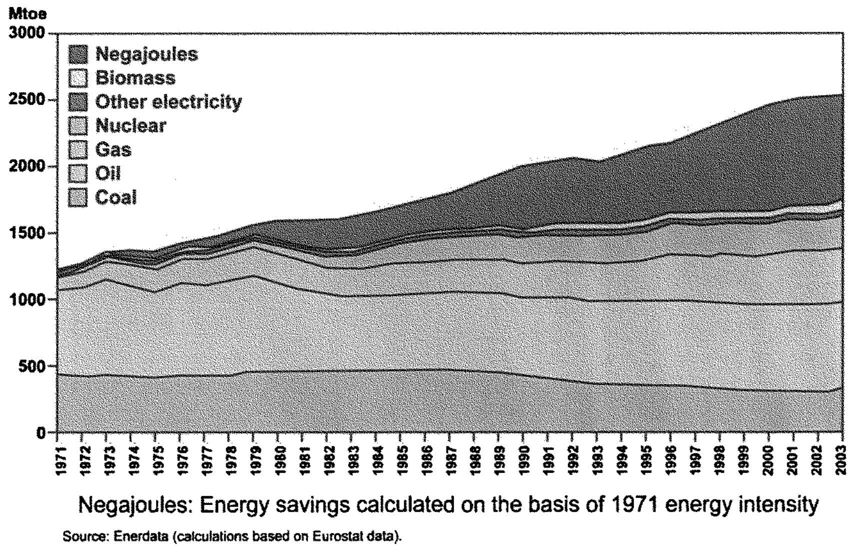


Figure B-3
Development of Primary Energy Demand and Avoided Energy Use (Negajoules) in the EU-24

The California Energy Commission has also estimated the savings in peak demand due to the application of energy efficiency programs and standards in California between 1976 and 2003 at roughly 22% (see Figure B-4).

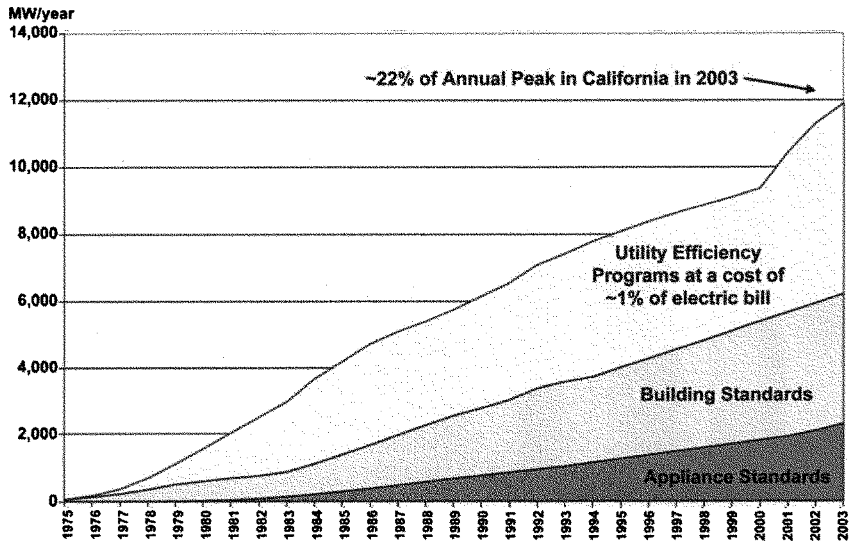


Figure B-4
Annual Peak Savings in California from Efficiency Programs and Standards

Potential Savings from Energy Efficiency

A number of studies have been conducted by various organizations in different parts of the United States on the future potential for energy efficiency. They tend to differentiate between technical potential (which looks at technical feasibility without regard to cost or implementation issues), economic potential (which limits the items to those that are cost effective), and achievable potential (which takes into account economics and the realities of program implementation). This filtering process reduces the amount of energy savings to that which is practical.

An array of data available on achievable potential is included in this appendix, including work by:

- Global Energy Partners, located in Lafayette, CA.
- Steve Nadel et al. in the paper, "The Technical, Economic, and Achievable Potential for Energy Efficiency in the U.S. – A Meta-Analysis of Recent Studies."
- The Best Practices Working Group of the National Action Plan for Energy Efficiency Leadership Group. This is a draft report.

One perspective on the potential savings from implementing end-use initiatives is provided in recent work sponsored by EPRI through GEP. Figure B-5 is a supply curve showing the cost of electricity savings in TWh. Note that it's possible to achieve savings of nearly 50 TWh for a cost of less than $0.05/kWh. Similarly, savings of ~100 TWh are achievable for a cost of $0.10/kWh to $0.20/kWh. In fact, savings of nearly 230 TWh (or about 5% of annual U.S. electricity consumption) can be achieved for less than about $0.20/kWh.

Moreover, it's possible to convert the cost data into a value or benefit. Projecting data from the US DOE/EIA, it's possible to estimate annual electricity consumption in the United States as about 4,300 billion kWh. At a retail price of $0.067 per kWh, the corresponding total revenue can be estimated as about $290 billion per year. The savings would be about 5% of this value, or ~$14.5 billion.

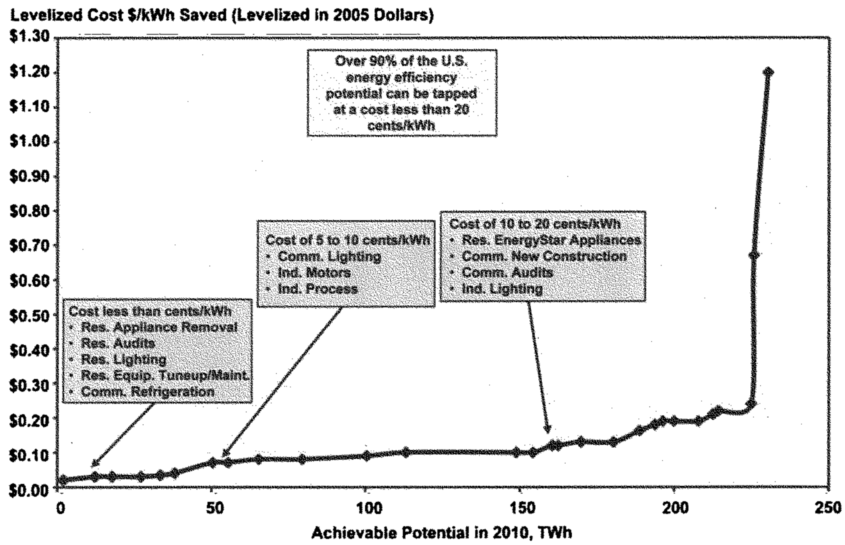


Figure B-5
Achievable Annual Energy Savings Through Efficiency Improvements, 2010

Disaggregating this composite supply curve into the three main sectors—residential, industrial, and commercial—reveals some important similarities. For example, the cost of implementing the technologies is initially low but increases steadily, mirrored by the continuous increase in the potential savings in energy and power. All three sectors exhibit this pattern, and all eventually reach a point at which the marginal cost of saving the next kilowatt-hour or the next kilowatt increases dramatically. (Figure B-6 shows energy savings for all three sectors.) Once this "knee" in the curve is reached, energy efficiency programs will no longer be cost effective.

But the low-cost portions of the supply curves offer many potential low-cost options for improving efficiency and demand response. Typical efficiency improvements include:

- Removal of outdated appliances
- Weatherization of the building shell
- Advanced refrigeration in commercial buildings

- o Residential lighting improvements
- o HVAC tune-ups and maintenance

All these technologies can be deployed for a cost of less than \$0.05 per kWh. For a cost of \$0.05/kWh to \$0.10/kWh, additional energy savings include:

- o Commercial lighting improvements
- o Industrial motors and drives
- o Industrial electrotechnologies

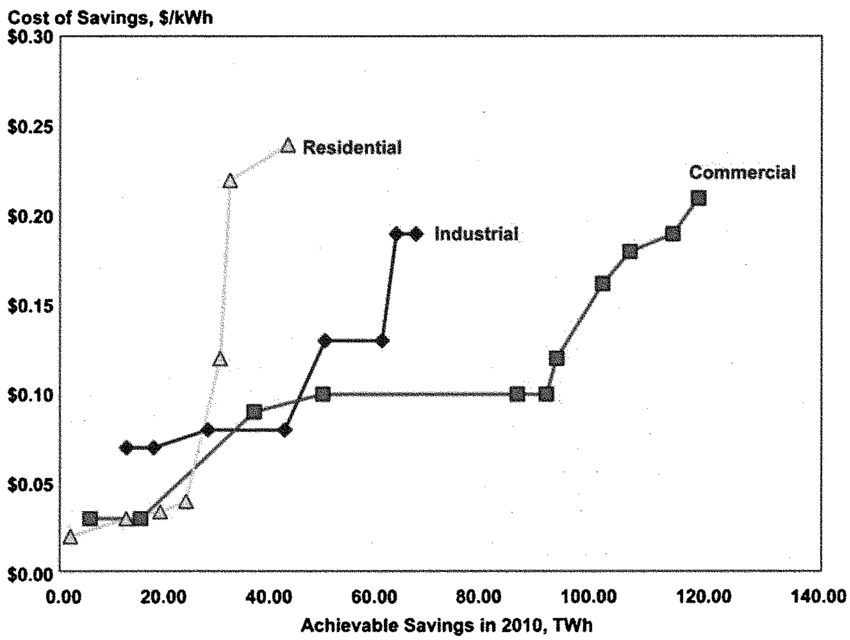


Figure B-6
Energy Efficiency Savings for Residential, Commercial, and Industrial Sectors

The Best Practices Working Group has evaluated data from a variety of sources and identified trends among data from different sources. These data are summarized in the Table B-1. In general, the Best Practices data exhibit somewhat smaller values than the data of Nadel et al.

Table B-1
Achievable* Energy Efficiency Potential from Recent Studies[25]

	Achievable MW Demand Reduction			Achievable GWh Reduction			Demand Savings (% of 2004 State Nameplate Capacity)	Energy Savings (% of Total 2004 State Consumption)	
	Residential	Commercial	Industrial	Residential	Commercial	Industrial	Electricity	Electricity	Gas
Pacific NW	1,275	937	585	N/A	N/A	N/A	5.7%	N/A	N/A
Connecticut	240	575	93	1,655	2,088	723	10.4%	13.9%	N/A
California	1,800	2,600	1,550	9,200	11,900	8,800	9.6%	11.8%	10%
Georgia	487	698	423	5,158	4,764	2,625	7.2%	9.7%	5.4%
Idaho	137	46	-	378	207	-	7.6%	2.7%	N/A

State Sources
California: Statewide Gas Savings, 2013, "California Residential Sector Energy Efficiency Potential Study, April 2003" and "California Statewide Commercial Sector Natural Gas Energy Efficiency Potential Study, March 2003" (KEMA/XENERGY)
Connecticut: Statewide Savings, 2012. "Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region" (KEMA, June 2004).
Georgia: Statewide Savings, 2010. "Assessment of Energy Efficiency Potential in Georgia" (ICF, May 2005).
Idaho: Statewide Savings, 2013. "Idaho Demand Side Management Potential Study" (Quantum Consulting, 2004).
Pacific NW: Statewide Savings, 2025. "Northwest Council Report on Energy Conservation Resources" (Northwest Council Draft, December 2004).

Other Data Sources
MMBTU per MCF: http://www.energystar.gov/ia/business/tools_resources/target_finder/help/Energy_Units_Conversion_Table.htm
Natural Gas Consumption by State: http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_a_EPG0_VC0_mmcf_a.htm
Existing Nameplate Capacity by State: http://www.eia.doe.gov/cneaf/electricity/epa/existing_capacity_state.xls
Electricity Sales, 2004: http://www.eia.doe.gov/cneaf/electricity/esr/table2.xls

* "Achievable" defined in the EEAP Best Practices document as "what can realistically be achieved from programs within identified funding parameters."

Value of Demand Response

A similar analysis can be used to assess the potential for reducing peak demand (see Figure B-7). Here, the appropriate metric is the cost of peak demand in units of $/kW, instead of $/kWh. Contributors to the opportunities for demand response are curtailment of commercial and industrial loads; commercial building tune-ups and maintenance for a cost of less than $200/kW; time-based tariffs and other innovative rate designs for a cost between $200/kW and $400/kW; and finally, commercial and industrial lighting and new commercial construction savings for costs between $400/kW and $600/kW. For comparison, the capital cost of new baseload generation is about $500/kW.

[25] See note 23.

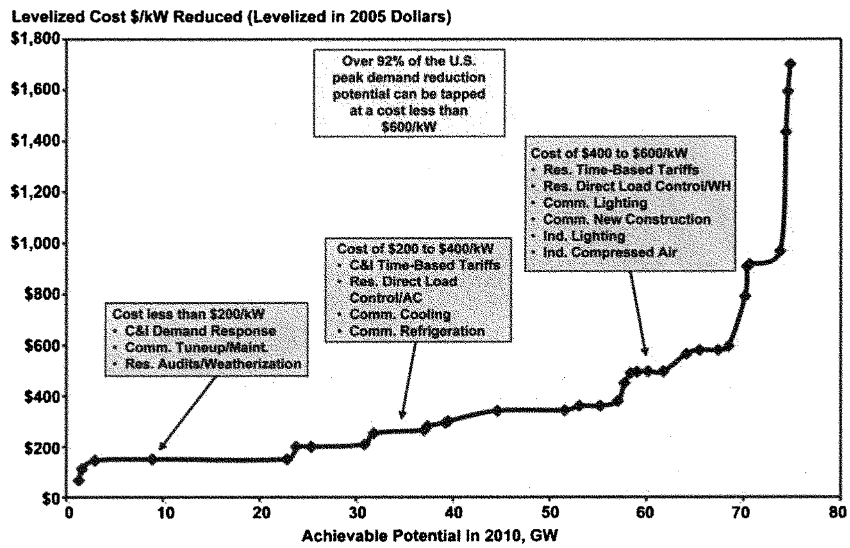


Figure B-7
U.S. Potential Peak Demand Reduction in 2010 – All Sectors

Again, this composite supply curve for peak demand reduction can be disaggregated into the three primary consuming sectors, as shown below. Some examples of the savings in peak demand include:

- o Audits and weatherization of residential building shells
- o Commercial building tune-ups and maintenance
- o Time-based tariffs for commercial and industrial customers

These improvements are available for less than $200/kW.

Other technologies can be deployed at a cost of $200/kW to $400/kW, for example:

- o Direct load control for residential air conditioning
- o Advanced commercial (building-integrated) cooling and refrigeration systems
- o Advanced lighting systems for industrial, commercial, and residential applications

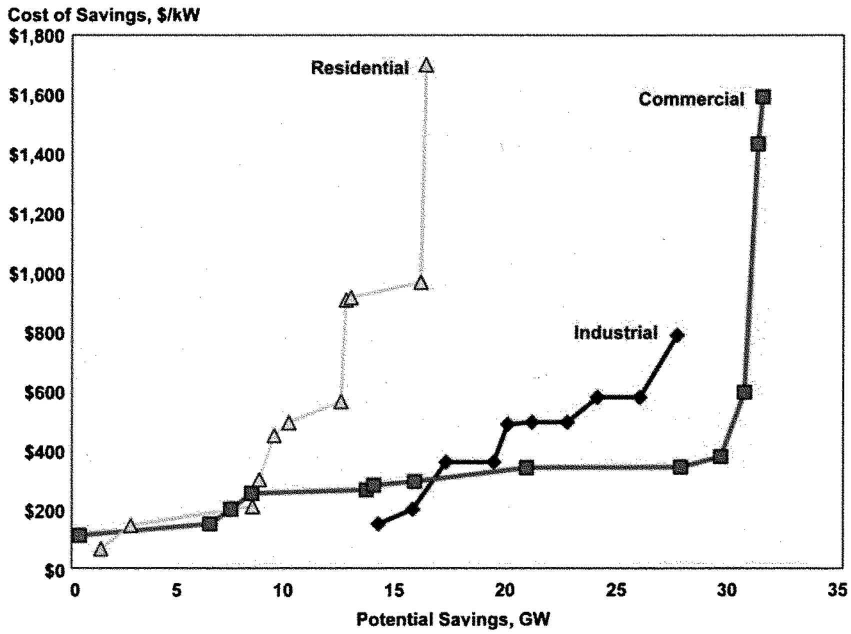
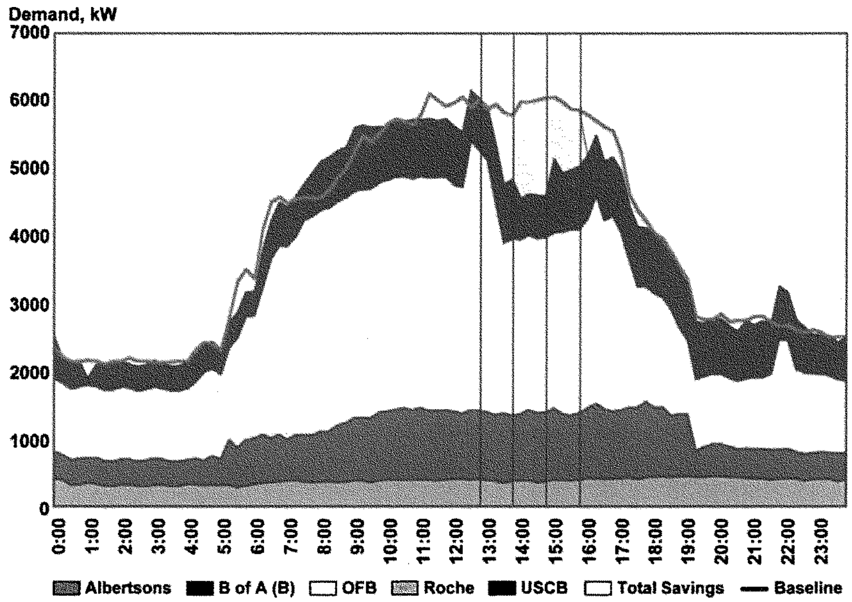


Figure B-8
Demand Response Savings for Residential, Commercial, and Industrial Sectors

Multiple Dimensions of Value for Demand Response

As shown in Figure B-9, The Public Interest Energy Research (PIER) program of the California Energy Commission is evaluating the automation of DR in commercial buildings. The objective is to link the demand response (DR) system to a price/signal server that will be the intermediary for defining technology responses for the eventual automation of the building energy system. In 2004, for example, 18 sites with a total area of 10 million ft^2 were linked to an Energy Information System through a proxy price signal. Similar results were obtained in 2005, along with an initial look at the economics of these programs. The chart shows the effect of load curtailment or shedding during periods of high demand.



Energy Efficiency Savings for Residential, Commercial, and Industrial Sectors, Lawrence Berkeley National Laboratory

Figure B-9
Aggregated Demand Savings for Building Efficiency and Demand Reduction Programs – Energy Efficiency Savings for Residential, Commercial, and Industrial Sectors (Lawrence Berkeley National Laboratory)

More broadly, the U.S. DOE study of DR, as mandated by the Energy Policy Act of 2005, evaluated several past research efforts on DR and summarized the qualitative benefits in Table B-2.

Table B-2
Benefits of Demand Response

Type of Benefit	Recipient(s)	Benefit		Description/Source
Direct benefits	Customers undertaking demand response actions	Financial benefits		• Bill savings • Incentive payments (incentive-based demand response)
		Reliability benefits		• Reduced exposure to forced outages • Opportunity to assist in reducing risk of system outages
Collateral benefits	Some or all consumers	Market impacts	Short-term	• Cost-effectively reduced marginal costs/prices during events • Cascading impacts on short-term capacity requirements and LSE contract prices
			Long-term	• Avoided (or deferred) capacity costs • Avoided (or deferred) T&D infrastructure upgrades • Reduced need for market interventions (e.g., price caps) through restrained market power
		Reliability benefits		• Reduced likelihood and consequences of forced outages • Diversified resources available to maintain system reliability
Other benefits	• Some or all consumers • ISO/RTO • LSE	More robust retail markets		• Market-based options provide opportunities for innovation in competitive retail markets
		Improved choice		• Customers and LSE can choose desired degree of hedging • Options for customers to manage their electricity costs, even where retail competition is prohibited
		Market performance benefits		• Elastic demand reduces capacity for market power • Prospective demand response deters market power
		Possible environmental benefits		• Reduced emissions in systems with high-polluting peaking plants
		Energy independence/security		• Local resources within states or regions reduce dependence on outside supply

C
SUPPLY-SIDE ENERGY EFFICIENCY IMPROVEMENT

Efficiency improvements can be gained throughout the entire energy chain—from fuel to electricity generation/delivery to end use. The focus of this paper remains on end-use efficiency improvement; however, this is just one element of the overall energy efficiency portfolio of the future. This section highlights some of efficiency gains to be realized on the supply side.

Generation

Supply-side opportunities are broadly classified as either improving the efficiency of existing plants or adding new high-efficiency plants to replace old plants and add new capacity to handle load growth. An example of the former is the improvement of the heat rate of fossil generation plants. (Heat rate is the amount of primary energy—coal, for example—needed to produce a kilowatt hour of electricity). Work by EPRI has shown that aggregate cost-effective reductions in heat rate of about 3% can be achieved by measures such as optimizing the thermal performance of the boiler, reducing the fouling of boiler tubes, reducing turbine blade corrosion, and adding performance monitoring and control software to keep the plants running under optimal conditions.

Natural gas generation has probably had the largest impact on supply-side efficiency during the last 10 years. In combined-cycle operation (using both a gas turbine and a heat recovery steam generator/steam turbine), heat rates are typically in the range of 7,500 Btu/kWh, as compared with nearly 9,000 Btu/kWh for supercritical coal-fired boilers. Unfortunately, the high efficiency of natural gas plants is partially offset by the high price and price volatility of gas. Even though gas is more efficient, coal generation prices are so much less that gas plants will be very low in the dispatch order. Efforts to reduce the cost and price of natural gas, perhaps by expanding the use of liquefied natural gas (LNG), will be needed to realize the high efficiency potential of gas generation.

In the case of renewables, as for nuclear generation, emissions are essentially zero and efficiency is most closely related to reducing the cost of generation, along with economic growth and the other factors mentioned above. In many cases, "footprint" issues have an efficiency impact for renewables. For example, if technology breakthroughs can increase the efficiency of solar photovoltaic (PV) generation to above 25%, it's possible to reduce the size and visual impact of a PV array. Similar arguments can be made regarding wind and some kinds of biomass generation. These "low density" renewables are sometimes quite inefficient in their utilization of the land resource.

The next generation of fossil fuel electricity production (with plans for commercial availability by about 2020) will include carbon capture and storage technology. The additional energy burden of removing CO_2 from the flue gas and storing it will substantially reduce the energy conversion efficiency. For example, integrated-gasification–combined–cycle (IGCC) units are projected to have an efficiency of approximately 42% if CO_2 is not captured, but only 37% if it is. Similar data are anticipated for other advanced coal-based generation options. These twin goals of increasing efficiency while minimizing CO_2 emissions rank high among the technology challenges that the industry must resolve in the power system of the next few decades.

Transmission and Distribution

Transmission and distribution (T&D) systems in developed countries experience efficiency losses in two respects: dissipated power in conductors and reactive power consumed by magnetic fields resident in several devices within the systems. Losses due to dissipated power (so-called I^2R losses) are on the order of 7%. Reactive power represents on the order of 35% of this dissipated power but varies depending on the specific combination of the voltage, current, and the degree of resistance, inductance, and capacitance present in a particular electrical load.

Driven by reliability and asset management criteria, several researchers, suppliers, and utilities around the world are exploring more advanced T&D cables composed of better conductors and advanced insulators. Some of these combinations will help reduce dissipative losses, but this will probably not be a significant effect relative to improved efficiencies achievable in electricity generation.

Two other significant issues affecting overall T&D system efficiency in the future are the level of distributed energy resources (DER) and the intermittency of renewable resources. Due to the variety of technologies and scales of generation, DER poses both opportunities and challenges to the T&D system. Local generation on a sufficient scale could reduce the burden of growth on distribution or even transmission networks while allowing customization of generation to different types of loads. Current research is looking at strategies and technical issues associated with treating aggregations of mixed types of DER as a "virtual" resource that provides stable, high availability output. The intermittency of renewable resources presents an interconnection challenge in that the T&D system is designed for sources with stable output.

The Electric Power Research Institute (EPRI)

The Electric Power Research Institute (EPRI), with major locations in Palo Alto, California, and Charlotte, North Carolina, was established in 1973 as an independent, nonprofit center for public interest energy and environmental research. EPRI brings together members, participants, the Institute's scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power. These solutions span nearly every area of electricity generation, delivery, and use, including health, safety, and environment. EPRI's members represent over 90% of the electricity generated in the United States. International participation represents nearly 15% of EPRI's total research, development, and demonstration program.

Together...Shaping the Future of Electricity

Printed on recycled paper in the United States of America

Mr. BOUCHER. Thank you very much, Mr. Howard.
Mr. Yeager.

STATEMENT OF KURT YEAGER, EXECUTIVE DIRECTOR, GALVIN ELECTRICITY INITIATIVE, PALO ALTO, CA

Mr. YEAGER. Thank you, Mr. Chairman. I am Kurt Yeager, executive director of the nonprofit Galvin Electricity Initiative. This initiative is described more fully in my written statement.

Today the United States faces a rapidly approaching perfect energy storm of rapidly rising costs, carbon constraints and declining security. The electric grid can either continue to be a vulnerable liability in meeting this threat or the key to its resolution and to the protection of our Nation's economy and its environment. The choice is clearly ours. We do have the technological means to achieve the prompt transition to a smart electric grid and we certainly have the economic and the environmental motives and opportunity as a Nation to do so now.

Over the three decades, the U.S. electricity grid has had to survive an effective moratorium on innovation and little more than a life-support level of infrastructure investment. This dangerous situation has left us in a very vulnerable situation. The result is an electric grid system that now costs the Nation, as Dr. Howard indicated, over $100 billion each year in avoidable reliability losses, has very limited ability to reduce its carbon emissions, and faces hundreds of billions of dollars in pent-up infrastructure expansion costs just over the coming decade.

In contrast, a small electric grid can largely eliminate these reliability losses and simultaneously increase both the efficiency of electricity use and the consumption of clean renewable energy. The result will be a very large reduction in infrastructure investment costs. For example, it costs about one-third as much to save energy through efficiency improvements than to build a new power plant to produce the same amount of energy. In addition, at least $1 trillion a year more in U.S. gross domestic product could be produced through the greater economic productivity and competitiveness in the global market that such a smart system would provide. All of these smart grid advantages could be achieved at an aggregate cost that is equivalent to about 1 year's worth of the unreliability penalty we are now paying, in effect a 1-year payback.

A smart grid is an electronically controlled, self-healing electrical supply system that maintains the instantaneous and continuous flow of both energy and information between electricity consumers and suppliers. It is indeed a two-way street entirely open to consumers and most importantly to their end-use devices. Key innovative technologies that enable this, instantaneous digital electronic sensors and controls, the integration of communications, which is what makes it smart. The electricity business of the future is not based on how many kilowatt-hours we sell but how much value we can put on each electron as it enables a microprocessor through both information and energy. Transforming the electricity meter, what I would call the iron curtain of electricity, behind which we are all still captive, into a true consumer gateway that allows real-time price signals, demand response decisions and network intelligence as well as electricity to flow instantaneously back and forth between utilities and consumers and their end-use devices. The incorporation of a wide range of distributed energy resources and combined heat and power capabilities that are key to incorporating significantly more renewable energy into the grid, and finally, highly efficient smart electric buildings, appliances and devices which frankly cannot be utilized to best advantage until we have truly a smart grid. This can reduce energy consumption by at least 30 percent and even more during peak demand periods with comparable reductions in emissions and in costs.

The quickest path to transforming the performance and to realizing the value of the smart grid is to target the breakthrough technical innovations on the consumer's interface with the grid, that is, on the local electricity distribution system. In this way, the tipping point to achieving a universal national transition to a smart electric grid can be achieved within 5 years.

In closing, Federal Government policies and actions can certainly be a critical motivator for the smart grid transition. These would include, in my judgment, first expediting new energy efficiency standards and establishing market incentives for much higher efficiency consumer products and best practices and buildings such as universally applying the International Energy Construction Code. Second, raising the reliability standards for the electricity grid to levels that are compatible with today's digital economy and society, not measured in minutes of outage but in fractions of a second. Three, mandating universal advanced electric metering infrastructure and real-time pricing and support of demand response on the part of every consumer. Four, establishing a national public education campaign to inform consumers about the value of a smart grid and to encourage local implementation. And finally, and I believe most importantly, convening the State electricity regulatory community and instilling in them the critical national importance of the smart grid and the need for their universal regulatory support. The rapidly approaching and unavoidable onslaught of rising cost rate cases that they face I believe provides a window of opportunity for regulators to incent and enable the smart grid on behalf of all their consumers, and in this regard, regulators must also decouple utilities' profits from the amount of energy they sell and make them whole on the basis of the reliability, efficiency and quality of consumer service they provide.

Thank you very much, Mr. Chairman.

[The prepared statement of Mr. Yeager follows:]

Testimony

Facilitating the Transition to a Smart Electric Grid

Kurt E. Yeager

Executive Director, Galvin Electricity Initiative

May 3, 2007

Thank you, Mr. Chairman, Ranking Member Hastert, and Members of the Committee. I am Kurt Yeager, Executive Director of the non-profit Galvin Electricity Initiative and the retired President of the Electric Power Research Institute. I appreciate this opportunity to provide testimony to the Committee on "Facilitating the Transition to a Smart Electric Grid." My testimony reflects both 35 years of personal experience in the development of innovative technology encompassing every dimension of the nation's electric power system, and the combined efforts of the team of technical and business leaders who are implementing the landmark Galvin Electricity Initiative.

Issues

The biggest impediment to the smart electric grid transition is neither technical nor economic. Instead, the transition is limited today by obsolete regulatory barriers and disincentives that echo from an earlier era. Thirty years ago AT &T was the monopoly provider of telecommunications services and it was illegal to plug a non-AT&T modem into the AT&T network. Twenty-five years ago the only credible point-to-point global network provider was IBM. What happened? Consumers and the courts insisted that it was in the greater interest of the nation and its citizens to open these monopoly networks. These open networks have since spawned an incredible wave of innovation, private investment and economic development benefiting all consumers, suppliers and the prosperity of our nation. A positive transition of even greater national value will occur if the local electricity distribution systems are similarly opened to entrepreneurial innovation, investment in efficiency and alternative clean energy sources, plus access to individualized electrical service opportunities for all consumers. This smart electric grid transition is also critical to national security and productivity.

The federal government, and most importantly the Congress, is in an essential and unique leadership position in terms of enabling this long-overdue transition to a smart electric grid. This transition is also the key to the United States successfully resolving the looming "perfect storm" of economic, environmental and security threats arising from the vulnerability of the nation's aging and obsolete electricity infrastructure.

In contrast, during much of the 20^{th} century, the electric grid was the epitome of high-tech and it literally transformed every aspect of the nation's economy and society. It was a wellspring of technical innovation and the prime mover for the creation of new industries, jobs and services. As a result, electricity became the lifeblood of the nation's prosperity and quality of life. In fact, the National Academy of Engineers declared that "the vast networks of electrification are the greatest engineering achievement of the 20^{th} century."

Electricity is indeed a superior energy form; however, it is not a tangible substance but rather a physical effect occurring through the wires that conduct it. Electricity must be produced and consumed in absolutely instantaneous balance as it can't be easily stored. Its delivery, therefore, must balance supply and demand at literally the speed of light. Yet the status quo suffers numerous shortcomings. Efficiency, for example, has not increased since the late 1950s and U.S. power plants throw away more energy than Japan consumes. Unreliability that results in blackouts or even momentary interruptions, in today's digital economy costs America more than $100 billion annually. This is equivalent to a 50-cent surcharge on every dollar of electricity purchased by consumers. This unreliability surcharge is now simply being added to the cost of the goods and services we all buy. If the equivalent of just one year's worth of this surcharge was invested in achieving a smart electric grid, both the surcharge and the unreliability penalty it reflects would be eliminated.

The typical U.S. power plant was built in the 1960s using even earlier technology, whereas factories that construct computers, for example, have been updated and replaced five times over the same period. Today's high-voltage transmission lines were designed and installed before planners ever imagined that enormous quantities of electricity would be sold across state lines in competitive transactions. Consequently, these transmission lines are often overloaded and subject to blackouts. Yet demand is still increasing at twice the rate of capacity. Most critically, the electricity distribution networks that deliver power to each consumer are effectively the last bastion of an outmoded analog, electromechanically controlled network in today's digital world. This is a particularly dangerous paradox given the fact that the electric grid powers the digital revolution on which much of the nation's present and future productivity and competitiveness depends.

How then did the U.S. electric grid – the high-tech marvel of the 20th century – become a vulnerable low-tech legacy by the dawn of the 21st century? The declining cost commodity business model which successfully enabled the 20th century electrification of the United States ceased to be a functional reality by 1970. Since that time, however, the electric utility industry has continued to be governed and incented by the same outmoded state regulatory policies that attempt to maintain the illusion of declining costs while still holding consumers hostage to an obsolete electric grid. This has effectively led to a moratorium on innovation and little more than a life-support level of infrastructure investment. From the policymaker's perspective, the successful transition to a smart electric grid must therefore involve transformation of the business model as well as the technology for the grid.

Efforts to competitively restructure the industry have been based on the rationale that competitive markets will incent innovation and investment more effectively than regulated monopolies. While sound in principle, the policy implementation of this rationale has thus far failed to reflect either the unique physics of electricity or its public entitlement characteristics. The consequence has been a breakdown in the traditional public/private partnership to most reliably serve the electricity needs of the nation's citizenry. This public/private partnership must be revitalized, based on technology innovations that increase the value of electricity service and consumer satisfaction – in short, the smart electric grid.

The Smart Grid Imperative

Restoring the integrity of the U.S. electric grid and eliminating its dangerous vulnerabilities in the context of 21st century needs depends on several fundamentals, as illuminated below by electricity's broad stakeholder community:

1. Electricity is the nation's indispensable engine of prosperity and its infrastructure is the most critical. Policies and incentives are desperately needed to stimulate system modernization. These policies and incentives must protect the profitability of utilities based on the quality and value of consumer service they provide, not on the quantity of electricity they sell.

2. The roles, responsibilities and rules governing the electricity enterprise must be clarified so as to reestablish the confidence and stability needed to incent smart electricity infrastructure investments.
3. Energy policies must emphasize U.S. energy independence and diversity. This places electricity at the center of a strategic thrust to create a clean, efficient, reliable and robust national energy system producing the greatest value for the nation and all consumers.
4. The transition to a smart electric grid must enable all consumers to become active participants in, and benefactors of, the electricity enterprise. The technology exists to give consumers the smart capability to exercise efficient, informed control over their electricity usage and choice of services, rather than remaining captive, behind an "iron curtain" meter, to the historic commodity energy grid.
5. The primary role of electricity regulation must therefore evolve from "protection" of rate payers to enabling and maintaining market transparency and access for all electricity consumers.

Until these fundamentals are established, the nation's electric power system will remain incented to maintain the past, rather than creating the smart electric grid.

The transition to a smart electric grid envisions an electronically controlled, self-healing electricity supply system that is fully capable of responding in real time to the billions of decisions made by consumers and their increasingly sophisticated, digital, microprocessor-controlled appliances and devices. In short, it is a grid that provides the same efficiency, precision and interconnectivity as the billions of digital devices and processors that it must power. A number of breakthrough innovative technologies will be incorporated into this smart system's architecture, enabling the instantaneous and continuous flow of energy and information between electricity consumers and suppliers. These primary technical breakthroughs, noted below, already exist commercially and only lack the necessary policies and incentives for their prompt application.

1. Digitally controlling the power delivery network with electronic controls rather than today's relatively slow electromechanical switches and relays. This is particularly important in creating a fully automated, self-correcting, electricity distribution system capable of instantaneously meeting changing consumer needs.
2. Integrating communications is the key to achieving a dynamic, smart, interactive electric grid for real-time power and information exchange. This smart system has the advantage of much higher reliability plus the ability to most efficiently provide electricity services that are tailored to each consumer's needs.
3. Transforming the electricity meter into a consumer gateway that allows price signals, demand-response decisions and network intelligence – as well as electricity – to flow back and forth through a smart two-way energy/information portal. This advanced metering infrastructure (AMI) will ultimately enable a variety of individualized electricity services at least as diverse as those in today's telecommunications.
4. Integrating distributed energy resources. The smart power grid will be able to seamlessly integrate an array of locally installed, distributed electricity generation and storage capabilities. These will become essential assets to electricity consumers and suppliers alike in dispatching reliability, capacity and efficiency. Particularly valuable will be the ability to achieve significant increases in the use of clean renewable energy technology such as photovoltaics without negatively affecting grid reliability. As a result, homes and businesses can become net energy producers reducing the need for infrastructure expansion while fundamentally improving efficiency and environmental performance.

5. Accelerating end-used efficiency through advances in digital electric technology. These advances will enable continuous, sustainable improvements in user productivity and efficiency that are simply not possible with today's outmoded electric grid.

The smart electric grid is therefore essential to serving today's knowledge-based economy and society. This smart grid will also be able to automatically recognize incipient reliability problems, take corrective action and constantly optimize the efficiency and performance of the electricity system. This is the key to eliminating the severe security vulnerabilities in today's electric grid, whether the threat is of natural or human origin. In short, the smart electric grid will eliminate the current grid vulnerabilities while meeting intensified 21st century consumer electricity needs and service expectations. In the process, the transformed grid will create major economic and environmental benefits for the nation. For example, today's more than $100 billion-per-year electric reliability penalty on the nation's businesses and consumers would be largely eliminated. In addition, more than one trillion dollars per year in GDP growth will be stimulated through enhanced U.S. productivity in today's globally competitive marketplace. The consumption of energy in both commercial and residential buildings can also be reduced by at least 30 percent with comparable reductions in carbon emissions.

Achieving the Smart Grid

As this hearing is illuminating, there is broad recognition by the electricity sector and its stakeholders of the need to modernize the utility industry's aging infrastructure and business model. This is reflected in a variety of complementary initiatives being pursued by both public and private organizations including the Department of Energy, the Electric Power Research Institute, and a number of utilities and corporations. In additional to the innovative technologies described above, the foundation for these complementary efforts is an interoperable, open systems architecture. This effort is being coordinated by the Gridwise Architecture Council. Interoperability here means the seamless, end-to-end connectivity of hardware and software from the consumer through to the electricity supply source. This capability is essential to coordinating energy flows with the real-time flows of information and analyses. Interoperability is also the necessary platform for innovative technologies and services that create new value for consumers.

The Galvin Electricity Initiative complements these grid modernization programs by focusing on the consumer rather than the utility supplier. This non-profit, public interest Initiative is inspired and sponsored by Robert Galvin, the retired CEO and chairman of Motorola who earlier led the transformation of the U.S. telecommunications industry and introduced quality management principles to U.S. industry. These principles are based on the demonstrated fact that quality always saves and the goal must be perfect customer service. The goal of the Galvin Electricity Initiative is a smart, 21st century electric grid that never fails to meet, under all conditions, each consumer's expectations for electricity service confidence, convenience and choice. The electric grid includes here all elements in the chain of technologies and processes for electricity production, delivery and use across its spectrum of residential, commercial and industrial applications. All Initiative results and reports are available on the website **www.galvinpower.org**. Additional summary information is attached to this testimony.

The Galvin Electricity Initiative's focus on consumer value is being initially implemented through smart local microgrids that incorporate the breakthrough innovative grid and end-use technologies described earlier. These microgrids effectively act as intelligent, quality enhancing, consumer service capillaries on the bulk electricity distribution arteries. These microgrids will also enable consumers and utilities alike to take full advantage of the 2005 Energy Policy Act ırovisions that encourage utilities to provide consumers with advanced net metering systems, nabling access to real-time electricity pricing and demand response opportunities.

'he microgrid approach reflects several realities: First, the quickest path to challenging the ıerformance status quo of the grid, and to realizing the value of a smart grid, is to target the ıreakthrough technical innovations on the consumer's interface with the bulk power grid. ;econd, the most confident and sustainable engine for quality improvement is to enable nnovative, self-organizing entrepreneurs to commercially engage in the electricity enterprise. 'hird, this approach initially circumvents the relatively intractable, rigidly regulated monopoly ıulk electric grid while utilizing it to best advantage as the primary energy source for the smart nicrogrids.

'he cost/benefits of each local smart microgrid will be site specific. However, prototype pplications of the Galvin Perfect Power microgrid architecture are showing significant savings. 'his promises broad commercial viability. These electricity cost savings typically accrue from nergy efficiency and reliability savings, plus the ability of consumers served by the microgrid to articipate in demand-response, spinning reserve and day-ahead economic load response narkets. As a result, consumers become contributors to the reliability and peak capacity of the ulk power grid while reducing the need for additional electricity generation. This is a win-win or consumers and utilities alike.

)ne such prototype application is the transformation of the Illinois Institute of Technology (IIT) 'hicago campus electrical system into a smart microgrid. This smart transformation is being onducted by a team consisting principally of IIT, Endurant Energy and Commonwealth Edison. 'he economic benefits to the university, the utility and the surrounding community will provide a write-off period for the smart microgrid capital investment of less than three years. This should be typical for the process of "smartening" the electricity distribution system in buildings, neighborhoods and whole communities alike.

The transition to a smart grid will be further encouraged by the impending significant increase in electricity prices driven by rising fuel costs, new environmental costs (potentially including carbon emissions), and the unavoidable need for new infrastructure. For example, the electric utility industry anticipates that as much as $900 billion in new infrastructure will be needed between now and 2020. This cost increase will inevitably lead to electricity rate cases. As noted earlier, such rate cases, reflecting rising costs, have long been a political third rail for state regulators and utilities alike. But smart electric grid improvements that offer consumers a fundamentally higher quality of electric service plus the opportunity to better control their electricity consumption (and monthly bill) provide a consumer-attractive quid-pro-quo for higher electricity rates. The efficiency and peak demand reduction advantages of a smart grid will also significantly reduce the need for new centralized electricity generating capacity.

Given these impending electricity rate increases, proactive advocates for the smart grid transition include state legislatures and community governments in the affected electricity service regions (particularly major urban areas). These elected bodies have already begun to express their dissatisfaction with unqualified rate increases and their encouragement for smart grid modernization investments that can produce savings for consumers. A number of other energy trends are also creating "consumer pull" for the smart grid transition. For example, the combination of ubiquitous low-cost communications (wireless and wired), standardization of Internet Protocols and low-cost mesh sensors is making precise, real-time, on-demand electricity management a low-cost increment to residential and commercial investments already being made. In addition, utility economics are driving advanced metering infrastructure (AMI) and demand response (DR) capabilities. The result will inevitably lead to a transformed electric utility industry that is a real-time, demand-driven, dynamic-priced business, unless restricted by the continuation of today's obsolete and counterproductive regulatory structure.

The Galvin Electricity Initiative is also demonstrating that a variety of innovative new entrants are eager to contribute to the smart-grid transition and to participate in delivering the enhanced consumer value it will enable. These include: Commercial building and real estate owners; residential and commercial building automation suppliers; network system developers; financial and venture capital firms; and distributed power/microgrid developers and installers. In each case, it is policy disincentives that discourage many otherwise commercially viable smart grid opportunities. Other smart electric grid transition constraints include lack of consumer knowledge, utility and regulatory resistance, rules and tariffs that discriminate against new entrepreneurial entrants, and dysfunctional building design and construction processes.

With the implementation of a more supportive policy structure, the "tipping point" for the universal transition to a smart electric grid can be achieved within five years. The factors reflecting this tipping point include:

- Intelligent energy management systems being built into the majority of new commercial buildings
- Home automation systems have become a staple offering available from both installers and retail outlets
- More than 40 percent of the aggregate U.S. electricity load is served by advanced metering infrastructure (AMI).
- Active Demand Response and real-time electricity pricing programs are widely used

- Grid interconnectivity is broadly (80 %+) activated.

Recommendations

In conclusion, the following recommendations are offered in terms of what the Federal Government should do to assist in the prompt transition to the smart electric grid.

1. **Expedite new energy efficiency standards**. These standards include space heating and cooling, lighting, home appliances and building performance. Also, ensure that these energy efficiency standards and measures are reinforced by sustainable market incentives.
2. **Establish incentives for higher efficiency consumer products** and appliances, plug-in hybrid electric vehicles, advanced electric batteries, and energy storage technologies. All of these advancements will both provide and receive major value from a smart electric grid.
3. **Raise the reliability standards for the electric grid**. Current reliability standards generally ignore outages of less than two minutes in duration and are therefore largely irrelevant to today's digital economy. This leads to unacceptable interruptions and costs for the nation and all its citizens.
4. **Mandate universal advanced electricity metering infrastructure (AMI)** and real-time electricity pricing in support of demand response (DR). The Energy Act of 2005 was a useful first step but its encouragement for these smart-grid enabling actions has been largely ignored by most jurisdictions.
5. **Authorize a national public education campaign** to inform consumers about the value of the smart grid and its ability to reduce consumer electricity costs while fundamentally

improving the reliability, efficiency, security and environmental performance of the nation's electricity supply system.

6. **Convene the state electricity regulatory community** and instill in them the critical national importance of the smart electric grid transformation and the need for universal regulatory support. Ultimately, it is in the state regulators' enlightened self-interest to facilitate this urgent grid modernization process on behalf of the constituencies they serve.
7. This state regulatory "transition" must also **fundamentally change the economic incentives for utilities** from simply selling the maximum quantity of kilowatt hours to regulating and rewarding utilities on the basis of their reliability and efficiency performance, and quality of consumer service they provide.

Congressional leadership for these actions will provide the breakthrough needed to realize the long overdue transition to a smart electric grid for the United States. The future is indeed now to comprehensively address the energy security, environmental and economic threats that our nation faces. The key is a smart electric grid.

Mr. BOUCHER. Thank you very much, Mr. Yeager

Mr. Kamen, we will be glad to hear from you.

STATEMENT OF DEAN KAMEN, PRESIDENT, DEKA RESEARCH AND DEVELOPMENT CORPORATION, MANCHESTER, NH

Mr. KAMEN. First, I have to give the disclaimer that I am not an expert on either policy or mega and giga scale energy. I suspect I was invited here because of another project I have been working on for about 10 years that ironically was intended for people that live in a world where there is no grid whatsoever, and I am happy to tell you that after about 8 years of working on a little box about the size of a dorm room refrigerator, we were able to convince ourselves it was reliable enough, robust enough, efficient enough that it could be tested, and this box was intended to produce enough electricity for a small village anywhere in the world where they have no grid. There are 1.6 billion people in Asia and Africa that have never used electricity and in our lifetime are unlikely to see a grid suddenly appear, and we said what if we could make a small box, the size I just said, that could be moved into a village that would run for many years, presumably and hopefully on any local fuel, anything that burns, liquid or gaseous, and produce a few kilowatts, also could do it in a place where you could use the waste heat. I am happy to tell you that about a year ago we placed two of those units in two villages, one about 75 kilometers north of Dacca, one 75 miles west of Dacca, in Bangladesh and for 24 weeks around the clock we did a trial. We electrified these villages and they ran without interruption. Not bad compared to what most utilities in this country can do. It turns out that we certainly have more work to do there but some of the members know about this box and I think the United States ought to work on these things and maybe help around the world but that is probably for a different committee.

How could that box or similar boxes be useful in this country? I think you have heard all the reasons. I would just simply ask you to do the mental experiment that the average homeowner puts a box in their house similar to their water heater or their furnace that can sit there and burn any locally available fuel. By the way, I should tell you the only thing that went into either of these boxes in Bangladesh for 24 weeks, they were put next to a small pit and cow dung, very naturally evolving methane gas with no intervention by any exotic biodigester was the only source of fuel, and by the way, it was preventing the methane that was coming off at 20 times the environmental damage of CO^2 from coming off. We then turned it into the CO^2 it would have become anyway. In any event, what does that got to do with all this? Well, it seemed to us hearing the great debate going on in this country that if you could put that unit in a house, you might have a very, very significant impact on a bunch of things.

The real effect of reliability and the real effect of measurement of how much energy we use and what we get for it and I would be the first to admit to the giant power company guys around here that a good, large closed-cycle steam turbine or other device can turn heat into electricity at about 40 percent efficiency. My little sterling cycle device does it at about 20 percent. Most people would therefore say my device is only half as efficient as a great big generator. I think that 19th century mindset has to change when you say what do you mean by efficiency because that 40 percent efficient system, let us say it makes a gigawatt, 1,000 megawatts, if it does it at 40 percent efficiency, it means you made 400 megawatts of electricity to go out through those lines which they do very well. That is why we built central plants for 100 and something years. The other 600 million watts creates the waste heat sitting in the river somewhere killing fish or polluting but that 60 percent, that 600 megawatts, can't easily be moved so it is gone. That is why we say 40 percent efficiency. My little box or other similar boxes that could do CHP, combined heat and power, could sit in somebody's house and only turn 20 percent of the fuel that goes into them into electricity but the other 80 percent is the heat that heats your house and your shower and washes your dishes and your clothes.

In other words, in most average homes in the United States, only 20 or 30 percent of the power coming in was meant to be electricity. The rest of the power the homeowner buys was from the gas company or the oil company because a unit of energy in terms of that you need for heat is substantially cheaper to buy than a very high-quality unit of energy called electricity. If you could take all the fuel that you would have burned in these central plants and build miniature power plants in somebody's home, as long as you burned that fuel efficiently and cleanly, you could make use of virtually all of the waste; it is no longer waste. Then for every unit of fuel we could use in this country, you would find that you make less of a carbon footprint, you got more overall total efficiency and a bunch of the advantages that you have heard about. If you put small distributed units around the country, even if they are only a couple of kilowatts apiece in people's homes, just do the math. If every homeowner got a couple of thousand dollar boxes put in his house and you put a million of them out there and each one was a couple of kilowatts, you get a couple of gigawatts without building another big plant. None of that power goes through the grid, which is getting a little old and a little tired and a little less reliable. If you build your smart transmission grids and these little boxes can talk to each other in the neighborhood, you get other benefits like energy security because no one plant going down will stop people from getting their critical loads. They will probably turn off their air conditioning and their Jacuzzi but if they can make a couple of kilowatts in their home, there is not a crisis when there is a snowstorm or other kind of interruption. Second, you can burn any locally made fuel which is, A, more efficient, and B, you can economically certainly advantage the homeowner in doing it that way, and oh, by the way, you can encourage all sorts of other, once you make this thing smart, interactions such that in a day where invention is now finally hitting the world of energy production the way it hit computing 30 or 40 years ago. We suddenly had to go from mainframes to distributed computing and then the cell phones took the 100-year system where you had to work with Ma Bell and gave us so many different ways to communicate, it got better and simpler and the Internet got—you guys had to start updating the way that people could do it. I think we are now at a point where whether it is solar cells getting attractive and efficient, wind turbines getting attractive and efficient, sterling cycle, any kind of device getting more efficient, you are going to see lots of inventions that could become great innovations, that could make this whole thing better and make great new jobs but you have got to create an environment—you asked for recommendations. You have got to create an environment where all these different new ways of thinking are encouraged rather than the technology is there but your systems are not keeping up with allowing them to be implemented.

[The prepared statement of Mr. Kamen follows:]

Testimony of
Dean Kamen
President of DEKA Research & Development Corp.
Before the House Subcommittee on Energy and Air Quality
Committee on Energy and Commerce
U.S. House of Representatives
May 3, 2007

Chairman Boucher and Members of the Subcommittee. Good morning and thank you for your invitation to testify before you today. I am Dean Kamen, President of DEKA Research & Development Corp., a small research and development company located in Manchester, New Hampshire. I testify today as an inventor and engineer, rather than as an industry participant or expert – and profess no policy expertise. However, as an inventor/engineer, I have spent considerable time and effort developing one specific solution to help address certain energy challenges.

I am pleased that this Committee is addressing the requirements for the grid of the future. I believe that modernizing the grid is an essential element of improving our nation's energy future, and that the role of the grid will begin to change dramatically over the next 5 to 10 years. My fundamental advice is that before we embark on a massive investment to upgrade the grid, we should have a roadmap that leads to a grid capable of leveraging not only the innovations of today, but those of tomorrow.

Framing the Question

Regarding the grid, properly defining the end goal is a necessary first step before proposing any solution. Today, the essential role of the grid is to move electricity from its point of creation to its point of use - in a reliable, safe and economical fashion. While much has changed over the past 100 years to improve the grid's reliability, safety and cost, one fundamental element has remained constant: electricity is generated centrally and distributed locally to homes and small businesses – basically a one way flow. However, in a world with ever greater constraints on the building of new generation and transmission infrastructure, but where energy demand continues to grow, it is my belief that the centralized generation, one-way flow paradigm is about to change. We are about to enter a world where a significant portion of our nation's energy production occurs at the residential or small business level, rather than solely at central power plants. Therefore, we must build a smart grid that both recognizes and enhances that inevitability. This paradigm shift is analogous to the way computing and telecommunications have changed over the last few decades - shifting from centralized to distributed structures. The good news is that much of the hardware and software necessary for a similar transition of our electricity infrastructure have already been developed and are readily available.

There are several technologies already being used, albeit on a very limited scale, for distributed generation. One I'd like to mention briefly is CHP, or combined heat and power, and more specifically micro-CHP which is the residential scale generation of both electricity and heat at the point of use.

Micro Combined Heat and Power (CHP)

The core benefit of CHP is that it is a significantly more efficient use of our scarce energy resources. Today's electricity generation and distribution systems are inherently inefficient, delivering only about one third of the energy of the primary fuels as useful electric power. The other two thirds of the energy are lost as waste heat at the central plant or as "line losses" when the electricity travels from the point of generation to the end user. The irony is that we could use that heat in our homes for hot water or space heating – which accounts for over 60% of the energy used in a typical US home - but it is impractical to recover and transmit the heat from those central plants. Why not replace the furnaces or boilers in our homes with a much smaller version of that central plant? This can produce electricity locally and instead of throwing away the wasted heat, we can use it for our hot water or space heating. This is the fundamental idea of micro-CHP, which would shift the efficiency of fuel to energy delivered from around 33% to as much as 90% - a significant savings. Not only does this higher efficiency result in greater utilization of our limited resources, it also results in potentially significant reductions in CO_2 emissions and harmful gas emissions (NOx, SOx, and particulate matter) by burning less fuel for the same amount of energy delivered. The higher efficiency of micro-CHP has the added benefit that it results in economic savings to the homeowner by reducing their combined heating and electric bills.

CHP has been around for a while, but has typically been implemented only on large commercial or industrial scale. The good news is that now the technology has advanced to enable CHP in everyone's basement. In fact, micro-CHP units have already been installed in homes in Europe and Japan, which has over 50,000 units installed after being introduced several years ago. This same technology has just become available in the US.

In addition to its higher efficiency, micro-CHP has all the advantages of any other distributed generation source, including:

- Reduced demand for new power plants and transmission and distribution systems with their associated NIMBY (not in my back yard) issues
- Reduced grid congestion
- Ability to add capacity in increments of kilowatts rather than in gigawatt sized central plants
- Potential to use a diverse group of fuels – some of which can be renewable and/or locally produced, further enhancing energy security and efficiency
- Voltage support for the existing grid, helping prevent power disruptions across the broader grid

An ancillary, but critical benefit of CHP, and other forms of distributed generation, is that it provides local reliability that is virtually unobtainable by improving the current grid design. With the current grid, average US customers lose power for 214 minutes per year (99.96% uptime). This sounds quite reliable, but in fact, the US actually ranks near the bottom of developed nations in terms of reliability. In an increasingly digital world, where even small disturbances can result in losses of information and productivity, this results in an estimated cost to US consumers of $150B per year. Unfortunately, improving the reliability of the current system from 99.96% to 99.999% would require significant resources and would likely not address some of the major causes for outages, such as major storms. Incorporating CHP and other forms of distributed generation is a more cost effective way of providing greater reliability at a local level, as well as bolstering the reliability of the broader grid.

It is important to stress that distributed generation and the current grid can and should coexist. The grid is very good at effectively distributing low cost baseload power to large, dense populations. In addition, the centralized generating plants used in the grid have useful lives of decades and will be producing power for many more years. Even if distributed generation grows to a significant portion of the generation in the US, the grid will still be an essential backup for these distributed systems, necessary for ensuring the highest system reliability.

The Grid of the Future and Role of the Government

Now imagine a world 20 years out – a new paradigm with generation both at the center and at the periphery: What must the grid look like? What "smart" features are required? Above all, the grid must continue to provide safe, reliable power. Beyond this, the grid should also be structured to allow the most efficient use of energy at any point and to take advantage of future opportunities for increased efficiencies. Specifically, the grid of the future should:

- Accommodate distributed generation sources easily

- Allow the realization of real-time two-way power and information flow

- Allow smart metering by which the true price of electricity can be measured

- Accommodate smart appliances which can be seamlessly integrated into a "smart metered" household

- Allow demand pricing and demand side management which will encourage more efficient energy use decisions

As I stated earlier, I am not a policy expert, however here are my thoughts regarding what the government can do to help this effort:

- Eliminate any regulatory barriers which impede rapid introduction and adoption of micro CHP and the required changes to the grid

- Implement policies which speed the adoption process, including creation of fair and equitable standards and incentives which drive individuals to appropriate behaviors sooner than they might without these policies

- Remain neutral as to which economic actors participate in these changes

* * *

In conclusion, I believe that with intelligent regulation and creation of a level playing field, there are tremendous opportunities for affordable, efficient, and environmentally friendly energy. Getting the "smart grid" right, while not the whole answer, is a critical piece of the overall energy solution. Thank you again for the opportunity to share my views with you today.

Mr. BOUCHER. Thank you, Mr. Kamen, very much. We will have some questions of you shortly.

Mr. Gammons, we will be happy to hear from you.

STATEMENT OF BRAD GAMMONS, VICE PRESIDENT, IBM GLOBAL ENERGY AND UTILITIES INDUSTRY, AMARILLO, TX

Mr. GAMMONS. Good morning, Chairman Boucher and members of the House energy committee. I am Brad Gammons, vice president of IBM Global Energy and Utility Industry. IBM appreciates the opportunity to testify before this subcommittee today.

Innovation is a major theme of any leader's agenda today. Listening to Mr. Kamen, that came up quite clearly. CEOs, academics, government leaders agree that innovating their business models, policies, problem-solving approaches and execution models are key drivers of economic opportunity. In fact, the pressure to innovate is heavy. In order to establish and sustain competitive differentiation and institutional value or to make advances in the world's most pressing issues from health care, globalization, the energy efficiency and the environment, you must innovate.

Across all industries, there are two significant changes in technology that have occurred which are providing the foundation for innovation. First, the Internet and other communication technologies have connected a million businesses and a billion people, making it in essence the world's operational infrastructure and it is still only in its infancy. Soon trillions of things will be virtually connected. Right now we have nearly 3 billion people that subscribe to wireless technology. This network ubiquity provides a vehicle for people and things to work and operate in a collaborative way. Second is open standards very much to what Mr. Kamen was talking about, is you have to have a way for these things to communicate together to allow for innovation. The evolution in open standards presents the opportunity in the utility industry to accelerate and optimize the implementation of a smart grid or what IBM calls an intelligent utility network. An intelligent utility network or a smart grid will provide an IT-enabled continuous sensing network which connects all parts of the utility, equipment, control systems, applications, employees providing for the automatic collection of data and asset conditions from across the utility on which analytic simulation and modeling to perform. Ultimately the smart grid will also connect the utility with the consumer, which will be bringing increased options, more control over energy usage and more choices for energy rates. It will literally bring power to the people.

In the utility industry, there is a great desire to achieve new levels of operational effectiveness, reliability and energy stewardship to reach beyond efficiently managing generation or transmission or distribution to have the business management and operational visibility across these domains and even to include raw materials, transportation, supply chain and the customer experience, in effect the entire energy ecosystem.

The evolution of the power grid or the smart grid is the connective tissue and the enabler for these utility desires but the appropriate infrastructure investment and policy is needed to create this reality.

The utility industry faces a series of significant dilemmas. How can a utility company contain costs while increasing power reliability? How can they ensure energy security while still providing access to all? How do they bring new supply into the system to meet growing loads when the current system is challenged to accommodate new energy sources? How do they build new generation and transmission facilities when there is significant social and political resistance? And as a matter of policy, how can energy be a source of economic growth while preserving environmental sustainability?

Innovation of business processes, operational practices and models will be key to addressing these competing demands utilities are facing so let us look at several examples of how utilities can enable innovation in their business by leveraging technology. We can use that technology in three important ways. First, to automate the power grid to make it stronger, cleaner and less costly; second, to integrate the power grid and create an end-to-end network; and finally, to expand the value of the grid with service and information. If we do these things, the grid can evolve to become an intelligent utility network or smart grid providing an interactive energy management system enabled by existing technologies such as system sensors, smart meters, analytical tools, high-speed communication networks and digitally enabled equipment and assets.

In most cases, these technologies are not new. What is new is how proven technology often developed for solutions in other industries are being applied to the utility industry to generate tangible benefits and foster innovative business models today. Imagine if a company were to integrate all these capabilities with the smart grid. Such a pilot is underway in Washington State, the Pacific Northwest Gridwise Project represents a groundbreaking collaboration between Pacific Northwest National Lab, utility companies and technology partners such as IBM. This initiative allowed a select group of homeowners on the Olympic Peninsula to have more information about their energy use and its costs as an incentive to reduce power consumption at peak times. Automated controls will adjust appliances and thermostats based on pre-determined instructions from the homeowners, allowing consumers to choose to curtail energy when prices are higher than their set preferences.

We talked how technology can address and help the current state of the grid. The benefits for our Nation's transformation to a smart grid will make the journey well worth it. In other words, a smart grid is a platform to enable the future. It can improve the Nation's ability to respond to increased energy demands and increased need for energy independence, improving reliability while still providing for a secure infrastructure. It can also help drive innovation across the energy supply chain providing value and enhancing the competitive position of all players in the U.S. energy industry, and oh, by the way, huge energy users like the IBM Corporation. It can enhance energy independence and protection of the Nation's critical infrastructure and save billions in energy productivity and increase national competitiveness.

The good news is, this innovation of new technology is not a factor from a policy standpoint. The technology is sufficiently mature and adaptation for utilities can be addressed.

Thank you for your time this morning.

[The prepared statement of Mr. Gammons follows:]

TESTIMONY OF BRAD GAMMONS

Chairman Boucher and members of the House Energy and Commerce Subcommittee on Energy and Air Quality, my name is Brad Gammons and I am Vice President of IBM Global Energy and Utility Industry. IBM appreciates the opportunity to testify before this Subcommittee.

Innovation is a major theme of any leader's agenda today. CEO's, academics and government leaders agree that innovating their business designs, policies, problem-solving approaches and execution models are key drivers of economic opportunity. In fact, the pressure to innovate is heavy in order to establish and sustain competitive differentiation, institutional value, and to make advances in the world's most pressing issues from healthcare and globalization to energy efficiency and the environment.

It is easy to confuse innovation and invention. Invention of new technologies is important to IBM and other companies in the technology industry. However, technology invention, in and of itself, is not what we mean by "innovation." Instead, we think about technology as an enabler of business, academic and government innovation. Technology is an enabler of new ways to do things whether that is developing a set of products and services, executing a set of management processes or rethinking entire business models.

Across industries, there are two significant changes in technology which are providing great leverage:

1) The Internet. The Internet and other communications technologies have connected a million businesses and a billion people. The Internet is, in essence, the world's operational infrastructure. And, it is still only in its infancy. Right now, we have nearly three billion people subscribed to wireless technology. This network ubiquity provides the vehicle for people and things to work and operate in a collaborative way.

2) Open Standards. Starting with Internet Protocol, the software industry has made major strides in establishing and delivering to the market open standards-based products and technology. Whole new classes of software, like middleware, make it easier to build solutions faster and based on "off the shelf" components and products. Open standards has been evolving over the last decade beyond traditional IT to include networks, digital media, industrial components like sensors and more. It has expended IT standards to previously closed and proprietary domains.

Leaders want to put in place new business designs that break down traditional and operational silos and enable horizontally-integrated institutions and enterprises. This is made possible with these open and ubiquitous technologies. The horizontally-integrated institution can make firms incredibly flexible in responding to business, marketplace and global needs.

In the utilities industry, there is a great desire to achieve new levels of operational effectiveness and to reach beyond efficiently managing generation, transmission or distribution. There is a desire to have business management and operational visibility across these domains and even to include raw materials, transportation, supply management and the customer experience—in effect, the entire energy ecosystem.

The desire is to improve network planning, operations and maintenance—improve the transparency of information, experience fewer and shorter outages, provide better customer service, and provide a platform for adding renewable energy and improved utilization.

The power grid is the "connective tissue" of the utility ecosystem. Today, we are here because we know the power grid challenges need to be dealt with now.

We need appropriate infrastructure investment as well as policies to encourage investment. No one cares about putting in a smart grid or what IBM calls an Intelligent Utility Network (IUN) just for the sake of it. What truly matters is creating advantage for your enterprise, value to your customers, and the ability to improve long-term environmental effects.

The utility industry faces a series of significant dilemmas. How can utility companies contain costs while increasing power reliability? How can they ensure energy security, while still providing access to all? How can they deliver increasing levels of service while at the same time being unaware that entire neighborhoods are without power? How do they bring new supply into the system—to meet growing load—when the current system is challenged to accommodate new energy sources? How do they build new generation and transmission facilities when there is significant social and political resistance? And, as a matter of policy, how can energy be a source of economic growth while preserving environmental sustainability?

In order to address these dilemmas, we need to innovate. Other industries have faced their own dilemmas and have responded by innovating their business models.

Let's consider another capital intensive "grid," but for the transportation industry—the airline industry. Airlines are able to change pricing structures and how they manage supply and demand in almost real time. If airlines operated the same way utilities do, they would charge one price for every seat, regardless of the class of service or the time of purchase or available capacity. This scenario is not different from demand management and pricing in the utility industry where customers are challenged in their ability to monitor and adjust their energy consumption.

Let's think about the banking industry. Banks can account for every dollar of every transaction every time. They can even leverage the data they have about consumer habits to target customers with new products and services. In the utility industry, kilowatt hours are the currency. But utilities are challenged to track kilowatt hours completely and use data to improve customer service.

Let's look at some examples of how utilities can innovate their business designs by leveraging technology.

We can use technology in three important ways.

(1) To automate the power grid to make it stronger, cleaner and less costly;

(2) To integrate the power grid and create an end-to-end network;

(3) And, to expand the value of the grid with new services and new markets.

If we do these things, the grid can evolve to become a Smart Grid.

Building intelligence into the grid provides the information backbone to better understand our energy use, and empowers utilities, regulators and consumers to better manage their energy environment and practices.

A smart grid represents the transformation into an interactive energy-management system. The proliferation of sensors and existing technology such as smart meters, analytical tools, Services Oriented Architecture, high-speed communication networks and digitally-enabled equipment have made this possible.

In most cases, these technologies are not new. What's new is how proven technology, often developed for solutions in other industries, is being applied to the utility industry to generate tangible benefits and foster innovative business models today.

Again, we're not talking about new technology invention. We're talking about applying mature technologies to new approaches. In my view, there's tremendous potential to seize the "low-hanging fruit" for "no-regrets" investments.

Utilities are extending equipment life and minimizing unnecessary substation inspections through remote asset monitoring and control. This defers costly equipment upgrades, maximizes the utilization of existing assets, and reduces and mitigates blackouts.

Utilities like Xcel have consolidated their multiple operational and IP networks and are using existing telecommunications infrastructure to transport data from equipment to the back-office to make it available across the enterprise and apply analytical tools to turn data into information.

Utilities are extending the value of their networks by using Advanced Meter Management. The installation of AMM includes the customer premise as part of the network enabling demand response and time-of-use pricing models.

CenterPoint Energy is deploying a number of smart grid solutions including remote connect/disconnect and Advanced Meter Management for Houston area customers. This will give utilities serving consumers better usage information and make power distribution more reliable. With more detailed information on usage and pricing, consumers can potentially save money by changing their consumption patterns.

A smart grid will allow for safe and reliable integration of distributed energy—such as wind, solar, storage and other environmentally desirable solutions—into the power grid. Examples of innovation at the intersection of the transportation and utility sector are: Pacific Gas & Electric, Southern California Edison, Xcel, and Austin Energy's vehicle-to-grid technology. This technology allows for two-way sharing of electricity between electric vehicles and plug-in electric hybrid vehicles and the electric power grid. The technology turns each vehicle into a power storage system, increasing power reliability and the amount of renewable energy available to the grid during peak power usage.

Imagine if a company were to integrate all of these capabilities. Such a pilot is underway in Washington State. The GridWise Pacific Northwest Gridwise Project represents a groundbreaking collaboration between the Pacific Northwest National Laboratory and utility companies and technology partners such as IBM.

This initiative will give homeowners on the Olympic Peninsula more information about their energy use and its cost as an incentive to reduce their power consumption at peak times. Automated controls will adjust appliances and thermostats based on pre-determined instructions from the homeowners. This allows consumers to choose to curtail energy use when prices are higher than their set preferences.

The smart grid is a platform to enable the future. It can improve the nation's ability to respond to increased energy demands and increased need for energy independence while mitigating security concerns and the economic impact of blackouts.

Smart grid can also help drive innovation across the energy supply chain providing value to and enhancing the competitive position of all players in the US energy industry.

Smart grid can enhance energy independence and protection of the nation's critical infrastructure, save billions in energy productivity, and substantially increase national competitiveness.

The invention of new technology is not a factor from a policy standpoint. The technology is sufficiently mature and the adaptations for utilities can be addressed.

At the same time, utilities must embrace innovation and collaboration to transform their business models and substantially improve the infrastructure. Technology providers must seize the opportunity to demonstrate how existing technologies can be applied for immediate improvement, as well as be a strong partner in research and development for future solutions on the horizon—for the benefit of consumers, the market and the environment.

Thank you.

Mr. BOUCHER. Thank you very much, Mr. Gammons.

Mr. Delurey.

STATEMENT OF DAN DELUREY, EXECUTIVE DIRECTOR, DEMAND RESPONSE AND ADVANCED METERING COALITION, WASHINGTON, DC

Mr. DELUREY. Thank you, Mr. Chairman. My name is Dan Delurey and I serve as executive director of Demand Response and Advanced Metering Coalition, otherwise known as DRAM. DRAM members include the leading providers of smart metering, communications and control technologies as well as companies that use those technologies to provide blocks of megawatts to utilities with these blocks being equivalent to what they would otherwise procure from conventional power plants.

Demand response is the term that refers to the business and policy area where electricity customers reduce or shift their electricity use on peak in response to price signals or other incentives. Demand response addresses the fact that in order to have a smart grid, we need to have smart rates and smart prices and smart technologies that provide customers and utilities alike with new options for how to manage electricity. That is not what we have today. Under our present system, the vast majority of customers and almost all residential customers pay no more for electricity on the hottest summer afternoon when the electricity system is strained and the cost to produce electricity is extremely high than they do in the middle of the night on a spring or fall day. That is not a smart system, especially when having only a percentage of those customers modify their peak use to prevent reliability problems and lower prices for all customers on the system. In order to deploy demand response, it is necessary for two things to happen. First, technology must be in place that allows electricity usage to be measured in time intervals instead of the present system where usage is measured cumulatively and all kilowatt-hours are treated equally. That information has to then be communicated in a timely fashion to utilities, customers and other parties. Second, customers must be provided with time-differentiated price options and/or other incentives to reward them for modifying their on-peak usage.

As to the pricing part, Congress is not in position to set prices for electricity. That is clearly for States and other bodies of jurisdiction over utilities to decide but it can ensure that the level of attention, support and funding is provided that will allow the States to tackle their role in establishing demand response and creating a smart grid. Congress began to address this in the Energy Policy Act of 2005 in section 1252. It established a requirement that States and other bodies with utility oversight examine whether or not its jurisdictional utilities should provide time-based rates and smart meters to all their customers. While many States still have a proceeding underway to consider this requirement, the majority of those States that have concluded their proceedings have decided not to adopt this new requirement. That is not to say that this section of law has not had a positive effect; it has. Demand response and smart metering are being discussed in more States and in more places than ever before. But in terms of States trying to tackle a new and multifaceted issue such as demand response and its enabling technology, they clearly have not received the training, education, technical assistance or other support they have needed as they have taken up this new requirement. States need more support from Congress so they can do the job that they have to. Smart grid will not happen with one big bang or in one fell swoop, and more than people think, much of it will happen in a disaggregated fashion by actions at the State level.

With these issues in mind and at the chairman's request, I would like to just highlight some of the policy recommendations that I have included in my written testimony. The first area would be taxation, recognizing that is not the jurisdiction of this committee but as with energy efficiency and renewable energy, the proper tax incentives, for example, reduction tax credit to go along with the production tax credit that is given lift to the wind industry, that would go a long way in helping this industry, and I think this committee could in terms of definition, policy frameworks and statements do a lot in terms of that. I think that the establishment of a temporary national commission on electricity modernization should be established with funding provided that could conduct the proper assessment of the smart grid and look at funding options and also develop a national action plan on demand response and grid modernization, not just a plan, not just a report but an actively managed plan that would do the things necessary in the many different places they need to be done to make sure that this happens. Congress should consider in terms of funding these new investments looking at a national assessment on the transmission system. Even an extremely small wire charge would generate significant revenue earmarked for smart grid investment.

In terms of the Federal Government showing leadership, Congress should consider establishing peak demand reduction standards for Federal agencies. In terms of appliances, you have heard about prices to devices. Congress should consider moving to additional types of appliance standards beyond those that govern internal energy efficiency. Congress should consider how to integrate smart metering systems in climate change strategies and regimes so that such systems and other technologies can be used to more precisely measure and verify energy reductions and the monetary rewards that accrue to those carbon reductions. Congress should consider providing funding and technical assistance to States or groups of States to undertake smart grid and demand response actions on their own or in conjunction with a national program as I described. Congress should consider requiring the Federal Energy Regulatory Commission to develop a framework on interoperability, something that has already been touched upon but is one of the key threshold issues to the growth of demand response and the smart grid.

In the absence of having more time to address it, I would like to talk perhaps in response to a question Congresswoman Harman introduced, an idea that doesn't get talked about enough and that does all this relate to the environment, and I have some comments on that. I would be happy to answer in response to a question in terms of how a smart meter is a green meter. But what I would like to do in closing is more make the comment that it is important as we talk about the smart grid to not always talk about it in future tense. Yes, better technology will come along. Meters and other demand response technologies are now high-tech items and as with other high-tech items, they will continue to evolve and improve but smart meters and other smart technologies are available now that provide all of the benefits that my testimony describes. If consumers and businesses had waited to buy their first computer or cell phone until the best technology came along, they would likely have gone for years without a computer or phone and in the meantime have foregone the obvious benefits of using the existing technology. The barrier to demand response and smart grid is not more R&D. What is needed most is to put demand response and the smart grid on a national commitment basis and to make policy changes that will help implement the smart grid.

With that, let me express my thanks once again for the opportunity to testify and I look forward to your questions.

[The prepared statement of Mr. Delurey follows:]

TESTIMONY OF DAN DELUREY

My name is Dan Delurey and I am executive director of the Demand Response and Advanced Metering Coalition (DRAM). DRAM is the trade association for companies that provide technologies, products and services in the electricity industry segment known as demand response. Its members include the leading providers of smart metering systems, communications and control technologies, meter data management systems, smart thermostats and other "smart" equipment. DRAM welcomes the opportunity to provide testimony to the Subcommittee on Energy and Air Quality on why demand response needs to be included in electricity policy, planning and operations, and to offer comments on how demand response and its enabling technologies, such as smart meters, not only relate to but are in fact necessary for the development of the smart grid.

Our testimony seeks to do several things:

Provide a brief explanation as to what demand response is, why it is important to national energy policy, and why it is an important element of a "smart grid".

Provide a brief overview and explanation on demand response technologies such as smart meters.

Discuss the many and varied benefits that demand response and its enabling technologies deliver to various parties.

Discuss the state of demand response policy and comment on the impact of provisions on demand response and smart meters included in the Energy Policy Act of 2005.

Present policy options that the Congress can consider and act upon to accelerate the deployment of demand response technologies, increase the amount of demand response in the national electricity mix, and put the foundation in place for development of the smart grid.

WHAT IS DEMAND RESPONSE?

Demand response refers to the policy and business area whereby electricity customers reduce or shift their peak demand usage in response to price signals or other types of incentives. At present, the vast majority of electricity customers, and virtually all residential customers, are on rates or prices that have them paying the same unit price for electricity at any time of day and any time of year, no matter how much the cost to produce or deliver electricity fluctuates as demands on the system rise and fall. These existing "flat" rates do nothing to stem peak electricity usage, which continues to grow unconstrained across the U.S. The lack of any disincentive to on-peak consumption does nothing to address the reliability of the electricity system, which continues to be threatened by the rapid growth in peak demand. When demand response is introduced, and when even a small percentage of customers modify their peak usage, outages can be prevented, overall prices to all customers can be reduced, and customers, utilities and many other stakeholders can reap significant benefits. More discussion of benefits will be provided in a later section of this testimony.

As with any new field, definitions of demand response are still in development within the policy and business community. One definition that many policy makers have accepted was developed by the non-profit U.S. Demand Response Coordinating Committee (DRCC), a diverse group exclusively dedicated to the development of new content and information on demand response. Its definition is as follows:Providing electricity customers in both retail and wholesale electricity markets with a choice whereby they can respond to dynamic or time-based prices or other types of incentives by reducing and/or shifting usage, particularly during peak periods, such that these demand modifications can address issues such as pricing, reliability, emergency response, and infrastructure planning, operation, and deferral.

An examination of this definition reveals that there are a number of different facets to demand response. While this can make an appreciation of demand response more challenging, it also means that the amount and type of benefits can collectively be very high. Each of these facets will be discussed in the benefits section below, but it is worthwhile to note that key to this definition, and to any definition of demand response, is that it is focused on customers, and providing them with new options to manage their energy use and reduce their energy bills.

One more background item is worth noting. Just as energy efficiency was at one point referred to as "energy conservation," early forms of demand response were known as load management. Under that name, a number of utilities have operated successful programs over the years where in return for some incentive, customers allowed utilities to put controls on certain of their appliances and turn those appliances off when peak demands on hot summer days or cold winter days threatened the reliability and integrity of the system. These programs have functioned well in years past and many continue today. The difference between demand response and load management is that new technologies in the area of metering, communications and controls means that many new types of demand response options are available to customers. These options are "smarter" and allow customers to maintain and share control of appliances and equipment or to employ automated controls that can respond to price and other signals. These options also allow other demand response options to be provided such as time-based rates.

DEMAND RESPONSE TECHNOLOGIES

The most ubiquitous demand response technology is the meter, and some background on metering can be helpful in understanding demand response, its benefits and how it plays a role in the development of the smart grid.

The vast majority of electricity customers in the U.S. do not have a smart meter on their home or business. (The Federal Energy Regulatory Commission, in its Report to Congress required by EPACT 2005, estimates only 6 percent have smart meters). Many customers still have the basic type of meter that has been in use for decades. This meter has one function—to "count" the units of electricity that the customer consumes and to maintain a cumulative total of that usage that at some point is multiplied by the price of that unit to produce a total electricity bill. In a modern society where customers can easily and quickly obtain information about the things they purchase, such meters and the information they provide are anomalies. A customer with a basic meter gets no informational feedback on how and when they are using electricity or information they can apply to their future electricity purchases. They also are unable to take advantage of any time-differentiated rates or prices that could help them reduce their electricity bill.

A smart metering system does two important things. First, it measures and stores electricity usage in intervals, normally on at least an hourly basis. This time-based measurement allows time-based pricing and rates to be offered and accepted. Second, the smart meter is part of a communications network that allows the data measured and stored to be collected and retrieved on a timely basis—at least daily—for use by the utility and other parties and for presentation to the customer. This communications network and connectivity with the customers' premise provides other non-demand response benefits to utilities and customers alike, as is described below.

Smart meters are not the only new technologies that enable demand response and that help create the smart grid. "Smart" advances have been made in remote controlled and price-sensitive thermostats and lighting systems that allow the new products to be utilized in demand response applications. Energy Management Systems (EMS), formerly only used for energy efficiency purposes, are being made smarter and thus capable of empowering demand response applications. New in-home display devices are available that can transmit information from the meter to the customer in real time. New building automation and management technologies are available that allow optimization of energy use with respect to time of use. New thermal and battery storage systems are available that allow dynamic storage and release in concert with peak demand management. Even automobiles are developing into dynamic storage media in the case of the Plug-In Hybrid Electric Vehicle (PHEV), where the replacement of petroleum with electricity has been shown to have environmental benefits as well as helping to optimize grid management.

It is important to note that it is not just the technology but also how it is employed and applied that creates demand response. For example, some demand response companies have a service, or resource-based business model, whereby they contract with utilities to provide a block of demand response (e.g. 10, 20, 30 or even 40 MWs) in the same manner as if they were offering a peaking power plant to the utility. The demand response provider takes on the responsibility for enrolling and aggregating customers and controlling the peak loads of those they enlist so as to create a "negawatt" resource for the utility that is a substitute for additional power generation.

DEMAND RESPONSE AND THE SMART GRID

It is perhaps intuitive to understand why demand response technologies such as smart metering are an integral part of the Smart Grid. In the context of the smart grid, demand response and its enabling technologies such as smart meters are the place where the smart grid touches the customer. The vision of a smart grid is that of an intelligent, dynamic "organism" that allows the electricity system to be planned and operated in a way that optimizes all of its components to lower costs, increase reliability and utilize new informational and communications technologies. That vision includes an optimization of not only supply side options but also demand side options, and demand response is the way for demand side resources to effectively and dynamically be engaged.

Viewed another way, given that the smart grid will not arrive in one instant in time or in one fell swoop, smart meters and other related communications and control technologies are, collectively, the building blocks of the smart grid that will provide the foundation upon which the rest of the smart grid will be built. Timely, and in some cases, on-demand information from customers will help smart grid operators better monitor grid conditions and assess potential threats to the reliability and/or security of the electricity system. By providing information, including price signals, to customers, those operators will in turn be able to deploy customer reductions as a resource. Demand response technologies allow information and control over the demand side to be individually addressed yet aggregated into sizable blocks of "negawatts" that will be key to the success of smart grid development. Not only will the deployment of demand response technologies help avoid electricity outages, but also will help utilities and regional operators restore electricity faster than otherwise when outages do occur. In the case of the last major Northeast Blackout, New York State, where a substantial number of demand response technologies are deployed with large customers, was able to use those technologies and customer connections to do a controlled restoration which resulted in power being restored a full day earlier than expected.

BENEFITS OF DEMAND RESPONSE AND ITS ENABLING TECHNOLOGIES

Demand response and its enabling technologies offer many different benefits in many different areas. In terms of reliability, a reduction in peak electricity demand reduces the threat of outages. In terms of electricity markets, demand response and its technologies allow dynamic demand reductions to be deployed instead of resorting to additional power production, with the result being lower wholesale prices, which all customers pay one way or the other. Also related to markets, reductions in peak demand serve as a means of mitigating market power of suppliers, which can otherwise occur when demand increases unconstrained during peak periods due to consumers not paying prices anywhere near the cost of producing the electricity during that critical peak period.

In almost all cases, technology is required to enable demand response even if it is only for time-based measurement purposes. In the case of the smart metering system, however, non-demand response benefits are introduced when the technology is deployed for demand response. A good example is grid outage management and restoration. At present, many utilities rely on customers who lose service due to a storm to make a telephone call to let the utility know of the outage. In other cases, utility truck crews drive around to identify which homes and businesses are out. With the communications and connectivity abilities that come with smart metering systems, a utility customer service operator can instantly know when a customer is out and can optimize dispatch of crews to address the situation, increasing the speed and decreasing the cost of restoration. Other types of benefits in the areas of customer service, outage management, system planning, system operations and security maintenance are possible when demand response technologies are deployed.

In terms of customer benefits, demand response and its technologies offer many new benefits. Customers will get information on their electricity usage that they have never had before and get it in a timely manner such that it acts as feedback to reinforce their energy management efforts. They will have price and rate options that will stimulate them to be more efficient energy consumers. Demand response technologies will be the answer to the question "how can you manage what you cannot measure?". Studies have shown that even where customers are not on time-differentiated rates, they may reduce their electricity usage by 11 percent just as a result of being more informed and understanding better how and when they are using electricity.

In terms of addressing climate change and other environmental issues, demand response can make important contributions. The obvious one is in the enhancement and reinforcement of customer energy efficiency, the accepted cornerstone of emission reduction policies. Demand response control and information technologies such as smart meters can be the platform upon which the U.S. moves to an entirely new, more expansive and effective era of energy efficiency. Also, demand response technologies and practices will not only lead to greater energy efficiency but also to greater accountability of reductions, something that will be increasingly important under any policy where emissions are constrained and reduction-based offsets are monetized. Indeed, the smart electricity meter, while not an energy efficiency device in and of itself, may prove to be not only a smart meter, but also a green meter, as it helps improve overall energy efficiency and track energy savings.

In the case of some pollutants such as NOx, time-based emissions (e.g. during hot summer afternoons) can lead to ozone non-attainment. In the case of NOx and ozone, demand response holds out the potential to be a dynamic emissions tool that can be used to reduce power plant productions (and emissions) precisely when they contribute the most to non-attainment. Finally, and still in the area of environmental benefits, is the contribution that demand response can make to renewable energy development. In the case of wind energy, a particular geographic wind resource may not be available during peak demand periods. By matching that wind resource with demand response during the period that wind is non-available, the wind resource may become more viable. The result is a greater chance that less environmentally friendly resources can be avoided through a combination of wind and demand response.

EXISTING POLICY ON DEMAND RESPONSE

Congress. Section 1252 of the Energy Policy Act of 2005 represents the first legislation by Congress on demand response. It included several important provisions:

• A new PURPA standard that would require that utilities provide time-based rates and smart meters to all customers.

As with other PURPA standards, States and other bodies with jurisdiction over electric utilities were required by EPACT to conduct an investigation as to whether this new standard was appropriate for its particular jurisdiction and to make a finding on such. States and other bodies were given until August 2007 to complete their investigation and make a finding.

Some observers questioned the impact that this new PURPA standard would have at the time of EPACT enactment, pointing out that the only true requirement in the provision was for states to consider the standard, i.e. utilities were not required directly by the statute to do anything with respect to time-based rates and smart meters.

While many states to date have chosen to not adopt the standards, EPAct 1252 has had significant impact across the country. It has become the common framework within which heightened discussion and debate on demand response has taken place at the state level over the past two years. While many state commissions are still in the middle of their proceeding to consider the standards, the level of attention, awareness and action has risen significantly from where it was prior to EPACT enactment.

Attachment A depicts the status of State Commission proceedings on the new PURPA standard at this time, based on DRAM's assessment:

• A requirement that FERC conduct an assessment and report to Congress on various aspects and characteristics of demand response, including an estimation of the existing penetration of smart meters.

FERC completed this report on time and the document delivered to Congress represents the first ever nationwide survey of smart metering and other demand response technologies and programs. It also includes a substantial amount of other information on demand response, including barriers to it and how they might be overcome.

• A requirement that DOE make an assessment and report to Congress on the nationwide potential for demand response and provide recommendations as to how to achieve a specific target by a date certain.

DOE delivered its report to Congress within six months of enactment as required by EPACT but it did not address the question of "how much by how soon." According to DOE, the short turn around time of six months to undertake and complete the report did not allow for such. Instead, DOE opted for a compendium approach where it produced a report that presented the range of work by other parties on estimating demand response potential.

FERC. The Federal Energy Regulatory Commission (FERC) has in the past several years made significant strides in fostering the development of demand response. It views demand response as a vital ingredient to the success of wholesale markets and has sought to foster demand response programs and markets at the various regional RTOs and ISOs. As a result, some of the newest demand response resources that have been developed are at the wholesale level. FERC continues to push to demand response both through its actions in party-specific proceedings and in generic rulemakings.

States, In order to employ demand response, it is necessary for two things to happen. First, technology must be in place that allows electricity usage to be measured in time intervals (instead of the present system where usage is measured cumulatively and where all kilowatt hours are treated equally) and provided to utilities, customers and other parties in a timely manner. Adding automated controls and other technologies that monitor and control usage enhances and increases the amount of demand response that can occur. Second, customers must be provided with time-differentiated price options and/or other incentives to reward them for modifying their on-peak usage.

Each of these requirements present state public policy issues that are only beginning to be addressed and resolved. As discussed above, the investigation required by EPAct 2005 represents for many states the first demand response activity they have undertaken. In many cases, state policy makers have been reluctant to support utility investment in new metering deployments. In many more cases, state policy makers have expressed significant reluctance to introduce time-based rates to customers, citing the political backlash that could or would occur. These expressions of concern have come even in the face of suggestions that such time-based rates would be voluntary, and even after research continues to accumulate that customers like having such rate options and the information and technology that comes along with them.

States for the most part "have the ball" on demand response and smart metering. They also therefore have much of the ball on development of the smart grid, even though this is not conventional thought on this topic. Yet states have the least amount of resources to adequately assess and understand demand response and the smart grid. It is imperative to the success of both that states receive additional support to be able to play their necessary role.

Policy Options for Congressional Consideration

DRAM believes that there are a number of steps which Congress can consider to develop demand response, which will in turn be steps toward development of the smart grid. Recognizing that some of these may not be jurisdictional to the Subcommittee on Energy and Air Quality, we list them as follows:

Congress should recognize that smart meters represent new, high-technology hardware and software and should be treated for tax and regulatory purposes as such. Tax policy should be changed to accelerate depreciation on smart meters and other demand response technologies.

Tax incentives should be provided to utilities and other parties, including customers, to install demand response technologies as quickly as possible so as to develop as much demand response as possible in the Nation's electricity mix. One option would be a reduction tax credit, similar to the production tax credit that has allowed the renewable energy industry to gain traction and grow. Such a credit could only be granted when reductions are measured and verified using demand response technologies and applications, in recognition of the capabilities of such. Another option would be an investment tax credit which helps accelerate the installation of devices and equipment.

A temporary National Commission on Electricity Modernization should be established, with funding provided, that would undertake the following tasks:

(a) Conduct a national assessment of the state of the grid and provide detailed proposals to Congress, the President and the States on how to accelerate the deployment of a smart grid. Included in the Commission's work would be development of a framework for how the smart grid would operate and how its components would effectively communicate and interface. Also included would be a proposal for funding the investment necessary to put smart grid infrastructure in place.

(b) Develop a National Action Plan on Demand Response and Smart Technologies that would provide support for education and training of policy makers, customers and other stakeholders, as well as a nationwide communications and outreach program that would lead to greater deployment of demand response.

A temporary independent Commission would allow the efforts of industry, state policy makers and other stakeholders to be integrated with the efforts of DOE, FERC and other Federal agencies in a holistic, comprehensive and effective manner. It would also be able to provide the required support to states, where much demand response activity must take place to realize the potential of the resource.

Congress should consider providing additional funds to develop demand response resources and the smart grid in general via the introduction of a national assessment on the transmission system. Even an extremely small "wires charge" would generate significant revenue earmarked for smart grid investments.

Congress should consider requiring the Federal Government to demonstrate leadership by establishing peak demand reduction standards for Federal agencies. These standards would require progressive reduction in peak electricity demand as compared to a baseline year, in a manner similar to renewable portfolio standards or energy efficiency resource standards. These standards would complement and enhance the other efficiency activities that Federal agencies already are required to do and/or have underway.

With the development of new communications and control technologies that allow individual consumer appliances to receive and "act" upon price signals and other control signals for purposes of demand response, Congress should consider moving to additional types of appliance standards beyond those that govern internal energy efficiency.

Congress should consider how to integrate smart metering systems into climate change strategies and regimes to allow such systems and other demand response technologies to be used to more precisely measure and verify energy reductions and the monetary rewards that accrue to the associated carbon reductions.

Congress should consider providing funding and technical assistance to States or groups of States for developing smart grid assessments and action plans which will allow them to move forward to begin to create smart grid components in their jurisdiction.

Congress should consider requiring the Federal Energy Regulatory Commission to develop a framework on interoperability, one of the key threshold issues to the growth of demand response and the smart grid.

As with any major endeavor such as the transformation of the Nation's electric system into a smart grid, it is important to consider the timing and nature of the transition. In the case of the smart grid, it is easy to always see it as something that is out in the future somewhere, just out of reach. It is easy to see it as something that requires substantial research and development and that can only be accomplished if new technologies, not necessarily yet invented, are developed and made available. Some aspects of the smart grid may indeed meet this future-oriented test. But in the case of demand response, smart meters and other smart technologies and applications, the future is now. These technologies, as with any modern technology such as in the computer or telecommunications area, will be on a continual path of evolution and will continue to improve over time. Yet those businesses and consumers do not wait for the next great product to be developed before deploying a computer or cellphone so as to capture the many benefits that present technology provides, even while recognizing that new technology will certainly replace what they have at some point. It is important to take this perspective with the smart grid and not in all cases wait for future technology. Demand response and smart technologies are available today which can deliver immediate benefits to utilities, customers, other stakeholders and the Nation as a whole. With a greater commitment by state and Federal policy makers to deploying these technologies now, expressed through funding and other types of support, the construction of the smart grid can begin now instead of in the future.

ATTACHMENT A

Status of State Commission proceedings to consider EPACT section 1252 PURPA standard requiring utilities to offer time-based pricing and advanced metering

ONGOING PROCEEDINGS ON STANDARD

Alabama, Alaska, Arizona, Arkansas, District of Columbia, Georgia, Illinois, Indiana, Kansas, Louisiana, Michigan, Minnesota, Missouri, New Hampshire, New Mexico, New York, North Dakota, Rhode Island, South Carolina, South Dakota, Texas, Washington, Wyoming

COMPLETED PROCEEDINGS AND/OR DECISION ON STANDARDS MADE

Delaware—decided to not adopt but proceeding still open
Florida—decided to not adopt
Iowa—decided to not adopt
Idaho—decided to not adopt
Kentucky—decided to not adopt
Michigan—decided to not adopt but proceeding still open
Montana—deferred adoption
Tennessee—decided to not adopt but proceeding still open
Ohio—decided to adopt; proceeding still open
Utah—decided to not adopt
Vermont—deferred adoption
Virginia—decided to not adopt
West Virginia—decided to not adopt

PROCEEDING DEFERRED

Colorado
Maryland

Mr. BOUCHER. Thank you very much, Mr. Delurey.

Mr. Bryson, we will be happy to hear from you.

STATEMENT OF JOHN BRYSON, CHAIRMAN, CEO AND PRESIDENT, EDISON INTERNATIONAL, ROSEMEAD, CA

Mr. BRYSON. Thank you, Mr. Chairman, members of the committee. I won't provide a summary of my testimony. The panel is so strong IN its entirely correct affirmation of the smart grid. I thought I might pick out the things I can distinctively offer and see if they add some value.

The smart grid makes sense, Mr. Chairman. Your letter inviting us to testify indicated arguably the smart grid has lots of benefits.

The short answer is absolutely very great benefits and we need to move in that direction, and Chairman Dingell defined the problem well at the outset. Electricity moves at the speed of light. Anything short of an automated high-technology means of controlling electricity is fundamentally insufficient, and as business consumers, residential consumers increasingly digitize their homes, their businesses, the traditional means, low-tech means of operating an electric grid simply mean lack of reliability, slow response, poor service, high cost. Changes are absolutely essential and some of them have been well described by members of the panel.

I thought I would say a little bit about what we are doing at Southern California Edison and I want to underscore, this is with the really great support of the State of California. California has had its reliability and its cost problems. The response now from the Governor, across the regulators, across legislators, Federal and State, Congresswoman Harman underscored the values we bring to this, has been so strong. It is enabling us to make investments that as recently as 4 or 5 years ago we couldn't make. So my key focus will be to describe some of the things that we are doing in a utility, a very large utility that serves a large part of southern California and central California that are smart grid-type initiatives, and I want to underscore just what Congresswoman Harman said and that is, the smart grid more than any one component of the system, it is the heart of it. It is the essence of bringing all these things together—reliability, cost reduction, environmental benefit. Let me just say just a little about that. I will start extremely briefly with the distribution system, then the transmission system, then talk about the reach to retail customers through energy meters and I will respond to some of the questions.

But very briefly. First, distribution systems in the country are critical. They reach all the consumers. They are aging. They are old technology. Designing them as we designed them in the past is just absolutely insufficient. A transition in that respect will be costly but it must be done. So just one example of what we are doing at Southern California Edison and I believe it is leading the country in most of these respects but we are now employing and will first put into operation this summer something called the Avanti Circuit so it is a distribution circuit. It will be installed and fully operational in July of this summer in San Bernardino County, enormously fast growing east of Los Angeles. To oversimplify, it incorporates the best, most advanced monitoring and control systems. So that means something very simple. It means the kind of minor disturbances to the electric system that turns people's clocks off in homes, for example, that affects businesses should be substantially overcome. This is an initial 2,000 customers. It needs to go much further but it is beginning. I wanted to say this was a test program. My engineers say don't say it is a test program, it is really the real thing, it will go further. That is distribution. I could talk much more about that.

Let me talk about transmission, the large wires that carry electricity and necessarily across a large region. So transmission has a long way to go, again a fundamentally not very sophisticated system. It is not a dumb system but is at best a half smart system. What needs to be done? Well, let me talk about one thing we are doing: synchronous phasor measurement developed by engineers with the help of the Electric Power Research Institute and others. We have now installed this new means of providing instantaneous reads on stress across a very large regional transmission system. We have installed them at our 500kV substations, some smaller substations. They allow us now, and this is brand new, everything I am talking about is brand new, to take readings on stresses on the system 30 times a second. So that is appropriate to the speed of electricity. It allows our manual operators of the system to get these reads, we act faster, identify problems. Over the next 2 to 5 years we will put in the automation system that allows this means of identifying from multiple sources stresses on the system and an automated response. That is the kind of thing that needs to be done at the transmission level.

Then let me turn to the retail level, the consumer level. The electric meters, there is talk about them. I think there should be no misunderstanding about the degree of which they need to be developed further so the meters that were available in the market as recently as 1 year ago were not cost-effective on our system. They are a modest improvement but still largely analog. Not a whole array of features of the best sort can be drawn from the computer world, Silicon Valley, so we declined to go ahead with those meters and instead use the base of 5 million meters that we will install and we have reliably committed to install them and challenge vendors to come forth and we set out specifications for an array of services and capabilities in these meters. And the very good news is that we have in our labs right now from eight manufacturers meters that we believe will meet our specifications for interoperability, for two-way communication, for an array of quality consumer-friendly services as well as smart grid friendly services. The key is tying it all together. It needs to be integrated. So what we see with this new capability is the installation on our system for an estimated $1.3 billion, so a large investment, starting next year and over 4 years across all our customers, not just large businesses, small businesses, residential customers. These meters will do lots of things and we don't have time to describe them all but kind of the immediate thing they do is what others have referred to and that is time-sensitive or time-abuse pricing that will allow consumers to better manage their energy, better manage their bills, respond to price signals. Costs are relatively high of electricity, that is certainly true in our area in California, but we want to engage consumers in helping us manage the system. So simply put, one of the most expensive things on an electric system is building power plants that are used only occasionally to meet peak load needs. The meters can help with that. They can do multiple other things. I am getting the time signal so I will stop there but I can take that further. There are large environmental as well as reliability benefits.

[The prepared statement of Mr. Bryson follows:]

TESTIMONY OF JOHN BRYSON

Thank you Mr. Chairman, Mr. Ranking Member and members of the subcommittee.

I am John Bryson, the chairman, CEO and president of Edison International, the parent company of the regulated utility Southern California Edison and the competitive power generation business Edison Mission Group.

My message to you today is that a high-tech world can no longer afford a low-tech electricity grid. We must together build the smart electricity grid of the future. This will require substantial capital investment in the modernization of our transmission and distribution systems, and in the replacement of the dinosaurs of our industry—analog household electricity meters—with state of the art digital meters. We are fortunate that in California our public officials have provided the necessary regulatory environment to make these investments possible. I'm pleased to have the opportunity to share a few observations from our experience.

I'll begin my comments by addressing the application of smart grid technology to the transmission and distribution system before focusing my comments on our advanced metering initiative.

At SCE, our distribution system—the component of the electricity grid that delivers power directly to most customers—is both aging and growing. In response, and with the support of the California Public Utilities Commission, we are making capital investments in the system at an all-time high rate.

We should not, however, continue to invest in the same old circuit designs. Even momentary interruptions can now cause significant economic loss for business customers. And residential customers using more digital home electronics have understandably higher expectations for service. The old standards are not good enough.

An early example of the smart grid's potential will be a 12 kV circuit that will become operational this July serving 2000 customers in the San Bernardino area. Called the Avanti Circuit, it will feature a large array of advanced monitoring and control capabilities and will interface with our new smart meters. What will that mean for customers? Current distribution technology can now take more than a minute to locate and isolate a problem on the system. The Avanti Circuit will do the job in seconds, limiting outages and improving reliability.

At the transmission level, we now have sophisticated new tools to measure stress on the system, including a new early warning system called Synchronous Phasor Measurement in which SCE leads the Nation. Over the next two to five years, we will increasingly have the ability to act on this warning system with faster and more sophisticated control technology. The result will be substantially improved system reliability.

Let me give you a sense of how significant this is. If the technology I just described had existed in August 2003, the Northeast blackout, which affected 50 million customers, some for as many as four days, would likely have been largely controlled.

These same advances will also facilitate the continued development of renewable power. The smart grid will be better able to react to the variability of wind and solar generation by activating other resources, dampening peak demand, and smoothing out disruptions. This is particularly important to us, since SCE leads the Nation with nearly 17 percent of our generation coming from renewable sources.

The feature of smart grid technology most immediately visible to customers will be the advanced electricity meter. This is a game-changer for our industry.

Through our advanced metering infrastructure effort, which we call Edison SmartConnect, every household in our service territory will be equipped with a truly state of the art "smart" all-digital electricity meter. These new meters will actually be small but powerful computers and communication systems.

Among many benefits, smart meters will allow time-of-use electricity pricing for all customers, including small business and residential. Time-of-use pricing will create powerful incentives for customers to save money by shifting their use to off-peak hours when electricity costs are much lower. Customers will be able to interface with these meters through their home computers to develop efficient usage patterns that can help reduce their electric bills.

In a few years, it will likely be common to see signs in appliance stores labeling household devices as ″communicating.″ Communicating thermostats already exist. Soon we will have communicating dishwashers, electric dryers, refrigerators and pool pumps. Some customers will program their appliances to respond to the smart meters and automatically reduce usage when power costs rise. Others will sign up for programs that allow the utility to control many of their appliances remotely when needed, in exchange for guaranteed additional cost savings.

Let me spend a few moments emphasizing the importance of this benefit. One of the keys to meeting our Nation's power needs in an environmentally friendly way—along with a large increase in generation from renewable sources and the commercialization of new clean generation technologies—is the substantial expansion of energy efficiency and demand response programs.

California and Edison International have led the way in both. We lead the Nation's utilities in helping our customers save electricity through energy efficiency programs. Since the Department of Energy started tracking energy efficiency in 1992, we have helped our customers conserve more than nine million megawatt-hours of electricity. To put this number in some perspective, that's enough to power 1.1 million homes for a year.

The CPUC has long supported this effort both by the commitment of program funds and also at a more fundamental level through ratemaking that decouples sales and revenue. For utilities this increases our risks because it requires more frequent rate cases, but constructive regulation makes it work in California.

Edison also has the largest demand response program in California. When needed, we can call on more than 1,000 megawatts of interruptible power. That's roughly equivalent to the size of a large power plant. It has the additional benefit of being spread across our service territory, which helps us manage the grid more effectively during times of peak demand.

Peak consumption levels are a key factor in determining generating capacity requirements, so managing peak load is essential to controlling the need to build expensive new power plants. We see demand response programs therefore as an absolutely vital part of our effort to provide cost-effective and cleaner power to customers.

After a one-in-fifty-year heat wave hit in Southern California last July, the CPUC very appropriately challenged us to increase substantially customer participation in our demand response programs. We responded with an enrollment push that since August of last year has added 58,000 new customers, bringing total participation to more than 250,000 customers. The added potential for load relief associated with those new enrollments is 105 megawatts, bringing total potential relief to nearly 500 megawatts. By the time summer arrives, we expect an additional 70 megawatts. Here is the key point: We added this capacity in less than a year, far less than time than it would take to build a generating station or transmission line.

We can achieve even more in this area and we see advanced metering as a significant step forward. When fully deployed, we estimate that Edison SmartConnect could reduce peak demand on our system by as much as 1,000 megawatts, essentially doubling our current portfolio.

It is important to note that participation in time-of-use and other pricing options will be completely voluntary. Some customers will surely choose not to participate and thus forego any direct benefits, although they may still benefit if SCE is able to defer the costs associated with building new generation.

Smart meters can offer other potentially significant benefits as well.

They will enable faster outage response. With the aid of our new meters, dispatchers will know immediately when and where an outage occurs. Crews will be able to respond faster.

All customers will benefit from improved customer service and service automation. For example, the residential meters include a service switch that provides the ability to remotely turn-on our customers; service—a real benefit for the more than one million customers who move each year.

For example, wind energy generally peaks in the early morning hours and solar energy generally peaks mid-day, so any shift in usage to those off-peak hours facilitates the future use of new solar and especially new wind power.

These new meters are compatible with future plug in hybrid vehicles which offer the promise of replacing petroleum consumption with clean electric power. A soon to be released EPRI study will quantify the savings in greenhouse gases and other pollutants from this shift. Even using power from traditional coal plants to charge a plug in hybrid is environmentally superior (for CO2 and criteria pollutants) to driving a regular Toyota Prius. This trend increases over time as newer, clean generating plants replace older, less efficient ones.

Just as importantly, integrating all these meters to a single open standards based system provides utilities additional communication and pricing tools and flexibility to respond to outages and emergencies in a far less disruptive manner than rolling blackouts.

A little more than a year ago, no existing meter technology met our requirements for cost effectiveness and customer benefits. So we used the prospect of a five million meter purchase by SCE to drive the development of technology that met our requirements for open standards and future flexibility.

Our strategy was successful and as a result new meters and communication networks from several manufacturers are being tested right now by SCE technicians. Field tests will be underway by the end of the year. And by 2013 we plan to install five million advanced meters with the largest array of customer-service features offered by any utility in the United States.

Beginning with the first meter installations in 2008, we expect a transition period of learning and assessment. Large commercial and industrial customers (above 200KW) have already received smart meters, so we have already begun to climb the learning curve.

Edison SmartConnect meters are a completely new breed. They contain two way communication capabilities and advanced software and computer capabilities that make them entirely different than the previous generation of meters. Edison International along with a number of other utilities has been working with the House Ways and Means Committee and the Senate Finance Committee on new tax policies that better reflect the nature of the new generation of high technology metering equipment.

Just last week, at a first-of-its-kind conference sponsored by the U.S. Department of Energy and others here in Washington, SCE received one of the inaugural awards for "Outstanding Leadership for the Advancement of a Smart Grid." We were the only utility to be recognized.

None of this would be possible without the full support and backing of the California Public Utilities Commission, which to its great credit saw the potential value of the Edison SmartConnect program and is strongly encouraging the other utilities in the state to adopt the same fully digital technology.

Thank you.

Mr. BOUCHER. Thank you, Mr. Bryson.

Ms. Zibelman.

STATEMENT OF AUDREY A. ZIBELMAN, CHIEF OPERATING OFFICER, PJM INTERCONNECTION, NORRISTOWN, PA

Ms. ZIBELMAN. Thank you, Chairman Boucher and to the members of the committee. We are absolutely delighted to be here today and are very pleased that the committee is embracing the recognition that the smart grid is actually going to be a very critical element if we are going to meet our goals of having an independent energy future and one that keeps electricity both affordable and environmentally sustainable, and we have provided written comments but let me summarize.

Like Mr. Bryson, I wanted to talk in terms of real time, since PJM is the real-time operator, of how we see the smart grid innovation helping us do what we need to do, and the two things that PJM needs to do most is, we operate a reliable grid 7 days a week, 24 hours a day, and in an area that serves 13 States plus the District of Columbia, which is about 51 million people and represents about 19 percent of the GDP. And the other thing we look at is, we look at how do we manage the markets to continuously optimize the efficiency of the investment we make both in terms of providing affordable electricity but also in terms of taking advantage of renewables and other types of investment so that we see true innovation in the marketplace. And with that, let me talk about the two things that we see the smart grid doing. One is clearly improving reliability. As Representative Dingell and as all the panelists I think have said, electricity is a real-time product. It is at the speed of light which means we can't move faster that the speed of light. That means from our operators, in order to keep the grid in balance, they always have to anticipate what is the next event that can create a disturbance and then they operate in order to secure against that next event. The more information you can get in the hands of the operator so that they can anticipate that next event quicker, they can respond quicker and that is through automation, and if we do that, what that means is, you are operating the transmission system at its actual limits, not some predictable limits, and if you do that, what you are doing is, you are producing greater efficiency of the grid, you are having to produce less electricity in order to manage the grid responsibly, and the net effect is reduced prices, greater optimization, and if you are producing less energy from carbon-producing resources, a better environment. So there is no question it is going to improve reliability. The automation also helps us against blackouts. One of the things that happens with a blackout is, if you can't see what is going on, you might have a cascading event like we saw in 2003. A smart grid allows the grid to essentially heal itself. We call it grid sectionalization so that we island the system and we don't create the cascading failures. That certainly helps the economy, it certainly helps the security and allows us to restore the grid because it is a physical machine, it will have disturbances, and the issue is just like any other machine we operate, how do we optimize it, and it is the intelligence and the smarts that allows us to do that.

The second is of course in terms of economic efficiency. Over the last several years PJM has begun in its markets to include a revenue source for demand response that is equal to the types of revenue sources we provide generators and we have had a tremendous increase in the amount of demand response in our markets. Again, what we do is, we keep electricity in balance by either increasing generation output or decreasing demand output. When by setting the price signals from the wholesale market to industrial load and other providers, what they will do is, they will respond to that price and reduce their take in response to that price. The benefit is that they are actually paid from the market at the incremental energy price but the fact is that by reducing demand, they reduce the demand curve, the supply curve and therefore we produce less expensive energy to relieve load. To give you an example, last year during our peak week, the first week in August 2006, PJM paid demand providers approximately $5 million from the energy market to reduce demand during the pricing peak. These are voluntary participants who have said this is my price point and I will reduce my demand during these prices. As a result of that, we are able to reduce the demand curve, and over the course of that week we calculated that the cost savings to the market represented approximately $650 million. So from the market perspective, we provide demand responders a payment of $5 million. As a result of their reduced demand, the peak prices in the market drop about $650 million, which we think is a fairly decent investment. The same time during that time because we were reducing the production of energy, we were able to save large gas and oil and we calculated that equivalated to about 13,000, to 14,000 barrels of oil or about 227,000 MCF of natural gas.

So the net effect is pretty clear. Demand response is the cheapest way to keep the energy system in balance. If we can do it this way, if we can provide these types of price signals to customers, then they could become active participants in the market, and while we are talking at the wholesale level, if we do it with our retail providers, they can work with their residential customers and the customers then, we have a conversion from electricity being a commodity to a service and where customers will be able to dictate how much they want to buy, at what price, from whom, during what hours. For us, that is the way of the future.

Again, thank you and I would be happy to answer any questions [The prepared statement of Ms. Zibelman follows:]

TESTIMONY OF AUDREY ZIBELMAN

I wish to thank Chairman Boucher and the Sub-Committee on Energy and Air Quality for inviting PJM Interconnection, L.L.C. (PJM) to address you on this very important subject. We are encouraged that the subcommittee recognizes the importance of gathering information on the need to transform our Nation's transmission infrastructure into the Smart Grid of the 21st Century as a key element of ensuring the country's energy independent future.

PJM is responsible for ensuring the reliable and non-discriminatory planning and operations of the transmission grid and the fair and efficient administration of the real-time wholesale electric market that serves 51 million people in an area that includes 13 States plus the District of Columbia. PJM operates the high voltage electric power grid in all or parts of New Jersey, Pennsylvania, Delaware, Maryland, the District of Columbia, Virginia, North Carolina, West Virginia, Kentucky, Ohio, Michigan, Indiana, Illinois and Tennessee. It is an area of the Nation that, standing alone, represents approximately 19 percent of the Nation's Gross Domestic Product. The power system under PJM's control is the largest in North America and one of the largest and most complex in the world. The PJM region incorporates 56,000 miles of transmission lines, 1,250 generating plants and 6,000 substations. PJM has 250 intertie points with adjacent systems in the Eastern Interconnection. This means that along with managing the PJM system, our operators manage the seams between PJM and seven adjacent electric systems. To put this in perspective, the next most extensively interconnected power grid in the world is the transmission system that serves France, which has 41 interties. To maintain reliability of the system, PJM has identified approximately $10 billion in new transmission investments that will be required over the next 15-year planning period. When built, we believe this transmission will help reduce current congestion on the system at a value that will approximate $1 billion a year in savings.

The wholesale markets that PJM operates represent the largest competitive organized wholesale markets for electricity in the world. The PJM spot markets were started in 1997 and in the last 10 years grew from $450 million to $23 billion in annual revenues. Today, there are more than 450 members of PJM representing all segments of the industry as well as financial and trading institutions that add liquidity to the marketplace. The buyers and sellers into and from the PJM Markets also include many generators and load serving entities from adjacent regions, all of whom benefit from the transparency and robustness of the marketplace.

The installed generation capacity in the PJM region currently exceeds 165,000 MW while the peak demand for the PJM region reached a record 144,644 MW in August of 2006. This peak demand exceeded the peak achieved in 2005 by 10.627 MW. In short, in one year we saw an increase in peak load that is equal to the level of generation that is required to serve a large American city. Although we do not anticipate that sizeable an increase in peak demand each year, we do anticipate load growth in the region to remain in the range of 1.5 percent annually over the next 10 to 15 years. During this same period, we envision retirements of older, less efficient generating units, which necessitates further development of new more efficient generation. Indeed, the pattern of retirement of older generating plants affected by environmental laws as well as the region's increasing demand for electricity has created new challenges. If we tried to meet this increased demand for electricity solely by building new generating plants, over the next 15 years this combination of factors could require as much as 55,000 MW of new generation investment, an amount equivalent to four large nuclear plants or coal plants being constructed every year.

To summarize, the industry challenges confronting the PJM community are reflective of those we are experiencing throughout the Nation. We are an electricity-dependent economy. The demand for electricity continues to rise reflecting a growing digital age economy. Yet, we have an aging infrastructure that will require significant new investment in all segments of the industry, from the fuel input to the customer meter. We also must actively consider how we can help achieve the energy independence that the country demands, while continuing to focus on maintaining fair and affordable electric prices and reducing our carbon footprint. We are in a period when we cannot afford to ignore the contributions of any segment of the industry to our energy policy objectives. In fact, based on PJM's perspectives as a grid operator and market administrator, we believe that the transformation of the bulk power transmission system to a Smart Grid of the 21st century should be considered part of the foundation of meeting America's energy policy and climate change objectives. I am attaching a brochure which was part of PJM's recently released Strategic Report. It is designed to explain the Smart Grid in understandable terms for the general public.

With this in mind, my remaining testimony will focus on four primary areas:

1. The PJM vision of the Smart Grid;
2. How Smart Grid implementation can increase reliable, secure and efficient system operations;
3. How a Smart Grid will enable true consumer participation in the electric marketplace as a means of gaining greater environmental benefit and affordable electric prices; and
4. The actions and public policy efforts we should focus on today to establish the right platforms for a 21st century electric power system.

1. The PJM Vision of the Smart Grid

There are many industry definitions and descriptions of the Smart Grid. For PJM, where we are required to keep the grid in balance 24 hours a day, 365 days a year, the Smart Grid is not a theoretical concept or a "gee, it would be nice" item. PJM's perspective derives from its dual focus on continuously looking for ways to improve secure, reliable and efficient grid operations, while assuring a robust competitive wholesale electric market that supports Federal and state energy policies. PJM's vision of a Smart Grid encompasses the transformation of the interconnected electric system in three critical ways:

- Ensuring a Multi-Directional Grid: The industry needs to transition from today's radial system linking generation to load to a true network with full connectivity and interoperability. The goal of this change will be to allow horizontal interconnectivity all the way through the energy value chain—from fuel management through to the end customer energy use. We have achieved much of this connectivity goal in telecommunications, yet are only beginning to work on this in the electricity sector;
- Moving to a Digital Grid: We will need to convert from today's electro-mechanical grid to a digital system that supports information and automation-enabled grid assets. The objective of this conversion is to allow for more efficient, cost-effective and secure system operations;
- Moving to an Interactive Grid: The grid of the future will require two-way communication between the system operator and the end-user. The objective of two-way communication is to convert end-users from passive to active participants in the marketplace.

Each of these elements will be a necessary component of implementing Federal and state energy policies.

2. Developing a grid that promotes a more reliable, secure and cost effective electric transmission system

The interconnected electric system is often alternatively described as either a single complex engine comprised of generators, transmission and distribution systems and end-user devices or an ecosystem with many interdependent elements. In either case, there are four fundamental attributes of the interconnected system that help explain the value of a transformation to a Smart Grid. First, is the fact that the system is interconnected. As the Nation learned again on August 14, 2003, an uncontrolled disturbance on one part of the system can cascade and impact large segments of the grid. A second attribute reflects that electricity is a speed of light product. Operators today must always operate the system in anticipation of what might happen next. Third, electricity is the only commodity that is consumed at the same time it is produced. At least at this time, large scale storage of electricity is not practical or economical. Fourth, the information environment required to operate and control the system is extraordinarily sophisticated. The information requirements of the grid continues to grow. Today, PJM employs an energy management system that processes about 88,000 bits of information every two to three seconds. This information need will grow in magnitude as we add more diverse demand side and generation resources on the system. The challenge for grid owners and operators is to make certain that we maintain the sophistication to be able to instantaneously translate this data into the information operators will need to perform their jobs.

PJM's Smart Grid vision contemplates transitioning the system from one which is highly dependent on human interaction to a system that is highly monitored and provides human operators with the best of current and future computing technology.

Advanced transmission technologies such as super conducting and other devices that are also considered part of the Smart Grid will further produce a system that is capable of moving energy more efficiently than the current system allows.

There are several direct benefits of this transformation. First, having a highly monitored transmission system will enable the grid itself to better optimize the performance of the system than can be accomplished today. Voltage and current can be monitored continuously and the system will be able to automatically adjust performance of the component parts. This will in turn allow operators the ability to manage the throughput on the system more accurately and efficiently. The societal benefits will include a more secure and efficient system from both an economic and environmental perspective. These objectives will be accomplished through the reduction of unaccounted-for energy, the reduction of transmission congestion since the grid assets will be operated at higher and more accurate limits, and the more efficient use of generation resources. In other words, to use our engine analogy, consumer demands will be met by a better running and operated machine.

The presence of monitoring devices will also increase the asset management capabilities of owners. By deploying a Smart Grid, owners will not be required to send employees in the field to identify potential problems on the system. Rather, they will have better information about the state of the system and be able to better target employees' repair and restoral efforts. This will in turn allow owners and operators improved capability to assure the reliability of the system at lower costs.

A Smart Grid also provides operators a better and more rapid opportunity to anticipate disturbances on the system. Today, operators have limited control over the entirety of the grid (which includes the distribution system as well as the high voltage transmission grid) and still make many emergency decisions over the telephone. The grid of the future will have pervasive control systems and rely on secure computers to help identify the best step to take if there is a potential disturbance created by a failed generator or transformer or line outage on the system. System operators will also be able to rely on secure and distributed computing capabilities to develop sophisticated decision support analyses so that they can select the best solution to either optimize the system or to reduce the risk of system failure. We call this a fast look-ahead simulation. The benefits are to provide greater predictability and security. This again allows operators to optimize the operations and secure the system at a much greater level of granularity and certainty.

The third advantage of a Smart Grid becomes readily apparent when there is in fact a significant disturbance. One critical goal of the Smart Grid is known as "islanding" or grid-sectionalization. This occurs when there is a disturbance. In these circumstances, pre-identified solutions will cause the affected part of the grid to "island" itself into defined self-sustaining regions. This avoids the type of cascading failures we witnessed in 2003 and also, when there is a failure, allows for much quicker and easier restoration. In turn, our economy and society as a whole realizes the direct benefit of a reduction in the risk and costs of widespread blackouts.

3. The Smart Grid will help reduce electric prices and produce environmental benefit by promoting a customer-centric electric energy marketplace

One of the primary lessons that PJM has learned repeatedly over the last ten years is that the information ubiquity provided by organized markets is the single most important factor differentiating well-functioning markets. With accurate and timely market information about the value of their generating asset to the marketplace, owners of generation operate their generating assets more efficiently which, in turn, makes electricity available at lower costs to consumers. With timely and accurate pricing information, the grid works better. PJM operators are able to find ways to optimize the system continuously by dispatching the lowest priced generator among a broad diversity of resources. Information availability and markets also allows greater diversity of resources and innovation. Wind generators and other forms of interruptible resources can compete more efficiently in the marketplace by participating on their own terms—not terms dictated by traditional utility operations. Finally, and most importantly, we have also learned in the last several years, that with real time information ubiquity provided by markets, end-use customers have the opportunity to participate in the electricity market and as a result save money and contribute to a cleaner environment.

As I mentioned, one of the chief attributes that contributes to the complexity of the electric power system is that electricity is not able to be stored in large quantities. To keep the lights on, the operator must keep the system in balance—which on a real-time basis means continuously increasing or decreasing the output of generators to meet the electric demands of customers and the economy as a whole. In a competitive market, we accomplish this objective by selecting the generators based on their price—and in the absence of reliability requirements—the generator payment is based on the lowest incremental price offered for that time period.

Until the last several years, competition in the electric industry has largely been characterized by the ability of customers to choose among generators at the wholesale level and, in certain states, suppliers at the retail level. However, several years ago, PJM and its members changed the characteristic of the wholesale market by starting to match every source of revenues provided to generators that sell their energy and capacity into the market to a similar revenue source for load customers who are willing to sell their demand into the market.

As I stated, as a reliability operator, PJM's responsibility is to make certain that generation and load are in balance. As an independent market administrator, we are indifferent whether that next megawatt of change occurs because we are increasing generation or decreasing load. When operating the grid in real time, PJM is also indifferent to the next megawatt of supply or demand that is produced or saved due to the operations of a central station power plant, a wind generator, a roof-top solar device, a stand-by combined cycle turbine at a manufacturing plant, a restaurant dimming its lighting or a family turning down the air conditioner. For the market and the system, that next megawatt has the same value. For customers however, there is a clear difference—since the price of electricity varies depending on the level of load on the system, reducing load by controlling demand allows us to run less expensive generation which ultimately saves customers money.

The benefit, of course, is a more efficient economic marketplace, both in terms of the economy and the environment. For example, during the week of extreme peak conditions last August, PJM calculated that it paid demand providers approximately $5 million to participate in reducing demand in the wholesale market. As a consequence, reducing that demand reduced the incremental price of electricity by approximately $650 million. On the assumption that during this period, PJM would have been dispatching coal or oil plants, the savings could also be seen as a reduction of 1,367 tons of coal or 15,855 barrels of oil. Similarly, a study prepared by the Brattle Group for PJM and a coalition of Mid-Atlantic State Commissions showed that a modest reduction in electricity usage by 3% through demand response could save consumers, on an extremely conservative basis, up to $182 million annually. I would note that this calculation only involved a portion of the PJM region. However, for demand response to work most effectively, we must have the ability to know with certainty that the load on the system is reducing in response to the price, similar to what now occurs when generating units produce more or less electricity.

For PJM then the issue is a truly a no-brainer. We have an opportunity and, I would suggest from a societal standpoint, an obligation to continue to promote demand response as a critical component of our electric market. The future as we would like to see it requires transforming wholesale competition, which today is almost exclusively among generators of power, to a new form of competition where customers are empowered, through interactive technology, to be able to select how much electricity they want to purchase, at what price, from what vendor and at what time. In other words, a truly customer-focused market that enables new technologies such as advanced metering, plug-in cars and distributed generation and storage, will result in innovative new ways of providing electric service at a net benefit to the economy and the environment.

To achieve this vision, we will need certain key elements in place. First, and most important, customers, whether directly or through an automatic metering device, need to receive timely price information so that they know the value of reducing or altering usage and can respond accordingly. Second, as the system operator, PJM has to have accurate information that the load is responding to price—otherwise we cannot guarantee reliability. Depending on the size of the customer load, this information can be provided directly or through the local utility. Third, since we are now talking about numerous devices on the system working in concert (a true network), we will need to make sure that these devices are interoperable. The PJM energy management system, the brains of our network, must be able to use the same communication protocol whether that information is coming from a large central station generator or an individual "smart" appliance in the home. Fourth, PJM and third parties will need to develop the computing capability to optimize this system. Today, PJM processes approximately 88,000 bits of information every two to three seconds. In the future, as we operate the system as a complex network of centralized and dispersed generators—in essence, an intelligent grid with active consumer participation—the information needs and the ability of computers to process that information will increase significantly.

4. The actions and pubic policy efforts that will support Smart Grid development

PJM has identified several actions that we believe should be taken today to support development of the Smart Grid. There is no one government or business organization that can make the Smart Grid happen all at once. Rather, from our perspective there are activities that have to be taken at the Federal and state levels and among all segments of the industry for the transformation to occur. With that said, however, we believe that there are some first steps that Congress can and should support:

• Development of a regional technology plan—Today PJM and its members and stakeholders develop long-term regional transmission plans that are designed to identify the transmission infrastructure required to assure reliability and economic efficiency. We believe that for the Smart Grid to develop we should work with our asset owners to develop a living technology plan to ensure that we have a coordinated, deliberate and realistic plan to make this transformation. In our view, this collaboration is essential to make sure that, in the end, the installations that are being made throughout the system will work together to achieve our common goals.

• Promotion of horizontal network systems, including standard communication protocol and service oriented architecture—Industry and policy makers must support the development of a web-based communications network that uses service oriented architecture to enable the Smart Grid network. In other words, industry and government must insist on the goal of interoperability to ensure that all devices on the system are able to communicate. This is the same sort of common information protocol that enabled the Internet. We believe that Congress can help "jump-start" this effort through encouraging the industry to develop uniform interoperability protocols, the equivalent of open network architecture that guided the development of today's telecommunications network. Today, there are a plethora of agencies with jurisdiction over some part of the Smart Grid—ranging from state PUCs, to the Departments of Energy and Homeland Security to the Federal Energy Regulatory Commission. We believe that a coordinated effort among these agencies can help to reinforce industry efforts at developing common protocols.

• Regulatory reform at multiple levels—We need to look at the current methods in place to regulate retail and wholesale utilities and identify any and all impediments to Smart Grid implementation. For example, industry and regulators must examine whether the timing and mechanisms currently used to recover capital assets are impediments to investment in new infrastructure and technology. We believe it is incumbent on regulators to examine methods for regulating retail utilities which might inadvertently be serving as impediments to advancing energy efficiency and demand response. If utilities are only economically rewarded for increasing throughput and making new investment in traditional generation, transmission and distribution plant, it will be difficult for them to embrace a regime where the goal is less throughput and increased consumption efficiencies.

In closing, we are on the precipice of requiring billions of dollars of investment in the electric industry, including billions of dollars in transmission infrastructure. This investment is necessary to ensure the continuing reliability of our electric infrastructure and hence, the well being of our Nation's economy. The challenge and opportunity before us must be to ensure that investments in technology and infrastructure are transformational and will allow us to secure a reliable, economically efficient and environmentally-responsible industry future.

Mr. BOUCHER. Thank you, Ms. Zibelman, and thank you to each of the witnesses for what has been a very informative series of presentations on your part. We have two votes pending on the Floor of the House of Representatives and all of us are required to respond to that. It is sometimes the most disagreeable thing I have to do all day because I wind up leaving very interesting conversations such as this in order to do it. But we will be going to the House floor, and my intention is to recess the subcommittee pending these two votes. We should be back in about a half-hour, and so stay where you are, if you will. Leave the room if you like, just come back in about a half-hour. And as soon as the last vote is over, perhaps 5 minutes following that we will reconvene this hearing. Thank you.

[Recess.]

Mr. BOUCHER. The subcommittee will come to order, and thanks for everyone's indulgence while we completed our business on the House floor, at least for this period of the day, and I am going to recognize myself for 8 minutes in order to propound a series of questions to our witnesses.

Mr. Delurey, let me begin with you. We worked very closely with you as we were placing in EPAct 2005, the energy bill that was signed in August of that year, provisions relating to smart meters and real-time pricing, and as you described in your testimony, that provision required the States to at least consider putting in place a regulation that would require real-time pricing and facilitate the introduction of smart meters. In your testimony today, you indicated that the States have made some efforts to follow through on those proceedings and consider rules, and I think you also said that of the States that have done so, most have decided not to adopt rules

Mr. DELUREY. That is correct.

Mr. BOUCHER. And I was somewhat concerned to hear that. Let me get you, if you will, to tell us how many States have followed the direction of EPAct 2005 and decided to undertake at least an examination of whether or not a rule is necessary and how many States are in that category, and among those that have started such a proceeding, how many have decided to adopt rules and how many have decided not to, and then finally, what is the reason that the States have given for not adopting rules and what I take are the very large number of instances where they have not?

Mr. DELUREY. Thank you, Mr. Chairman. The provisions that you speak of indeed established a requirement for all States as well as jurisdictional bodies with respect to co-opportunities and municipal utilities and so on to conduct an investigation but also importantly to make a finding as to whether or not utilities under their jurisdiction should be required to offer not just real-time rates but time-based rates and the smart meters that are needed to go along with them. The legislation gave them until August 2007 to complete their work and to make a finding so there are still a large number of proceedings underway. By our count, approximately 14 States have completed their proceeding. Only one State has made a definitive adoption, a clear adoption of the standards, but not all the other States are complete rejection, at least I wouldn't want to characterize them, and this is what I referred to in my testimony where I think these provisions have had a big impact in terms of building awareness and visibility for this entire area and it has had States looking into this that have clearly never looked into it before but most have rejected it. Some have rejected it in a formal way but they have requested that their utilities move forward in certain directions so I want to be fair and state that.

In terms of why they haven't done it, in some cases they have stated, and this is factual, that they have had these types of rates "on the books" for a number of years and that customers don't seem to be interested in them. But again, I think that is looking backwards and not forwards. The type of metering technology we are talking about today is what is available over the years and it was very expensive to put a customer on these types of rates. So I think those States incorrectly looked backwards to cast forward instead of really assessing the current situation.

Mr. BOUCHER. Well, it is not a very encouraging report but I appreciate your making it nonetheless.

So let me ask the obvious question. What do we need to do now in order to improve the situation and address the shortcomings that exist and encourage both the time of use and real-time pricing methodologies at the State level, and also encourage the greater deployment of the smart meters? What is our role in helping to narrow that gap and move all of this forward?

I would ask that question of everyone, not just one.

Mr. DELUREY. One of the things I would say, and this also perhaps is an additional answer to the question of why it hasn't happened to a greater extent than it has, and that is, your average State utility commission, I think the challenges of trying to put all this together, the many moving parts of demand response and the smart grid, the technologies, the prices and all of that, that can be a challenging endeavor and I know from having witnessed some of these proceedings that they haven't necessarily had the resources, the training, the technical assistance, the tools and so on to be able to maybe do the best job that they would otherwise could have.

Mr. BOUCHER. So the State commissions need better resources in order to carry this forward?

Mr. DELUREY. I believe so and I think that is an area where the Congress could be of assistance.

Mr. BOUCHER. Do you have concrete recommendations for us on that?

Mr. DELUREY. Well, again, as I noted in my oral remarks today and in my testimony, I think there are vehicles by which you can create that type of supportive infrastructure, if you will, to be able to do that. I think whether it be through the establishment of a new temporary commission and a national action plan in this area, I think that is one way to do it. There are probably other ways as well.

Mr. BOUCHER. All right. Would other witnesses care to comment? Ms. Zibelman.

Ms. ZIBELMAN. A couple things that come to mind that we have been talking about. One is this whole issue is just education and I think with adding to it, as I was indicating, we measure the impact of demand response on the markets because we actually have that price information. I think something that we would look forward to working with DOE and FERC and our States on is, how do we get a consistent way of measuring it because if the States could see the cost benefit, that would enable them to answer to their constituents, why are we putting this new investment in, what is the benefit back to us, so I think having a consistent way of measuring it so everybody understands how to do it and then the RTOs or the utilities can come up with these measuring devices. We are already doing this with renewables when we measure emissions and I think adding this type of information would be helpful. I think the second piece that we have identified is actually technological obsolescence. One of the problems, as you are well aware from the telecommunications industry, of moving from copper wire to fiber optics is how do you deal with old technology that is not depreciated. So rather than actually tax incentives, I would think that looking at the rules of depreciation and encouraging utilities to invest more in technologies which will depreciate faster and having the structures that support that would also be another way of moving forward.

Mr. BOUCHER. Is there any need for national uniform standard setting with regard to smart grid technologies?

Ms. ZIBELMAN. Absolutely. The other issue is, I think looking at the national standard setting and the various agencies that are going to be interested in that like Homeland Security, DOE and FERC and coordinating that. We think it is going to be very important. Our issue, as the witness from IBM said, is going to be interoperability. It makes no sense for a retail utility to put a meter on and that the device of that meter can't communicate back to the brains of the energy management system and vice versa. And so we need to move to an open architecture system, very much like we have seen in telecommunications, and we need to make sure, insist on interoperability among all these devices, which is a common information protocol and something this Congress can do is insist on that as the first stage of developing the smart grid.

Mr. BOUCHER. Should we designate a lead agency, the FERC, for example?

Ms. ZIBELMAN. I think that looking at the national institute standards, maybe with coordination of the DOE. The challenge with the FERC is that they don't regulate all the potential providers, namely municipals and co-ops, so I think if you have a broader-based energy working with the FERC as well as Homeland Security would be a good way to go.

Mr. BOUCHER. OK. Thank you.

Yes, Mr. Yeager, we will hear from you.

Mr. YEAGER. Based on my own experience, I would underscore the fact that you have a cultural issue in the regulatory community to deal with. The regulators and their staffs view themselves in effect as the agent of the customer and the customers are commoditized, if you will, behind that. So any time you talk about reducing that role and being the representative, you run into resistance. So I think what you have to recognize is that is part of the culture. I saw it in California and I have seen it in other States as well.

Mr. BOUCHER. OK. Dr. Howard.

Mr. HOWARD. Let me just reinforce a couple of comments that have already been made. From what we are seeing, there is not a uniform standard and it is something that is certainly needed. I spoke last week at Grid Week that was here in Washington about the importance of a uniform standard so that you could have plug and play, whether it is the meter or it is an air conditioner or something else. If we didn't have that in the computer industry, just imagine what it would be like on a USB port. We wouldn't have one. And so we must move in that direction on the smart grid, and part of what we are doing with our IntelliGrid Initiative is to help reinforce that and lay out the blueprint that would help develop some of these standards, and I know that Mr. Bryson, his utility is certainly leading that by looking at what they are doing on their advanced meter and trying to standardize some of these so that they are interoperable, they communicate together and they tie with all the other devices that fit on the grid so that you can truly have millions of sensors that work together, communicate together to optimize the whole system.

Mr. BOUCHER. From my work in telecommunications, I am aware of the IEEE and the outstanding job it does just on the private side in national standard setting for new technologies. Is there a role for IEEE or some parallel organization to help with this?

Mr. HOWARD. Absolutely. In fact, we have been heavily involved in several of those activities and working with other government agencies and utilities but we all have to come together to develop the right standard and——

Mr. BOUCHER. You are saying it is not happening fast enough?

Mr. HOWARD. It is not happening fast enough. That is correct.

Mr. BOUCHER. And so government has a role to play in order to facilitate it moving forward more quickly?

Mr. HOWARD. Well, there is a role that the government would play along with the utilities. Even manufacturers of equipment have to come together and focus on a standard being implemented, and that was a big part of my statement last week at Grid Week.

Mr. BOUCHER. All right. I think we understand that. I am trespassing on other members' time here.

Mr. Gammons, can you be very brief?

Mr. GAMMONS. Just one comment. Most of the times that standards are adopted, it is driven by the industry itself so it is really implicitly needed that the utilities, the consumers of these products demand the standards. There are a lot of standards, both international standards and U.S.-based standards that are out there and working very well. The real key is for the industry to demand those standards and the interoperability and that will drive the standards change. That has been key in every industry.

Mr. BOUCHER. Thank you all very much.

The gentleman from Illinois, Mr. Shimkus, is recognized for 5 minutes.

Mr. SHIMKUS. Thank you, Mr. Chairman.

It is great to have you all here. I would concur based upon the years here that we have to have national uniform standards, especially if we move to hopefully a distributed system. Otherwise that inhibits all the advancements and I think that is something that we will work on with the chairman to ensure that. I have got some questions that my staff didn't feed me. There is a debate. On the next panel I have got one individual from the Illinois Commerce Commission and of course Illinois is going through some interesting electricity issues so let me just pose this question. I am a competitive market guy and I like wholesale wielding of power, retail folks, but the question I pose is, are we best to get to this new era with the investment required through a regulated monopoly or is the competitive market system the best way to get to this next generation of how we I think produce power because that is on one end but also consume it and manage it on the other. And if you can be real brief because the chairman only gave me 5 minutes, and anyone who wants to address that issue. Monopolistic system or a competitive market model? Mr. Yeager?

Mr. YEAGER. Thank you, sir. The Galvin Electricity Initiative started by Bob Galvin, one of the leaders in your State, is really based on opening up the system to entrepreneurial competition just as was done with telecommunications and computing, and it is in fact the last network industry that is in this closed monopoly position. There is a great deal of private money out there that can increase the quality and reliability of service with the creation of microgrids that connect the bulk power grid to the consumer, bringing in all the technologies that my colleagues here at the table have talked about but applying them in a private sector environment that really raises the quality bar on electricity. It uses the bulk power grid as the primary energy source but does not be constrained by the reliability and quality—there are tremendous numbers of very large entities in the private sector who both need and are prepared to provide and help in that whole effort.

Mr. SHIMKUS. Anyone else? And please be quick if you can. Go ahead. Just go left to right.

Mr. DELUREY. I will just quickly say that with demand response and smart metering, in one sense it doesn't matter in terms of making it happen. You can do it under a traditional vertically regulated system or you can do it in a competitive system. One note of history——

Mr. SHIMKUS. But the real question is capital formation. How do you get the money and is that through a regulated price increase set by the commission or by a market response on a return on investment?

Mr. BRYSON. We have competitive power generation in Illinois there. We have the regulated utility in California. I think California has taken a reasonably good approach to this mix of competition where there are competitive advantages. There are opportunities with a competitive system to introduce new products and drive costs and innovation, and having a regulated distributed system so they can work effectively together, it is a question of thinking hard about which works best and which model so fundamentally the distribution system as a system that serves universally everybody is driven by forces that innovation bring I think are working well in California. Certainly that has contributed to our leadership on all the smart grid technology.

Mr. SHIMKUS. Great.

Ms. Zibelman.

Ms. ZIBELMAN. I would echo. The way we look at it is, the distribution system will remain regulated but unless you have the competitive markets that support the prices to the devices, you won't get the customer response and so you do need to continue on the march towards competition and true innovation.

Mr. SHIMKUS. And innovation, it is easy when you build a new home to put in the new technology and the wiring stuff but it is folks like me who have a home, want to stay there and then rewiring, reconnecting and stuff to get to a smart system and that is where we come in with maybe tax incentives and how we do that.

Ms. ZIBELMAN. And I think though that is where you can change the model because if you have competition, it may not be that the homeowner actually makes the investment but that somebody else looks at your load and realizes that is valuable in the market and actually pays you for your load, which is as valuable to the market as generation. And so you are changing the model of the industry from a commodity model to a service model and that is really where the true innovation I think will occur.

Mr. SHIMKUS. And Mr. Chairman, if I may, with one last question. I also serve on the Telecommunications Subcommittee. We see a convergence obviously in all this stuff in the digital age. There is a lot of debate about high-speed Internet access over electric wires. That is all part of this, isn't it? Or could it be? Because if you are able to send digital information over the current distribution and transmission system, then that will help us in the interactivity that has to be done with the metering systems and the individual appliances. Is that a correct analysis?

Mr. DELUREY. I would say that is correct. There is a number of different communications technologies that all compete today—power line technologies, wireless radio frequency—and in terms of your own home, your existing home, there is a lot of work that has been done for in-home wireless devices that allow the meter to talk to other devices in the home as well as through the existing power lines within your home.

Mr. SHIMKUS. Thank you, Mr. Chairman. I yield back.

Mr. BOUCHER. Thank you, Mr. Shimkus.

The gentlewoman from California, Ms. Harman, is recognized for 5 minutes.

Ms. HARMAN. Thank you, Mr. Chairman. I think the testimony of our witnesses exceeded expectations. This is a fascinating subject and I continue to believe that if we only do one thing, this is what we should do. But if course we should do more than one thing.

Mr. Kamen, you have charmed us all and all of us want to learn more about what you do. I just had a thought that maybe one of your little black boxes ought to be used to power Congress. We generate a lot of wasted heat here and some would even say we can produce cow dung, and what we need here is some light. So I would just like you to think about this. It might be a project that would be worthy.

I have lots of questions but limited time and I do want to direct a question to John Bryson. I hosted an energy expo in California a couple of weeks ago at the large green industrial facility that Toyota has and I think it is the largest green industrial building in America and I commend Toyota for that. Edison was one of the exhibitors and participated in panels on what individuals can do and what are the big policy issues on climate change. But there was a guy outside with his plug-in hybrid and he showed how he had improved the engine of what was a hybrid car to add the electric feature and he said that his total energy costs per year for his car and his house, which had solar panels on the roof, was $44. So in 3 minutes and 18 seconds, I would love to hear what these smart technologies could do to move us all along to plus-in hybrids and other car engines that would eliminate our dependence on oil and give us clean and abundant energy.

Mr. BRYSON. I appreciate the question and I will try to do it within 3 minutes. This is an enormously exciting period of time for those of us that love this field. We see electric transportation as transforming. It can't take place unless it is enabled by a smart grid. It just won't happen. So we have to have the capacity as soon as possible to price to customers in ways that reflect our true cost, and since our true costs are so very low through the night, the plug-in electric vehicle is a natural complement to an electric system. And by the way, the electric system is so much more controlled environmentally than, for example, the existing or future generations of conventional gasoline-powered automobiles.

It doesn't matter what section of the country you are talking about, even let us say it is coal-fired power generation, the controls are sufficient that generating electricity as a transportation fuel has huge environmental benefits even with the dirtiest source of traditional fuels for electricity.

But what can happen, wait for 15 years, have this lack of transportation work in California? Now Ford Motors says it will come forth by 2010 with a plug-in electric vehicle. General Motors has a similar time frame. Toyota doesn't announce but you know Toyota is doing a lot in this area so there has been a kind of monopoly on gasoline and petroleum as fuels for vehicles. That will change. The U.S. Department of Energy itself did this study. It is an amazing study that said we had this fundamentally wasted resource in the electric grid because so much of it is built to serve only those needle-peak times like California in the summertime when it is so strikingly hot. In the inland we demand all the electricity. The rest of it goes to waste. The electric vehicles could tie into that, reflect the low cost of adding service to them with overnight in the garage, simple plug-in. We could empower, the Department of Energy says, over 70 percent. It just won't happen but it is an image, over 70 percent of the vehicles existing today could be transformed into electric vehicles and no additional demand on the infrastructure of the electric system. So high productivity, you bring in the additional revenues, you bring down costs for everybody, so it would be economical, it would be environmentally beneficial and it would provide transportation alternatives.

Finally, as you know, Congresswoman Harman, it is not just vehicles. There has to be electrification of transportation in Los Angeles simply to meet air quality standards. The ports have to change. Idling trucks in truck stops have to change. So electrification with a smart grid can make a huge difference. Oh, by the way, the last point, on the sell back, we have at Southern California Edison a new program that would allow, for example, plug-in electric vehicles, solar on rooftops, to sell back into our system and reduce their net bill.

Mr. BOUCHER. Thank you very much, Ms. Harman.

The ranking member of the full committee, the gentleman from Texas, Mr. Barton, is recognized for 5 minutes.

Mr. BARTON. Thank you, Mr. Chairman. I am not going to take that much time. I have got to go to the Texas delegation lunch so I will just make a few comments more than a question. I think this is an excellent area that we can work together on with the stakeholders because it has such potential. The only problem I see is the perennial problem, do we preempt the States as we do this, but it is obvious that there is emerging technology and technologies that are about to emerge that would make our grid much more efficient and market sensitive, time sensitive in terms of pricing and things like this. So you have got three panels. I will try to get back for one of the other panels later this afternoon but this is a very informative, fact-based hearing and it is the kind of thing that we need to be doing, and I want to commend our witnesses for being here, especially Mr. Kamen, who I have worked with before on some of his innovations for handicapped folks. I think we have got a winner in this hearing today.

With that, Mr. Chairman, I yield back.

Mr. BOUCHER. Thank you very much, Mr. Barton.

The gentleman from Pennsylvania, Mr. Doyle, is recognized for 8 minutes.

Mr. DOYLE. Thank you, Mr. Chairman.

It is a fascinating hearing, and thank you to all our panelists. I was just telling my good friend Jane Harman here that Mr. Kamen, I would like to have one of your little boxes in my home in Pittsburgh but I can't figure out where to put the cow. I guess that is a technology issue.

Actually, we are delighted to have you here. I co-chair the Distributed Generation Caucus with my good friend Lee Terry from Nebraska and like you, I believe that distributed generation technology can, should and must play an important role here, and you know, when you look at some of the barriers to widespread deployment of distributed generation, it includes, No. 1, just a lack of public understanding about the benefits of distributed generation, the higher cost up front to the consumer and the lack of ability to sell excess generation back into the electric market. I just want to get your thoughts. What do you think we can do as a Congress to address some of the barriers that exist to widespread deployment, and in an ideal world, what role would you see distributed generation technology playing?

Mr. KAMEN. The first thing I can tell you is you don't need the cow.

Mr. DOYLE. We don't have a lot of them in Pittsburgh.

Mr. KAMEN. Well, the great thing about that little engine is, it is omnivorous. It likes hydrogen, methane, propane, natural gas, diesel fuel, gasoline. It is external combustion. It literally doesn't care. The cow worked just fine but you can use whatever is in your house, which we think is critically valuable and important and maybe to answer your question about what you could do, I could tell you a short story. While we did develop that thing for the world that has no grid, here where we do have a grid I don't think it should be seen as a competitor. Where you already have a grid, I think it is a perfect complement, and I was very nervous this morning that I would hear people saying quite the contrary but since everybody recognizes the fundamental issue here, I would say one of the great things about a little box like ours or anybody's that can do combined heat and power since every home I know of needs a kilowatt or 2 of electricity and at least 3 or 4 or 5 kilowatts of heat and if you could use at least the fuel whatever is your cheapest fuel, your gasoline, your heating oil, few people would use electricity to make heat, until you run out of the need for heat, you essentially used every unit of your energy to first turn 20 percent of it into the electricity and then the heat, you would have a system which is better for everybody, not just the environment. It would be cheaper for every homeowner and that is a good thing.

You are not asking anybody to do anything except save money here. That is good.

I took that story to someone who will remain nameless, a CEO of another company, probably near the scale of Mr. Bryson's, and said why don't we put this thing in people's homes, why don't we try distributed power, and they are a massive, massive organization that burns a lot of coal, and he literally said to me, if I could put that thing in the rate base, I would buy 10,000 of them right now. He had a lot of his experts in the room with him. They started explaining the rules to me including ones, and I may get this wrong, well, since we are a power producer, of course we can't own the transmission, something about regulation and deregulation, and all I am literally thinking if this is like telling a doctor he can't own a stethoscope.

And then he goes on telling me and his experts more and more about the incentives or disincentives, the regulations, the rules or barriers, but it all came down to what I think is the good news, that these guys are saying look, if I could incrementally add when I need generating capacity instead of 10 years later I got to add a gigawatt so in the meantime I spend a few years with under-capacity, then I build it and it is overcapacity and these days it takes 10 years to—for all sorts of reasons he said for the billion dollars, if I could buy a million machines, put them in a million homes, he ticked through the same things I said. It would be way more convenient for me. I could build my capacity incrementally. I could know that I could put critical load capability and control in every home, and we have heard, people are more and more concerned about reliability. You are already at 99.96. You are only off by 0.04. That is 200 minutes a year. You are not going to be able to get those 200 minutes by even hundreds of billions of dollars of spending because you are too close to perfect now. But if you could put little boxes everywhere so that during that 200 minutes your critical stuff wasn't the problem, you turned a potential catastrophe into an inconvenience.

So all the issues that I thought I would have to sell him on looking at the 21st century with the 21st century in mind instead of a 19th century infrastructure, I thought he would buy. He did but he ended up saying maybe this is what you guys have to fix, I don't know how, your problem. He literally said it is not clear whether a utility company could own such a box. It is not clear how they would account for it. He had a load of issues, and by the way, we are one of those few companies that does do electricity and gas and heat but there is a lot of places in the country that are different than that and they have different vested interests, keeping them separate, and your box sits at the nexus. You plug your cow, your natural gas, your heating oil into one side, your electric into the other. You are a hermaphrodite. We wouldn't know what to do with it. And in the end, I left there thinking it is interesting that once again technology got ahead of an old system but what I would say and what I would hope you would agree with is, we are not only not competitive to the utility companies at this point but seeing what this country wants, what people need, what costs are, what the global issues are, we could help them extend the life of an aging grid that could use a little support out there. We could solve a lot of these other issues of reliability. And I personally think that even, and I was saying that a few minutes ago, why I think this would be so great for a utility company if you guys can encourage them or at least not prevent them or discourage them from doing it is, I think we have a society that has grown up with a grid. In Bangladesh, everybody will be pure distributed. In the developing world, there are more cell phones per capita than here because the enemy of great is good. We have a pretty good grid so the rest of the world is going to leapfrog, we stay here.

But as I was saying, where does the grid fit, where does the utility company fit. How do we make this work? If I knocked on a door in this town or any town where you live and said to Grandma who opens the door, I got this box, I am going to put it in your basement, it will sit in that dark corner next to the thing that makes hot water or the things that make electricity and you never go down there and you don't worry about it, I will give it to you free and it will save you money on your electric bill and on your oil bill, I am pretty sure if I could walk around giving them away free, I couldn't do it because the average homeowner has grown up in a society where I don't worry about that magical stuff down there but I really care that my house stays warm and my lights stay on and that big utilities, whatever it costs, they do this for me and that is what I need. Even if I put these in production or any private industry other than maybe the really, really big guys, I don't think you could do it, but if I could give those boxes to the utility company or those utility companies could go to Grandma and say last month you spent $70 on electricity and $50 on oil, if I put this box down next to the other boxes you have down there which you may own or I may own and she doesn't even know, I am going to lower your monthly aggregate bill, I will give you more reliable electricity and more heat and I will take care of all of this and you don't have to pay for the box, if a utility company was encouraged to do that, I think the rate of adoption of distributed power because they could control it, they would win, they get past the problem of who is connecting to who because they are on both sides of that connection, it would be simple and straightforward. You ought to figure out how to do it.

Mr. DOYLE. Ms. Zibelman, with 5 seconds left on my question time, you operate a pretty big grid. What do you think about what he just said?

Ms. ZIBELMAN. I think that is the lead-in in terms of where we need to go. We have a rule, we talk about it in terms of behind-the-meter generation, which is what distributed generation is, and I think one of the things that we can do which is actually something within the congressional and Federal arena is to make sure that the rules that are in place, particularly where we have markets, is that behind-the-meter generation is treated fairly in the markets both in terms of maintaining reliability standards as well as the ability for load to sell into the markets. If we do that so again from a perspective is from a market administrator, we don't care if that next megawatt of generation comes from a central station, power plant or a distributed generator. We are just going to optimize and then where the role of FERC can come in is making sure that the rules around demand response in the organized markets are fair and treat demand response as well as central station generation and distributed generation in a way that would eliminate any impediments to market participation.

Mr. DOYLE. Fascinating stuff. Thank you, Mr. Chairman.

Mr. BOUCHER. Thank you very much, Mr. Doyle.

The gentleman from Utah, Mr. Matheson, is recognized for 5 minutes.

Mr. MATHESON. Thank you, Mr. Chairman, and it has been a fascinating hearing.

Mr. Bryson, in your testimony you noted some customers will program their appliances to respond to smart meters and automatically reduce usage when power costs rise. We have also heard talk about we can have appliances that will automatically do that and customers don't need to program it but of course everyone already owns their appliances now and you are not going to see everyone go out and buy the automatic ones right away. I assume that is what you are talking about in terms of customers who respond.

Mr. BRYSON. Slightly different. What we see and I think will evolve quite rapidly in California is customers that want to have remotely controlled or automated appliances will have these communicating appliances. Thermostats exist today, air conditioners, dishwashers, electric dryers. But we will offer a program in which a customer on a voluntary basis says to the utility, will you please manage that at least cost for us, give us some parameters, we will do it remotely with the aid of the advance meter and the communication systems associated with it or the computer, the individual homeowner's computer or business owner's computer can do it without us being involved.

Mr. MATHESON. As I look at the issue of smart meters and sending price signals to consumers to affect behavior, one of the impediments that I am trying to figure out and maybe the panel can help us with this, is that right now we have time-of-day metering and time-of-day rates for large industrial users but at least where I live as a residential customer, I don't, and I have no incentive to get a smart meter or any of this until my utility adopts a rate structure that sends me those price signals, and Congress isn't going to go out and tell all the utilities to do this. It is up to the State regulators, as I understand it, and I know this is probably a good topic for the next panel actually. But isn't that really the impediment to getting people, one of the impediments to having consumers go out and embrace the notion of getting smart meters in their home?

Mr. DELUREY. That is part of the conundrum. You can't have a smart meter and not do the pricing. You can't have the pricing if you don't have a smart meter. And so a lot of that does come down to the State regulator having to decide and many of them have been politically concerned about changing what have been decades of flat rates that customers are used to. Even when presented with options where it would be voluntary for those customers to be on those rates, there has still been reluctance, and I think part of the remedy is what I talked about before, we need more support in many different ways provided to State regulators but also the State regulator as the watchdog for how the money is spent in a State. Anything we can do to buy down the cost of these technologies to get them in more quickly would be useful as well.

Mr. MATHESON. But when you talk about a conundrum, in my mind this is not one of those which came first, the chicken or the egg. I think you have to have the rates and the price signals in place before people are going to get the meters. Would you agree with that?

Mr. DELUREY. Well, you actually can't do it that way though. If you don't have a meter in place that measures on a time basis, you can't bill on a time basis.

Mr. MATHESON. Understood, but I am not going to go buy a meter if the rate is not in place. Maybe I am missing something here, but to me, the utilities have to indicate to me what a cost is at 2 o'clock in the afternoon versus 2 o'clock in the morning, and once I know that as a consumer, I can make an informed decision and go out and buy one of these meters but I am sure as heck not going to go buy a meter when the utility says yes, some day we will tell you what the price is and we will give you those price signals later, go out and buy your meter now.

Mr. BRYSON. The model needs to be that the utilities go forth and put the smart meters and smart grid in, and I guess I am at least cautiously optimistic about that. With what we put out, we put out this, as I indicated, challenge to the market and they have come forth. We are doing this on an open architectural model. We have eight manufacturers in the last year that have come up with this. We have utilities all over the country, all over the world coming to our offices in southern California to see how this is going. A Canadian utility is moving with one part of this. So I don't want to be overly Pollyannaish about this but I think this is coming and coming fast.

Ms. ZIBELMAN. If I could just add, you are absolutely right. The only way you are going to have customers see the value of participating is if they get the price information, and then they become partners, and plus from the standpoint of the operator, the operator needs to see the customer respond as well because that is the only way we know that the system is going to remain reliable so we need the price signal to get the customer and then we need the signal back to the operator to preserve reliability.

Mr. MATHESON. Thank you, Mr. Chairman.

Mr. BOUCHER. Very good, Mr. Matheson. Thank you.

The gentleman from Washington State, Mr. Inslee, is recognized for 5 minutes.

Mr. INSLEE. Thank you. I really appreciate your ideas. One of the reasons I appreciate your testimony is, you have confirmed my prejudice, which is always comforting. I just spent a year writing a book about clean energy and looked at the great things people are doing right now in energy efficiency, both business-wise and consumer-wise, and you are sort of confirming this potential. I sort of hear you say there is somewhere between a 5 and 20 percent reduction of electrical usage while still enjoying our lifestyle that we now enjoy and that is a huge number when you start looking at the challenges we face on global warming and everything else. I really appreciate your testimony.

I wanted to ask you if any of you had comments about the idea of decoupling utilities to inspire them to start to make investments in the smart grid or otherwise take actions to really move to a more efficient system. Some of us have looked at some other models where decoupling would suggest it would help utilities move in that direction where there would be an economic incentive to sell less product rather than more. The current situation in most utilities is, the way the rate structure is set up, there is an economic incentive to sell more product and the more electricity you sell, the more money you make, whereas our need in global warming is to quit wasting energy and particularly that created by CO^2-emitting generating facilities. So it seems to me that is an opportunity. I just wonder if any of you have any comments about that. And I am sorry if you have talked about this already. I was at a global warming hearing the rest of this morning.

Mr. BRYSON. I would be pleased, in fact excited to respond to what I think is an incredibly important issue and question, and I will give you just a little personal—California has decoupled so there is no linkage between the opportunity for revenues or more importantly for net income for investor-owned utilities in California associated with additional sales of electricity. That goes all the way back to the second oil price spikes of 1979. Just a personal note, I was made chairman of the California Public Utilities Commission at the time. I had this environmental background. But we did that in 1981 and it has been true with a short lapse ever since. That I think in turn has enabled a lot of the programs that we have in California so it is in my testimony but our company was very pleased that the Department of Energy has given us this recognition. We, through what I think have been cost-effective programs of energy efficiency and energy conservation, support from the utility had much higher level of energy conservation and efficiency associated with our programs than any utility in the United States but that delinkage is essential because otherwise we have these conflicting incentives. That is the reason it was changed in 1981 and the California Public Utilities Commission is now looking at a proceeding as indicated. It will not only make it neutral with the decoupling so it is neutral to the opportunity for a utility to earn but will affirmatively incentivize it so as of something like August of this year, it is anticipated that the State of California for investor-owned utilities will provide an affirmative earnings opportunity for efficiency programs.

Mr. INSLEE. Does anyone else want to comment on that? Yes?

Mr. YEAGER. I would just observe that I think we are entering into a period that is going to force considerable change at the regulatory level and introduce the kind of smart technology we are talking about, and it is basically that rate cases are a political third rail for regulators and usually for the governments in the State. We have frozen rates for years, decades. They cannot be frozen any longer and I think if the commissions go to their communities and say we are going to double your rates but we are not going to give you any better service and we are not going to give you any control over your bill, I hope there is considerable pushback. In fact, I have seen that here in Maryland recently. I think you are going to see that all over and basically this is an offer that can't be refused. We can offer you much better service, we can offer you the ability to control your bill and we can also fundamentally reduce the cost of the infrastructure we have to put in because we are going to effectively have the customer build some of that infrastructure and also reduce the demand. So I think there is a window of opportunity here but I think that the commissions really have to be, I don't want to use the word educated but I think that their consciousness and they have to be encouraged to move in this direction.

Mr. INSLEE. Thank you. The witnesses have all been helpful. I want to leave you with some optimism today. Things are happening here in Congress and you are helping that. I have introduced several bills that I think would advance this agenda, a net metering bill which I have been trying to pass for 4 years, we now have a good chance of passing that to help the smart grid develop, a plug-in hybrid bill to incentivize the creation of plug-in hybrids which will give us a large battery to use our generating capacity. It is incredible. This study came out saying we got enough capacity, idle capacity at night if we have a storage facility for all that energy, we don't have to build any more plants. In the western United States, we have got existing infrastructure built that we just need a storage capacity. The Low Carbon Fuels Act, which will create a standard for low-carbon fuels which will incentivize, making the grid more efficient, so I appreciate your testimony. I think we are going to get some things done here, and thank you for your work.

Mr. BOUCHER. Thank you very much, Mr. Inslee.

I would like to again express the committee's appreciation to this panel for your excellent presentations here today. This is one of the more interesting panels we have had the privilege to hear from, and we are grateful for your taking time to join us here. There probably will be some additional questions that other members would like to propound to you. That will be done in writing. And when you receive a letter, if you could respond to it promptly within a matter of a week to 10 days, that would be much appreciated. And the record shall remain open for the purpose of those questions and answers. With the committee's thanks, this panel is excused.

We now welcome our second panel of witnesses consisting of three witnesses. The Honorable Jon Wellinghoff is a commissioner of the Federal Energy Regulatory Commission who has been very active on the issue of advanced metering and smart grid development. The Honorable Robert F. Lieberman is a commissioner with the Illinois Commerce Commission. Mr. Kevin Kolevar is the director of the Office of Energy Delivery and Electricity Reliability at the U.S. Department of Energy. I want to say welcome to each of our three government representatives today. We appreciate your taking time to testify before us. Your prepared written statements will be made a part of the record and we would welcome your oral summaries hopefully kept to approximately 3 minutes.

We will be pleased to begin with Commissioner Wellinghoff from the FERC.

STATEMENT OF JON WELLINGHOFF, COMMISSIONER, FEDERAL ENERGY REGULATORY COMMISSION, WASHINGTON, DC

Mr. WELLINGHOFF. Thank you, Chairman Boucher and members of the committee. I first want to indicate that I am testifying here today on my own behalf and not on behalf of the Commission but

I would like to thank you all for inviting me here to testify before you on this very important issue, the smart grid. I actually found the last panel fascinating. I am going to send all my remarks right out the window. I know you are going to put them in the record. I am going to sort of shoot from the hip here a little bit with respect to a few comments that I have on the last panel and some of the things that were said.

As you are all I am sure aware, the FERC does regulate wholesale rates and the wholesale electric markets. We are very interested in ensuring that those markets work effectively and work on behalf of consumers. We think we can do that with competition but we think competition has to be on both sides of the meter. We have to have competition on the supply side and we have to have competition on the demand side. With respect to demand response, we heard earlier Mr. Delurey talk about it. I think that it is important that demand response have an equal place to play in those competitive markets and I think by doing that, we can enable the smart grid. We need to give consumers the opportunity and the tools to respond to a smart grid. As you heard from the earlier panel, we do need to have price signals correct but consumers have to have means to respond to those price signals, and the way they can respond to those price signals best is, No. 1, have regulatory tariffs in place that allow them for economic benefits for responding to them and No. 2, have the technology in place to be able to respond. We heard about some of the technologies that I think are very important to recognize. One that Mr. Gammons talked about that the Pacific Northwest National Labs is doing, the Olympic Peninsula experiment that they have done, very interesting work by embedding in appliances in homes certain types of chips that can respond to the grid and frequencies in the grid and price signals from the grid. Those things need to be enabled so that consumers have opportunities to respond.

Mr. Kamen's box I think is fascinating and I think it is complementary to the grid. We need to figure out how to enable distributed generation and look at choices between capital flows between centralized generating plants and more distributed generation. I think distributed generation in fact can be an enabler for the smart grid because when consumers in fact put distributed generation in their facilities both their commercial and residential facilities ultimately will allow more smart grid technology to be pulled in.

And then finally, I would like to mention plug-in hybrid electric vehicles. I think those vehicles also can be an enabler for the smart grid because we can use them not only to charge from off-peak times and also do things like integrate better in wind technology and other renewables into the grid but we can also use them to provide power back to the grid, do things like regulation and spending reserve. In fact, there was a recent study that came out by the National Renewable Energy Lab that indicated that payments could be provided back to an individual owner of a plug-in hybrid electric vehicle as much as $2,000 to $4,000 per year per vehicle for spending reserve and regulation services. This could in fact allow consumers to buy these vehicles at cost that would be similar to a gasoline vehicle and also provide for efficiency of the grid. If we can make the grid just 5 percent more efficient, we can ultimately reduce the need for 85 large coal plants. That is power we don't have to use, emissions we don't have to make.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Wellinghoff follows:]

TESTIMONY OF JON WELLINGHOFF

Good morning, Mr. Chairman, Ranking Member Hastert, and members of the subcommittee. My name is Jon Wellinghoff, and I am currently serving as a Commissioner on the Federal Energy Regulatory Commission

I would like to thank you for inviting me to appear before you to discuss a vitally important issue: the potential of a smart electric transmission grid that employs advanced communications and control technologies to enable and utilize bidirectional flows of information. Before addressing that issue, however, I wish to indicate that I am speaking only on my own behalf and not on behalf of the Commission. By way of background, I have 32 years of experience in the field of electric utility regulation and electric system analysis and oversight. I authored the Nation's first comprehensive integrated resource planning statute for electric utilities (enacted in Nevada in 1983), as well as one of the Nation's first electric utility portfolio standards that combines renewable energy and energy efficiency in a single portfolio (enacted in Nevada in 2005). A copy of my biography is attached to my testimony.

The electric transmission grid in the United States is one of the largest and most complex machines in the world, capable of carrying over 850 gigawatts of energy. Unfortunately, a decades-long decline in transmission investment and a precipitous decline in investment in demand response, primarily in the last decade, now threaten to impair the reliability of that machine and cause billions of dollars in congestion costs.

This large and complex machine and our associated energy infrastructure are in desperate need of improvement. However, it is essential to recognize that we cannot simply build our way out of these problems. The primary impetus of change in the past, and no doubt, of change that we will see in the future, is technology. Therefore, as we invest in new energy infrastructure, we must spend smartly. We must spend efficiently. We must promote investment in efficient transmission facilities and state-of-the-art transmission technologies, as well as facilitate demand response and distributed generation, in order to address the Nation's energy challenges and ensure the greatest benefits for consumers. As an example, if we could make the electric grid even 5 percent more efficient, we would save more than 42 gigawatts of energy: the equivalent of production from 42 large coal-fired power plants. Those are plants that we would not need to build and emissions that we would not produce.

In the Energy Policy Act of 2005 (EPAct 2005), the Congress emphasized many of these same principles. In particular, the Congress required the Commission to promote reliable and economically efficient transmission and bulk power markets by, among other things, encouraging deployment of advanced technologies. Indeed, in section 1223 of EPAct 2005, the Congress provided the Commission with guidance as to types of technologies to encourage, including, among others, controllable load such as demand response; distributed generation, including fuel cells, microturbines, and photovoltaic energy systems (like the one now under construction at Nellis Air Force Base in Nevada); energy storage devices; and enhanced power device monitoring.

The Congress recognized the benefits of these technologies and emphasized the need for their wider deployment. These types of distributed resources can discipline peak market prices, provide a hedge against volatile fuel prices, alleviate congestion, improve reliability, and potentially be a cost-effective means to complement or defer transmission expansion or improve the efficiency of transmission upgrades.

BENEFITS OF DEMAND RESPONSE

I would like to focus first on demand response, which the U.S. Department of Energy defined as follows in a February 2006 report to the Congress:

Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.

The Commission's Staff has reported that the total level of demand response reductions achieved by independent system operators (ISO) nationwide on peak days during the summer of 2006 was approximately 8,800 megawatts. These reductions represented between 1.4 and 4 percent of ISO system peaks, with reductions in load pockets such as Southwest Connecticut approaching 6 percent. The corresponding reductions in wholesale market clearing prices were between $100 and $300 per megawatt hour. These price reductions mean that consumers saved hundreds of millions of dollars last summer alone due to the use of demand response by the ISOs in these wholesale markets. The benefits of demand response are also the subject of a study that Dr. Ahmad Faruqui of The Brattle Group presented at last week's National Town Meeting on Demand Response, which found that just a 5 percent reduction in U.S. peak demand is worth $31 billion (NPV) over a 20-year period, based only on avoided costs.

We should not underestimate the power of consumers to drive smart-grid technologies. The more that consumers see economic benefits of demand response, the more they will want demand response opportunities and the more they will support investments in the smart electric grid that makes more demand response possible. Thus, not only does a smart grid enable wider use of demand response, but demonstrating the benefits of demand response to consumers also brings us more rapid implementation of the technologies necessary to enable a smart grid.

COMMISSION ACTION ON DEMAND RESPONSE AND OTHER ADVANCED TECHNOLOGIES

The Commission has taken to heart the Congress's directive to encourage wider deployment of demand response and other advanced transmission technologies. Over just the past eight months, the Commission has taken several steps to develop a platform to support a smart electric grid. For example, in February of this year, the Commission reformed its open access transmission policies to, for the first time, put demand response and other distributed resources on equal footing with other resources in directly contributing to the reliability and efficient operation and expansion of the electric transmission system. The Commission's Order No. 890 provides that demand response and distributed generation may provide a variety of ancillary services when they are capable of doing so. The Commission also found that when such resources are capable of performing needed functions, they should be permitted to participate on a comparable basis in open, transparent transmission planning processes, and that stakeholders should have a forum to come forward with demand response project proposals that they wish to have considered in development of a regional transmission plan.

The Commission has also taken steps to integrate demand response into new mandatory electric reliability standards, the development of which is one of the most important responsibilities that the Congress placed on the Commission in EPAct 2005 (section 1211). In March, the Commission issued a Final Rule that found that demand response should be allowed to be used to comply with reliability standards governing contingency reserves, reactive power, emergencies, and planning the reliable bulk power system. The Final Rule also makes clear that demand response must be technically capable of providing the function required by a reliability standard. The Electric Reliability Organization (ERO) will develop the process for determining such technical capability through its standards development process.

Last fall, the Commission and the National Association of Regulatory Utility Commissioners (NARUC) jointly launched a Demand Response Collaborative to explore how to better coordinate approaches to demand response policies and practices. The Collaborative has laid a solid foundation in its initial meetings, and I look forward to further discussions this summer. Initiatives are also underway at the Commission and several ISOs and regional transmission organizations (RTO) under our review to integrate demand response into energy and capacity markets. In addition, the Commission is conducting a series of conferences to examine the state of competition in wholesale electric markets and to explore the role of demand response in those markets. The Commission is also developing a plan for a new staff unit that will focus on demand response in order to create additional expertise within the Commission on such innovative technologies.

On a related matter, the Congress directed the Commission in section 1241 of EPAct 2005 to provide incentives for transmission investment that promotes reliable and economically efficient transmission and generation of electricity and to encourage deployment of transmission technologies and other measures to increase the capacity and efficiency of existing transmission facilities. In its rule implementing that directive, the Commission highlighted the importance of investment in economically and technologically efficient transmission infrastructure. I have emphasized in a number of subsequent cases that the Commission should target incentives that increase an applicant's return on equity to investments that provide incremental benefits, such as gains that result from the deployment of best available technologies that increase operational and energy efficiency. Targeting incentives in this manner would encourage the deployment of smart grid technologies.

FURTHER STEPS TOWARD A SMART ELECTRIC GRID

Thus, the Commission is moving forward in developing a regulatory framework to enable an efficiently designed, smart electric grid. It is my hope that States will examine how their consumers can benefit most from that framework, including the opportunities for demand response to participate in wholesale electric markets.

There is much more work to do, however, if we are to achieve the full potential of a smart electric grid. For example, widespread deployment of advanced metering technology will empower more consumers to take advantage of opportunities that are available for demand response in the wholesale electric markets under the Commission's jurisdiction. It is my understanding that other witnesses will discuss in greater detail the provisions of EPAct 2005 that address advanced meters, including provisions related to the responsibilities of State regulatory authorities. I would like to highlight briefly an August 2006 report that the Commission's Staff prepared in response to a directive in section 1252(e)(3) of EPAct 2005. In preparing that report, the Commission's Staff developed a comprehensive national survey on demand response and advanced metering. The report concludes that demand response has an important role to play in both wholesale and retail electric markets, and that the potential immediate reduction in peak electric demand that could be achieved from existing demand response resources is between 3 and 7 percent of peak electric demand in most regions. Unfortunately, the report also found that technologies such as advancing metering that are needed to support significant deployment of demand response resources have little market penetration.

I agree with the conclusion reached by the Commission's Staff that demand response has an important role to play in both wholesale and retail electric markets. I also see that conclusion as reinforcing the need for coordination of Federal and state approaches to this issue. The Demand Response Collaborative launched by the Commission and NARUC marks a promising step toward that goal. It also would be valuable to more formally establish this coordination. I encourage the Congress to establish a Federal-state working group through which the Commission and interested state representatives would be tasked with identifying best practices and developing consistent standards for demand response.

Lastly, I would like to highlight two recent projects and an emerging technology that illustrate how a smart electric grid can benefit a wide range of consumers. The two projects are initiatives pursued by Pacific Northwest National Laboratory (PNNL), which I had the opportunity to visit earlier this year. First, the Olympic Peninsula Distributed Resources Demonstration showed that residential, municipal, and commercial consumers equipped with automated control technology took advantage of a virtual real-time market in which they could see real monetary benefits to adjusting their consumption during times of peak demand. These demand response adjustments not only provided economic benefits to particular consumers, but also created wider benefits by relieving congestion. Second, the Grid Friendly Appliance Demonstration showed that smart appliances improved reliability by detecting fluctuations in frequency when the grid was under stress and responding automatically within seconds by turning off some functions for short periods. That automation increases the appeal and the benefits of demand response. These projects, which PNNL conducted with support from DOE and other partners, hint at the full potential that could be achieved through wider deployment of demand response enabled by a smart grid.

The emerging technology I would like to highlight is a plug-in hybrid electric vehicle with vehicle-to-grid (V2G) capability. Substantial research has been conducted on this technology, and important issues remain to be resolved before these vehicles will be ready for large-scale commercial availability. Nonetheless, the potential of this technology is enormous. Plug-in hybrid electric vehicles could create widespread demand response opportunities and offer emergency power supply through energy storage, as well as smoothing the integration into the grid of renewable resources such as wind generation. With V2G capability, plug-in hybrid electric vehicles would improve efficient grid management by providing a variety of ancillary services and thereby improve power plant efficiency. Because these additional services could also create payment streams to individual vehicle owners that would significantly offset the incremental first costs associated with these vehicles, V2G capability could be an enabler of both plug-in hybrid electric vehicles themselves and the smart electric grid.

In these ways, plug-in hybrid electric vehicles with V2G capability exemplify the benefits of demand response and a smart electric grid. We have only begun to capture those benefits, and doing so is essential to making the complex machine that is our electric grid function in the efficient manner that will bring the greatest benefits to American consumers and address our Nation's energy challenges.

Mr. BOUCHER. Thank you very much, Mr. Wellinghoff.

Mr. Lieberman, we will be happy to hear from you.

STATEMENT OF ROBERT F. LIEBERMAN, COMMISSIONER, ILLINOIS COMMERCE COMMISSION, OAK PARK, IL

Mr. LIEBERMAN. Thank you, Mr. Chairman. I have to say, after the sort of spanking that State commissions got from the other panel, I ought to be clear that I am here representing only myself. I as well am going to throw out my written remarks because the panel this morning was really quite good and covered a lot of what I was going to say.

I do want to say a couple of things quickly though. In anticipation of this discussion, I actually went and looked at half a dozen of the EPAct smart metering dockets sort of from around the Midwest and I want to sort of follow up on your questions this morning. The three things that come across pretty clear when you read those dockets, and again, they are not all done and they may end up differently but at least the stuff that is in the record to this point, there is really three things and I think these three things represent from the State perspective the barriers and I think lead to opportunities that the Federal Government could take advantage of.

The three things are, there is really sticker shock. If you look at the dockets, people go, "man, these are expensive." These new shiny gizmos that we want to install, they are really expensive. Even if they lead to better price signals, all of the things that people said, I think the first response that you get out of the EPAct dockets is man, this is expensive to do, and this is in the context of course of rising energy prices and it would take a brave commission to throw additional costs on in light of that. Second, I think the issue of what are the benefits, how do we measure them, is absolutely critical. In all of the dockets that I looked at, people said we don't know how to measure these benefits. We don't know what the value of doing this is. Commissions are used to thinking in a sort of deterministic way. They are used to thinking about we can measure what the benefits are if we can measure the costs and in a sense what we are doing here is, we are saying we can measure the cost but the benefits could be huge, they are great, everybody thinks they are wonderful, and I think until we come up with some systemic way to talk about the benefits, it is going to be difficult to do. The third, and I thought this was pretty interesting. The third was kind of across the board. In these dockets people are saying no one is asking us for this, no one is asking us for these, there is no demand for these meters, which reminds me a little bit of 1979, the what would I do with a computer on my desk problem but the dilemma is that we don't really know, there is no demand for this. In many States there has been a demand for wind power and so people have started to think about how to provide wind power, but this is very geeky and no one is going damn, I want one of those meters.

So I think those are the three problems. Let me suggest three approaches to getting to them. Without seeming hopelessly naive, I would suggest that if putting in the smart grid and smart meter was a serious Federal priority, I would think about a subsidy to utilities, a subsidy in some way that Congress was recently very generous to the nuclear industry and to the wind industry and I think if we were actually serious about a cost-effective energy policy that provided energy independence and environmental benefits, we would seriously think about subsidizing, getting over the sticker shock, helping States to get over the sticker shock. Short of a direct Federal subsidy, we are not proud, we will take an indirect Federal subsidy. I think the depreciation question that was raised earlier is an excellent idea. The question of the benefits, I have done a lot of work with Kevin Kolevar's division at DOE and I have a lot of respect for them. I think that if they could provide additional resources to help States understand what the benefits are, develop models, I think that would be extraordinarily useful. We don't have the resources to do this and I think until those resources are provided, it is going to be very difficult.

Let me close by saying we are all real smart and we know that energy prices vary by the hour and we know that most of the hours out of the day, the price of electricity is really low in the wholesale markets. I will go out on a limb and say that 98 percent of the people in Illinois don't know that. Ninety-eight percent of the people in Illinois think the price of electricity is what they pay the utility and I think that until people understand that there is a lot of inexpensive electricity out in that market that they can't get because the technology is not installed, I think you have to create a demand for the meter, and the way you create that demand for the meter is, you start making that transparent and you start educating people about the value that would be available to them. The reality is, their prices would be lower if they could get hourly prices. But they can't because those aren't available. Just as an example, and I say this only half facetiously, which means I guess the other half is not facetious, but imagine if DOE were to purchase time on the Weather Channel so that every time they gave the weather for Chicago or Pittsburgh or Montpelier they told you what the hourly electricity price was. You start driving the fact that the low-cost power up there to people—right now people have no idea that that is available. I think that using mechanisms to make those prices transparent and to get people saying why can't I have that, I am interested in that, and I think that would be a public education campaign that if DOE had the resources to run in conjunction with the States to identify the opportunities to get people interested would motivate commissions in ways that we haven't seen up to this point. When people don't see any demand, they don't see any reason to take the regulatory risk.

Thank you. I am happy to take any questions.

[The prepared statement of Mr. Lieberman follows:]

TESTIMONY OF BOB LIEBERMAN

My name is Bob Lieberman and I have been a utility regulator in Illinois since February 2005. I am currently the Chairman of the Midwest Demand Response Initiative, a collaborative effort of 14 Midwest state regulatory commissions, utilities and other stakeholders trying to educate and learn from each other about how to implement regional price responsive retail demand. I am also on the executive committee of the Organization of MISO States (OMS), a Regional State Committee working together to ensure that the regional RTO—the Midwestern ISO—works in the interests of customers as well as suppliers.

Before that, for nearly ten years, I ran a Chicago-based not-for-profit called the Center for Neighborhood Technology where we created and managed community-based demand response and energy efficiency programs in partnership with Commonwealth Edison, the local Chicago utility. As part of that effort, we introduced the first in the Nation hourly pricing pilot for residential customers, the success of which prompted the Illinois General Assembly to recently mandate that electric utilities offer such a program to all residential customers in the state. Prior to that, among other things, in the mid–1980's I worked with then-State Representative Hastert on re-writing the Illinois Public Utility Act, a generally thankless if necessary task.

In testifying before you today, I do not represent the views of the Illinois Commerce Commission, the Organization of MISO States nor the National Association of Regulatory Commissioners. My perspectives today are mine alone.

The question I was asked to address relates to possible actions that the Federal Government might take to create incentives for state public utility commissions to move more rapidly to upgrade retail electricity distribution information systems from their current state of the art 1920's technology to something that more closely resembles early 21st century technology, i.e. systems that are digital rather than analog, two way rather than one way, open rather than closed and network-based rather than hierarchical.

Unfortunately, I have no easy answers. This is, in fact, a very difficult question to answer as it goes right to the heart of the well-documented legal and institutional eccentricities of our current regulatory and governance system for electricity markets.

In anticipation of this conversation and in order to more precisely underscore some of the barriers to implementation, I have recently reviewed a few of the docketed cases from Midwest states that were initiated to address the Epact smart metering standard. To be fair, many of these dockets have not been completed, but I think there is enough in the record at this point to be able to summarize what some of the major issues are.

In short, most of the dockets express—roughly—the following concerns.

These new gizmos are really expensive; We have no way to measure the benefits, or alternatively—in some of the dockets, there is no discussion of benefits at all; There is no demand - no one is asking us for these meters;

Let me examine these barriers one at a time.

Expensive gizmos: I think it is fair to say that in many cases state commissions and their staffs—when seeing the initial cost of a "smart grid" deployment—suffer from sticker shock. The subtext, of course, is that in an era of rising energy prices, it takes a brave Commission to pile more costs on, particularly given the indeterminacy and uncertainty of the benefits, even in the name of possible lower system costs and more accurate customer incentives in the long run. Despite the fact that the costs of deployment have fallen dramatically over the past ten years, and are likely to continue to fall, the initial costs still seem high.

Unknown or unknowable benefits: The benefits are uncertain and hard to calculate. Most public utility regulatory commissions are—largely by history, design and culture—what I will call "practical and practicing incrementalists." Vision and imagination are not our strong suit. We can only decide on the basis of the record before us, and we generally react to the petitions of others. Future calculated benefits have to be greater than real visible costs. Rates have to be deemed just and reasonable.

In the old days, before restructuring, state commissions' assumed away the future uncertainty implicit in their decisions and pretended to know what the costs and benefits would be in the future. It was never a particularly good assumption, but at least it allowed decisions to be made within the static analytic tools and existing legal frameworks that were available. After restructuring, however, along with the rise of organized regional wholesale markets, the ability to simply assume away the uncertainty disappeared. Also, some state commissions may be more willing to shift the uncertainty to some vague market mechanism to deliver benefits or costs, rather than take the explicit responsibility for waving significant new costs into rates. In either case, state commissions can no longer assume that we know what the future looks like. The condition of indeterminacy—a constant reality of the world outside of the regulatory process -is not the regulator's friend. The inability to predict the behavior of some critical variable vastly complicates the regulator's job and in large measure stymies the analytic tools regulators and their staff's have at their disposal.

Lack of demand: One gets a sense that regulators are reluctant to take the initiative because they don't perceive much of a demand from end-users for the increased capacity and functionality that a wide-spread smart grid and smart meter deployment would provide. Why should they impose costs on customers when the customers aren't asking for functionalities that the costs would support. Doesn't this remind you of the early days of telephone deregulation when you heard such things as "plain old telephone service" and no one wanted to pay for network upgrades to digital technologies?

For all these reasons—and given the context in which state regulators function—a "transformational" technology innovation that requires a significant up-front investment to achieve an uncertain level of future benefits like "smart meters" or "smart grids" is viewed with some perhaps not unreasonable skepticism and trepidation.

So what is to be done?

First, I would suggest that—if possible - you deal with the sticker shock problem. I don't want to pretend that I understand the intricacies of the Federal budget process nor do I want to be seen as utterly naive, but if achieving a more rapid deployment of smart grid technologies was a high Federal priority, nothing would get it to move faster than some kind of Federal subsidy. I have no idea what the likelihood of such a policy might be, but it occurs to me that the Congress was recently quite generous—in the name of increased energy security and environmental improvement—to various electricity production technologies, including nuclear, coal and wind power. If we were really interested in a policy of cost-effective energy security and environmental improvement—we should be at least as generous with "smart grid" deployment as we are with nuclear and wind. Giving consumers the information and tools that they need to consume energy more efficiently and smarter is by far the most cost-effective energy production, security and environmental improvement policy we could adopt. As far as I'm concerned, the "smart" in smart grid and smart meters applies not only to the technology but to consumers as well. Consumers, themselves, are a grid resource, just like a peaking turbine. What we need are smart and efficient consumers—"smart" grids and "smart" meters are—in part - a tool to achieving that end.

In addition, a Federal subsidy could help to ensure interoperability and other important national criteria through the establishment of outcome-based performance standards for the receipt of the subsidy.

However, we are not proud. Short of a direct Federal subsidy, we will take indirect Federal subsidies. One of the problems often cited as a barrier to rapid deployment is the fact that existing investments in traditional metering and distribution information technologies are still in service and have not been fully depreciated. To remedy this so-called stranded cost barrier, for example, Congress could tell the IRS to allow accelerated depreciation for old transmission and distribution assets if they are replaced with new "smart grid" assets.

State public utility commissions may be encouraged by this action to follow suit and approve rate treatment that accelerates removing these antique meters from the utility rate base.

Second, we need to deal with the uncertainty about the level of benefits that will be achieved. Frankly, state regulatory commissions have limited staff and extremely limited resources to take on new ideas and to develop new tools and methods. In Illinois, we are so overwhelmed with our current assignments that the idea of trying to develop the extensive knowledge base to adequately address these new technologies and new ideas is simply outside the realm of our current reality. In my conversations with other regulators, this is the case in many other states, as well. It is my sense that when Congress simply tells the states to study this or study that, the result is an effort commensurate with the State's staffing and budget resources, which—all other things being equal - usually provides for a less than satisfactory outcome.

So we need help. We simply don't have the resources to develop the knowledge or the expertise on our own. We need help in developing the tools, analytic methods and models that would allow us to understand how to manage uncertainty instead of being overwhelmed by it, and how to estimate the benefits of a rapid deployment of smart grid technology on a probabilistic basis. We need access to the best thinking from around the country in this regard.

To this end, I want to note that I have great regard for Kevin Kolevar, and the staff at the Office of Energy Delivery and Electricity Reliability for the excellent work they have done to educate stakeholders on the intricacies of these difficult issues and to support regional efforts like the Mid-Atlantic Distributed Resources Initiative and the Midwest Demand Response Initiative. In the future, it would be enormously helpful if they had the additional resources to provide state commissions with the kind of on-going technical assistance I mentioned above.

Finally, and maybe most importantly, we need to deal with the problem of the lack of demand for the new functionalities provided by the new technologies. It really is no surprise to me that there is not a rising clamor among the population for smart meters. For eighty years, we have lived—and prospered—with a dumb network and dumb meters. Other than the geeks among us, why would we even know enough to want to change?

In this context, one of the real successes of the organized wholesale electricity markets over the last decade—and a success that I think has been largely underappreciated—is the development of a visible and transparent hourly price. If you know where to look, you can determine the value of electricity at any hour. If you look at those hourly prices over time, you know that as much as 98% of the hours, the prices are really low—in fact, often lower than the hedged same-price every hour electricity product offered at retail by the distribution utilities. And if you take the average of the hourly prices over the course of almost any year, they are almost universally lower than the hedged same-price-every-hour retail price.

But I would argue—based on my experience in Illinois—that 95% of all customers—residential, small commercial, municipal—have absolutely no idea that the price of electricity varies by the hour and that the average of the hourly prices is likely to be significantly lower than the hedged retail price they have traditionally seen. And until they know that, they won't realize that there is something in it directly for them; that investing in smart meters will give them access to lower cost electricity. Unless they are informed of these benefits, why would they be willing to start asking, and more importantly, start paying for the technologies that would allow that to occur?

In many ways, therefore, it seems to me that the single most cost-effective way to move state commissions to more rapid deployment is to increase the demand for these technologies, and the most direct way to increase the demand is to explain to consumers what they are missing. What we need is an independent third party to make consumers aware of what the hourly prices are, to make them aware that there are lower prices available and that they can't have access to them because the technology to give them access to those lower prices is not in place. State commissions or state energy offices are perfectly suited to this educational role with DOE providing resources and technical assistance

I say this only half facetiously—I guess the other half is serious—but imagine the RTO or DOE buying time on the Weather Channel so that every hour—when they give the weather for Chicago, or for Cleveland, or for Philadelphia or for Washington DC, they also told you what the local wholesale price of electricity was for that hour. Or every time you checked the weather for your hometown on Yahoo, you also got the hourly electricity price?

Until we make these markets transparent and the wholesale prices visible to retail customers—until we educate customers so that they understand what's in it for them to invest in these new technologies—we are unlikely to get a national deployment any time soon. We will continue to talk about actions needed rather than seeing a smart grid implemented.

Thank you for your attention. I will be happy to answer any questions.

Mr. BOUCHER. Thank you very much, Mr. Lieberman.

Mr. Kolevar.

STATEMENT OF KEVIN KOLEVAR, DIRECTOR, OFFICE OF ENERGY DELIVERY AND ELECTRICITY RELIABILITY, U.S. DEPARTMENT OF ENERGY, WASHINGTON, DC

Mr. KOLEVAR. Thank you, Mr. Chairman and members of the committee for the opportunity to testify before you today. I will also truncate my remarks as the first panel covered a lot of ground in a particularly effective fashion.

The Department of Energy embraces its role as helping to lead national efforts to modernize the electric grid by researching, developing and demonstrating next generation technologies for the grid. To advance grid modernization, our approach is to assess the grid from a systems perspective, taking into account electricity supply, to electricity delivery and incorporating energy efficiency measures throughout the system including demand response to produce peak loads. We recognize that a change at one point in the system will affect the whole system.

In the Office of Electricity, we sponsor a range of research and development for grid modernization in areas such as advanced communications, energy storage, grid visualization and control technologies. For example, our office has helped develop an autonomous storm detection system that adjusts system default levels during thunderstorms and automatically resets them after the storm is past. So how do we transition to a smart grid? First we need to recognize that grid modernization is a major undertaking for our Nation and that it will only be realized through the dedicated involvement and cooperation of Federal and State governments, industry partners, academia and investment communities. Historically, the Federal Government has had few tools available to help with the transition to the smart grid as compared to those certainly in the 50 States and the District of Columbia. Notwithstanding this historical State primacy in regulating electricity distribution, the Federal Government should be active in encouraging the needed transition to a 21st century grid. Consider for a moment the implications of 51 different jurisdictions taking separate action. Put simply, the Federal and State governments need to work together to address the challenges before us.

I am pleased to report that we already see positive movement toward collaboration. Some State regulatory commissions are engaging in a smart grid issue, in part as a result of provisions such as EPAct section 1252 on smart metering. In addition, a handful of States are or will be considering deploying smart and advanced electric meters in residential and small commercial sectors. The FERC and the National Association of Regulated Utility Commissioners have jointly established a collaborative informal working group to consider all aspects of integrating demand respond between retail and wholesale markets. This effort is co-chaired by Commissioner Wellinghoff of the FERC and Commissioners Irvin and Reha of North Carolina and Minnesota, respectively. Jon is too modest to mention this effort. I hope you will give him the opportunity to address it in Q&A. It is a very effective forum. Commissioner Lieberman has also played a role, a key role in evaluating what is improved demand response through the new Midwest Demand Response Initiative. This kind of activity needs to continue and grow if we are to effectively identify the types of practices to be undertaken by the State and Federal Governments that will complement one another to facilitate the development of an intelligent, resilient and reliable grid.

I would also like to announce that on April 26, the Department released a competitive solicitation to work with utilities to implement smart grid technologies that achieve a 15 percent peak load reduction on a feeder system.

So Mr. Chairman, I will conclude my statement by reflecting on an event that amply demonstrated the growing momentum behind the development of a smart grid. Last week the DOE was a partner in hosting a 4-day national conference dedicated to advancing grid modernization entitled Grid Week. This event provided a forum for the individuals and organizations that are already working on various aspects of the smart grid concept to network and catapult the electricity grid into the 21st century. We thank you for your participation in this event, sir, and we believe it is extremely promising that these key participants are now united in the vision of bringing about the smart grid. It is now incumbent upon all levels of government to work together to develop and implement this vision.

This concludes my statement, Mr. Chairman. Thank you.

[The prepared statement of Mr. Kolevar follows:]

Statement of Kevin M. Kolevar
Director, Office of Electricity Delivery and Energy Reliability
U.S. Department of Energy

Subcommittee on Energy and Air Quality
Committee on Energy and Commerce
U.S. House of Representatives
"Facilitating the Transition to a Smart Electric Grid"

May 3, 2007

Mr. Chairman and Members of the Committee, thank you for this opportunity to testify before you today on facilitating the transition to a smart electric grid.

Today, the availability of and access to electricity is something that most Americans take for granted, even though it is vital to nearly every aspect of our lives, from powering our electronics and heating our homes to supporting commerce, transportation, finance, food and water systems, and national security.

OE Mission

The mission of the Office of Electricity Delivery and Energy Reliability (OE) at the Department of Energy (DOE) is to lead 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. These functions are vital to DOE's strategic goal of protecting our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally responsible energy.

Meeting our Future Electricity Needs

As our Nation's economy continues to grow, consumers' demand for more electricity will steadily increase as we move forward into the 21st Century. In fact, even when accounting for advances in energy efficiency, the Energy Information Administration estimates that by the year 2030, U.S. electricity consumption will increase by 43 percent from the 2005 level. Although this is a positive indicator of a growing economy, it is also a significant amount of new demand on an electricity infrastructure that is already stressed and aging. Our society and our economy require affordable, reliable, and clean electricity.

Meeting our future electricity needs will require new generation, transmission capacity and demand response programs, as well as more energy conservation and efficiency. Much of the new generation will need to be from cleaner sources of energy, as highlighted by the President's Advanced Energy Initiative. What's more, our increasing use and dependency on high technology electronics is creating the need for a much more reliable flow of electricity, to levels far beyond the design capabilities of our 20th Century grid.

Yet, despite increases in electricity consumption and in demand for electricity reliability, there has also been a period of under-investment in power generation, power transmission, demand-side investments, and infrastructure upkeep. This state of the grid can be linked to regulatory uncertainty, environmental concerns, changing market dynamics, and the difficulty of siting and permitting new transmission.

Modernizing the Grid

Innovations that modernize the grid system will pave the way for important new uses of electricity, such as plug-in hybrid electric vehicles. I am pleased that this hearing's previous panel was able to illuminate these many possibilities.

Now is the time to bring the enabling benefits of the IT revolution to our Nation's electricity system, thereby creating what many have dubbed a "smart grid." In general, a smart grid includes real-time visualization technologies on the transmission level and smart meter and communications technologies on the distribution level. These new technologies enable the advancement of demand response, distributed energy systems (generation, storage, thermal), consumer energy management systems, distributed automation systems, and smart appliances. I will note that we must not forget that implementing a "smart grid" also means maintaining strong cyber security practices.

DOE's Role

The DOE is leading national efforts to modernize the electric grid by researching, developing, and demonstrating next-generation technologies for the grid; the Department is also responsible for implementing various electricity-related provisions of the Energy Policy Act of 2005 (EPACT).

To advance grid modernization, our approach is to assess the grid from a systems perspective—taking into account electricity supply to electricity delivery and incorporating energy efficiency measures throughout the system, including demand response to reduce peak loads. We recognize that a change at one point in the system will affect the whole system.

OE Research & Development (R&D)

In my own office (OE), we sponsor a range of Research and Development for grid modernization in areas such as the development of advanced sensors (call phasor measurement units) that are GPS synchronized to monitor the health of the transmission system. Our researchers now have access to a wealth of technical data that we are translating to real-time information for grid operators. This will improve the overall reliability and efficiency of the system. Our vision for the future is to enable real-time monitoring of the electric system that optimizes the physical operation of the grid and integrates market operations.

OE has also made advances to the distribution system. Our office has developed technologies such as an autonomous storm detection system that detects and adjusts system default levels during thunderstorms and automatically resets them after the storm has passed.

Smart Technology Solicitation Announcement

I am also pleased to announce that, on April 26, 2007, the Department released a competitive solicitation to work with utilities to implement smart grid technologies that achieve a 15 percent peak load reduction on a feeder system. We are soliciting proposals that will implement smart meter and communications technologies that enable demand response, distributed energy systems (generation, storage, thermal), consumer energy management systems, and distributed automation systems or autonomous control systems.

Transition to a Smart Grid: Federal, State, and Consumer-Driven Mechanisms

I will now focus on the transition to a "smart grid." First, we need to recognize that grid modernization is a major undertaking for our Nation and that it will only be realized through the dedicated involvement and cooperation of Federal and State governments, industry partners, academia, and investment communities, for example.

Much of the smart grid concept involves automating the distribution grid. This is achieved by outfitting the grid with smart controls, communications, and sensors that connect to the homes and businesses (commercial and industrial) of the end users of electricity.

Non-Federal Authority with Respect to the Grid

It is important to note that much of the actual operation of the grid as well as decisions on investments to the grid with respect to generation, transmission, and especially on the local distribution grid, are under the jurisdiction of the States – typically State legislatures and/or public utility commissions – and not the Federal Government. These decision-making bodies have authority over generation, transmission, distribution, and demand-side (energy efficiency and demand response) management. Generally speaking, publicly-owned and cooperatively-owned electric utilities are regulated by their own elected or appointed boards.

The Federal Role for Implementing "Smart Grids"

Historically, the Federal Government has had few tools, when compared to those of the fifty States and the District of Columbia, available to help with a transition to a "smart grid." Yet, one mechanism to facilitate the transition to a "smart grid" lies within the scope of the Federal Government – it is leadership. The leadership we can provide is not insignificant—this hearing demonstrates that fact, as have the efforts of the DOE and the Federal Energy Regulatory Commission to sponsor needed R&D and related efforts that encourage voluntary and market-based efforts toward building a "smart grid."

Increasing Coordination among Federal and State Authorities

Notwithstanding historical State primacy in regulation of electric distribution, the Federal Government can be active in encouraging the needed transition to a 21st Century smart grid. A uniform and timely transition to a "smart grid" is made much more challenging when one considers the implications of fifty-one different jurisdictions taking action. Consider, for example, the difficulty of having fifty-one sets of standards as we work to achieve widespread use of smart appliances, plug-in hybrids, and other advanced electric vehicles, or the use of the grid to enable extensive energy efficiencies and demand response management. Put simply, the Federal and State governments need to work together to address the challenges before us.

I'm pleased to report that we already see positive movement toward collaboration. Some State regulatory commissions are engaging in the "smart grid" issue, in part as a result of the several provisions such as EPACT section 1252 on smart metering. A handful of States are or will be considering deploying smart and advanced electric meters in residential and small commercial sectors. Although small in unit costs, these technologies are an important necessary first step to automating the distribution, or end-use, part of the grid. Many large commercial and industrial customers already use advanced metering, which enables them to take advantage of time-varying electric rates. Given time, some States will undoubtedly enact laws and regulations to facilitate smart grid investments.

Achieving a "smart grid" may require regulators to realign utility incentives. For example, components of a "smart grid" that enable greater energy efficiency may result in reduced utility sales, thus reducing profits for investor-owned utilities. Alternative regulatory structures can reduce the "throughput incentive," by creating a "conservation incentive" that either makes the utility neutral or motivated to earn a return on selling less electricity (in essence, "selling" more energy efficiency).

Some State commissions are already pursuing this path. Under the President's National Action Plan for Energy Efficiency, DOE and its partner in this joint effort, the Environmental Protection Agency, provide State commissions upon request with best-practices-based assistance. The Department is also helping States across the country explore how to better coordinate and change regulations on a regional basis to better enable a demand response from electric customers. Specifically, DOE provides technical assistance and facilitation to States (utility commissions) and to bodies representing non-State jurisdictional utilities *on a regional basis* to discuss/learn about their roles on transition to a smart grid.

And finally, the FERC and the National Association of Regulated Utility Commissioners (NARUC) have jointly established a collaborative, informal working group co-chaired by Commissioner Wellinghoff of the FERC and State Commissioners Ervin (NC) and Reha (MN) to consider all aspects of integrating demand response between retail and wholesale markets. This kind of activity needs to continue and grow if we are to effectively identify the types of practices to be undertaken by the Federal and State governments that will complement one another to facilitate the development of an intelligent, resilient and reliable 21st century grid.

Conclusion

I will conclude my statement by reflecting on an event that amply demonstrated that the energy behind or momentum developing behind development of a "smart grid." Last week, the DOE was a partner in hosting a four-day national conference dedicated to advancing grid modernization, entitled "GridWeek." This event provided a forum for the individuals and organizations that are already working on various aspects of the "smart grid" concept to network and catapult the electricity grid into the 21st century. It is extremely promising that these key participants are now united in the vision of bringing about a "smart grid." It is incumbent upon all levels of the government to work together to develop and implement this vision.

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

Mr. BOUCHER. Thank you to each of the witnesses.

Mr. Kolevar, let begin with you and ask if your department has any legislative recommendations for us with respect to what we might do in order to facilitate advancement of the smart grid.

Mr. KOLEVAR. Sir, at this time we do not. There are discussions within the administration on this matter but I do not have anything for the committee today.

Mr. BOUCHER. Do you think you might have something in the near time frame or is this something that has a longer incubation period for you?

Mr. KOLEVAR. I think the decision to forward recommendations to the Congress will be made by others above me so I would hesitate to jump to conclusions about the availability of recommendations, sir.

Mr. BOUCHER. A very cautious and wise answer.

Mr. KOLEVAR. Thank you, Mr. Chairman.

Mr. BOUCHER. Mr. Lieberman, you and Congressman Matheson touched on what I think is a very key point and that is that in the absence of real-time pricing and a price signal sent to consumers, there is going to be essentially no demand for smart meters, and I listened carefully to your explanation of the kind of commentary coming out of the various commissions that reflect their concerns. You indicated that smart meters are expensive and they don't want to impose a cost in the absence perhaps of a demand or greater knowledge about the benefits that could be derived. You indicated that they can't really measure those benefits and then you focused on the fact that there really is no demand at the present time. But it seems to me that all of this has to start with a regulatory regime that says that utilities need to make electricity available at variable prices at different times of the day depending upon what the real cost of electricity is at that hour as determined by whether it is high peak time or low peak time, and why can't there be a bifurcation of the approach so that you get the regulation in place first without having to incur any cost at all with regard to smart meters? I think the regulation writing exercise perhaps for the State would not be particularly costly or burdensome, a little controversial perhaps but maybe not costly and burdensome, so why not take that step first and once that price signal is there and can be sent, the demand will begin to grow for the smart meters and then people are less concerned about taking the next steps in order to make them available? What is wrong with that kind of step-by-step approach?

Mr. LIEBERMAN. I think the idea of price transparency, the idea that these prices exist in the world and you don't see them and you can't have them, which is really the circumstance we are in today. Not only can't you have them, you don't even know they are there. And I think that is really the first step in sort of generating a reason for customers, a reason for consumers to say why can't we have this. Before I got the regulator's job, I ran a not-for-profit in Chicago where we put in place the first real-time pricing program for residential customers in the country as a pilot in conjunction with Commonwealth Edison, a program that was so successful, I say modestly, that the Illinois General Assembly recently mandated that utilities offer this to all residential customers. But the key point that I took away from that experience was that people had no way to know that there was value for them given the information systems that we have today. They didn't know that prices in the summer in the afternoons in July were high and that the rest of the time that they were low. And once you started telling people about that, once you started talking to that and once you started explaining to people how they could manage that, they became very interested. The pilot we ran had 98, 96 percent sign-up rate. People kept signing up. And so I think the price transparency question, and this was an issue perhaps for FERC or DOE or the RTOs because they really are the—the prices—one of the successes of the wholesale markets, of the organized wholesale markets has been the development of this hourly price.

Mr. BOUCHER. Let me come back to maybe a more precise formulation of the question. You don't have to get, if you are a State commission, to the question of how expensive the meter is or the fact that there is no demand for it until you have addressed the question of making sure that the real-time pricing is made available and that it is advertised sufficiently so the consumer knows about it, and once you have done that, then you can perhaps expect to see the demand develop and then the consumer can make a choice about whether or not he wants to incur costs in order to purchase this meter, and I am going to ask you also basically how much this meter costs. We don't have that information. But don't you agree that that step-by-step approach makes sense and that commissions at the State level could be encouraged and should be perhaps not required but we are a little reluctant to take that step here for jurisdictional reasons but at least encouraged to put the real-time pricing regulation in effect and to make sure that that price signal gets sent and that customers are made aware of the fact that it is available on that variable price basis?

Mr. LIEBERMAN. I go into this in some more detail in my written testimony. I think we are essentially saying the same thing. Until people can see what the value is, they are not going to do it, whether you call it actually developing a rate or publicizing the hourly price. One way or another, you have to make it transparent. You have to give people an opportunity to see what they are getting into.

Mr. BOUCHER. Well, I think we all agree with that, but I am asking a process question.

Mr. LIEBERMAN. Without the meters in place, developing the rate, I suppose we could. Well, in Illinois' case, we do have the rate and people who ask for I can get a meter and we will see over the next few years what the level of demand for that is and I guess——

Mr. BOUCHER. So how long have you had that in place?

Mr. LIEBERMAN. Since January 1.

Mr. BOUCHER. OK. So that is really very new.

Mr. LIEBERMAN. It is very new.

Mr. BOUCHER. And you don't have any experience yet——

Mr. LIEBERMAN. It is very new, and as Congressman Shimkus pointed out——

Mr. BOUCHER. How many States have done what you have done? How many States have put it in place that way?

Mr. LIEBERMAN. I actually don't know. Not very many.

Mr. BOUCHER. Well, I think maybe I should call on my colleague. All right. This is helpful and I thank you.

Mr. Shimkus.

Mr. SHIMKUS. Thank you, Mr. Chairman.

The premise of these hearings is getting to an energy security bill which as the panel before and EPRI would talk about CO^2 and these wedges, so energy efficiency issues like smart grid technologies, these things help us on that efficiency slice. That is why it is important and that is why we are pursuing it I think somewhat aggressively in trying to pin down good responses, and there are a lot of distributed issues on generation which there are a lot of things that happened in Illinois recently that have caused great interest and consternation and problems but we experienced over the last year two major power outages that lasted over a period of 7 to 10 days, and I personally was affected in the first one for about a week and my parents, who live about a mile way from me, were. Mine was in the hottest part of the summer and hers was the coldest part of the winter. So there is for distributed generation issues, there is a signal being sent when you fall under catastrophic outages and I know that people are looking at, solar panels, battery ability to at least have a minimal capability of power and I think that would transmit into distributed if we got to that point or whether that generation hooked up to natural gas for electricity much like Mr. Kamen's own power plant but this is a separate power plant. So there are other signals than just price if you experience them. We hope people don't experience catastrophic outages, but when you do, you start thinking about other aspects of this debate which I think are helpful in a full picture. I was going to continue on the line, Mr. Lieberman, on this smart metering thing but I think the chairman really kind of cleared that out as far as we are relatively new and we will see how the response—I think it is going to be very positive. In Illinois, we are in difficult straits because we moved to deregulation. We required the utilities to cut retail consumer costs 20 percent and then we froze those rates for 10 years. Eventually that ends. And we have had astronomical price increases and we have had, especially homes that were incentivized to go all electric, it is sad and there is a lot of pressure on the State legislators to freeze that even further, and if you don't have a capital investment to expand or do even this new technology, you are always going to be behind the eight ball so it is always capital formation. That is why I asked the question earlier of what is the best way. I believe the capital markets through a competitive system but you have got to have the price signals to allow that to occur. So I don't really have much more. I was going to highlight the net metering and issues, Mr. Chairman, but I just wanted to make those points that there is, especially in my part of the State where we have had catastrophic power losses over multiple days, there is a new variable in distributor power or net metering or battery power or solar or other generation that somehow, I don't know how you throw in a price signal but we should at least recognize that and put that in maybe in report language or just as an important aspect of energy security so that if there is—even in the terroristic aspect. We talked about it during September 11, if someone takes down transmission lines, distributor power is going to be pretty important.

So I am waxing philosophically, Mr. Chairman, and I will just yield back my time. Thanks to the panel for being here.

Mr. BOUCHER. You are welcome to wax on for at least another 30 seconds. Well, thank you very much, Mr. Shimkus.

Mr. Lieberman, let me come back to you and I am so glad we have you here today because Illinois does in fact have the kind of program now in place since January that we had hoped to see other States put in place and I understand about seven States have done something comparable to what Illinois has done. Is that correct?

Mr. LIEBERMAN. I can't really respond to that. I know that there are a number of States that are experimenting with time use and real-time rates but there are some pilots going on.

Mr. BOUCHER. OK. How expensive are these smart meters? You mentioned cost, and we don't have that number.

Mr. LIEBERMAN. It really depends who you talk to and it depends what functionalities you want in the meter and it depends how you frame them. The ones that we have been looking at in Illinois are in the $100 to $150 range, and I think it is important to note that meters with far less functionality 5 years ago cost $750 and that in a way these devices are falling in price rapidly and—but $150, if you don't know what you are getting it for seems like a lot of money.

Mr. BOUCHER. True, and so what is the deployment methodology for these meters? Do the utilities take the responsibility for making them available to their customers on an optional basis so that a customer who wants to take advantage of real-time price can acquire from the utility for this $150, the meter, and then I guess that cost is built into rates until it is paid off or something like that?

Mr. LIEBERMAN. Two things. The utility is responsible for the meter and the utilities remain the monopoly distribution company so that there are no sort of free market meters. The meters are all owned by the utility. They put it in. We had to demonstrate in Illinois that there was value for everyone in the customers—that the whole rate base, all the customers benefited from a reduction in peak and that therefore we could spread some of the costs across the whole rate base so in a recent case before the Illinois Commission the proponents demonstrated that everybody was better off if we cut the peak and therefore their cost would not go up if they in a sense spread the cost of the meter around. So basically the way it is structured in Illinois today is that the person taking the real-time price pays for half the cost of the meter and the other half is spread over the rate base. And I think that the issue, the methodology to show that is critically important and one of the things in terms of benefits that I was trying to talk about earlier is I think that that is a tool that needs, that DOE could help develop and give to States because the States don't have the capacity to do that, in part.

Mr. BOUCHER. I am sorry. What is the "that" in that sentence?

Mr. LIEBERMAN. It is measuring the tool, the methodology actually, the model to sort of demonstrate that there is a value to this.

Mr. BOUCHER. Mr. Kolevar, are you listening?

Mr. KOLEVAR. Yes, sir.

Mr. BOUCHER. OK.

Mr. LIEBERMAN. Mr. Kolevar's office and his staff——

Mr. BOUCHER. I didn't mean that in a scolding way.

Mr. LIEBERMAN. No, they have been very helpful. They have been remarkably helpful in sort of building whatever capacity is out there but I think that significant more capacity is needed. I know in our case they have been very helpful in giving us access to people at Lawrence Berkeley who know about this stuff in ways that you can't really find. So I think that the next step for me, if I were king would be to say we need these methodologies so that it is easier for the State commissions to understand and to develop what the values are. Because that is one of the big things that holds this is up is, nobody knows how to estimate what the value is.

Mr. BOUCHER. I have one other question and that relates to some national standard for smart meter technology and for other equipment that would help facilitate the smart grid, and I would like to have the comments of each of the three witnesses concerning the value of that, the extent to which the Federal Government already is involved in encouraging this or other ways facilitating it, and what in the future you might be considering doing with regard to a Federal role to help establish a national standard for this. So who would like to begin and comment on that process? Mr. Wellinghoff.

Mr. WELLINGHOFF. Yes. Thank you, Mr. Chairman. In my testimony that was submitted to the committee, I did recommend with respect to this working group that Mr. Kolevar referenced, it is an informal group that FERC and NARUC have put together to collaborate on demand response issues and I would indicate that I think it would be helpful for Congress to further encourage and focus that work by establishing a Federal-State working group through which the commission and State representatives would be tasked with identifying best practices in developing consistent standards for demand response. I think that would be helpful in encouraging that industry overall because certainly if we have these demand response aggregators operating one region of the country, one RTO, they want to know if they can go to other regions of the country, in essentially operate utilizing the same communication protocols and the same standards to be able to aggregate customers to participate in demand response in the wholesale market. So I think that could be very helpful, very useful, and we would appreciate that assistance.

Mr. BOUCHER. OK. Mr. Kolevar.

Mr. KOLEVAR. Mr. Chairman, I think the Department could play a very useful role in working with the innovators who are developing these technologies, who have developed a lot of these technologies today. I hesitate to say that development of standards, performance standards, metric standards would be the best way to go. My initial concern with that would be that we might be unintentionally inhibiting innovative development and future generations of smart grid technologies. Of course, the Department assists with this kind of development right now. We do do a great deal of testing with respect to some technologies to determine what their level of performance is versus standard equipment and infrastructure today. I think that there will be an ongoing role for the Department in that respect.

Mr. BOUCHER. Well, that is the classic tension of course between the need to have uniformity on the one hand and to encourage continued innovation on the other. The previous panel testified I thought rather generally that having some national standards would be helpful and appropriate in terms of facilitating the introduction of smart grid applications.

Mr. KOLEVAR. Mr. Chairman?

Mr. BOUCHER. Yes, Mr. Kolevar.

Mr. KOLEVAR. Mr. Chairman, if I could mention one point.

Mr. BOUCHER. Certainly.

Mr. KOLEVAR. I think we would be interested in seeing work go on at the State level and in cooperation with the Federal Government to try and establish methodologies for incentivizing greater and greater and greater performance. That might be one of the better tools. And then certainly if ether are questions about whether or not technologies are capable of meeting some specific levels of performance, I think the Department of Energy would play a role in helping that kind of test.

Mr. BOUCHER. All right. Thank you very much.

Mr. Markey is recognized for 5 minutes.

Mr. MARKEY. Thank you, Mr. Chairman.

Mr. Wellinghoff, on the question of smart grid technology to facilitate the use of plug-in hybrid vehicles technologies to store electric energy, you say that these vehicles would help smooth the integration into the electric grid of renewable generation resources such as wind generation. Can you explain to us how that would occur?

Mr. WELLINGHOFF. Yes. Ultimately when wind generation would be providing into the grid at an amount that might be excess, in some instances they might have to dump that wind generation or it may not be able to fully integrate into the grid because of the low loads on the grid. These smart plug-in hybrid electric vehicles could be used as storage devices in essence to help integrate it better into the grid. There has been a number of papers written by Dr. Willet Kempton of Delaware and I would commend you to Dr. Kempton's papers. In fact, I will be happy to provide them to the committee. In fact, he explains exactly how this integration could better work and better integrate in renewables using the plug-in hybrid smart vehicle.

Mr. MARKEY. Would this type of innovation allow us to reduce the number of very large, new central power stations that we have to build and allow us to avoid the cost and the pollution that would be associated with such plans?

Mr. WELLINGHOFF. In my opinion, yes, it would. And I mentioned earlier, to the extent we can make the grid more efficient, if we could make an 850-gigawatt grid just 5 percent more efficient, we could in fact save the output of 42 large central plants.

Mr. MARKEY. Wow. Are there any estimates that you have seen about the potential scale of the demand response and power storage opportunities that widespread deployment or plug-in hybrids could lead to?

Mr. WELLINGHOFF. Well, we know that plug-in hybrids, if you took all the automobiles on the road today and you converted them into kilowatts instead of horsepower, I think it is like eight to 10 times the total energy capacity we currently have on our grid. So you can see the opportunity there is vast if you converted them into storage vehicles in essence for the grid.

Mr. MARKEY. So you wouldn't have to build a single new power plant? Is that what you are saying?

Mr. WELLINGHOFF. I am not saying that but I am certainly saying that between distributed generation and large amounts of storage through plug-in hybrid electric vehicles, you would——

Mr. MARKEY. Could you cut it in half, the number of plants?

Mr. WELLINGHOFF. I don't have an exact number, Congressman Markey, but I can tell you it would be substantial.

Mr. MARKEY. You are making me feel good. That is good enough. You also suggested plug-in hybrids could provide a variety of ancillary services and thereby improve power efficiency. Can you be more specific? What are the ancillary services that these plug-in vehicles could provide?

Mr. WELLINGHOFF. I can. The two primary ancillary services are spinning reserve and regulation which are the services that are required now by generators to provide the grid to maintain a very narrow frequency level so the grid can remain stable. Generators now have to ramp up and down to provide spinning reserve and regulation services. These services, and I think it was indicated by Mr. Gammons earlier, PNNL has demonstrated that appliances in essence can in part provide these services through microprocessors that PNNL has demonstrated on the Olympic Peninsula. But going beyond that, a plug-in hybrid electric vehicle could in fact do these services, provide them to the grid and that way obviate the need of generators have to ramp up and down, ultimately making those generators run more efficiently so ultimately make the grid more efficient by putting in these plug-in hybrids to substitute for them, for these——

Mr. MARKEY. How would the owner of one of these hybrid vehicles be compensated for services that their vehicle would be providing back to the grid?

Mr. WELLINGHOFF. I think somebody this morning talked about millions of sensors and massive amounts of data. We have millions of sensors and massive amounts of data right here. It would be similar to how a cell phone operator keeps track of your length of calls and how much the call costs.

Mr. MARKEY. And by the way, do you think we need more privacy laws if we are going to allow that kind of information about the personal habits of Americans be gathered?

Mr. WELLINGHOFF. Certainly the data would have to be encrypted and there would have to be privacy issues that are addressed. There is no question about that, but ultimately——

Mr. MARKEY. Do you think the Federal Trade Commission should implement the rulemaking that does provide the protections that they are already required to do?

Mr. WELLINGHOFF. I couldn't speak to the Federal Trade Commission, Congressman.

Mr. MARKEY. Do we need more protections?

Mr. WELLINGHOFF. We may, yes.

Mr. MARKEY. You are not sure we do? OK. What regulatory obstacles do you see to widespread commercial deployment of such vehicles?

Mr. WELLINGHOFF. The regulatory obstacles are ensuring that we have the tariffs in place so these vehicles can in fact get the payments that would be necessary to provide these services and we starting to do that already in the organized markets in the RTOs and ISOs through allowing demand response in fact to participate in spinning reserve regulation, other types of services. So the regulatory tariffs have to be place so that the consumers in fact can get the payments and the settlement processes have to be set up in the wholesale market so in fact they can have those payments provided back to them.

Mr. MARKEY. I thank you. I see my time is expired. I am going to point out that the Federal Trade Commission, when I contacted them recently, indicated that they are not going to issue any implementing regulations whatsoever to protect the privacy of consumers' electricity bills or to combat slamming and cramming. They have that authority, and what I am going to do is, I am going to organize an effort to put the pressure on the Federal Trade Commission to build these privacy protections into the law because concomitant with the development of a capacity to gather all of this information which gives a detailed profile of who Americans are and their use of electricity, when they are home or not, very interesting for a crook to know what your electricity habits are. They would be able to figure out when you are home or not, and I just think that the Federal Trade Commission has a responsibility to act in that fashion.

I thank the chairman.

Mr. BOUCHER. Thank you, Mr. Markey.

We want to thank this panel of witnesses. We very much appreciate your sharing information with us today and thank you for your patience. It has taken a while to get to you this afternoon, and you have been very helpful in your answers to questions. There are potentially other questions members may want to submit to you in writing, and if so, we would appreciate your prompt response.

So with the thanks of the committee to this panel, this hearing is adjourned.

[Whereupon, at 1:10 p.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

ONE HUNDRED TENTH CONGRESS

U.S. House of Representatives

Committee on Energy and Commerce

Washington, DC 20515–6115

JOHN D. DINGELL, MICHIGAN
CHAIRMAN

August 31, 2007

Michael Howard, Ph.D.
Senior Vice President, Research
and Development
Electric Power Research Institute
3420 Hillview Avenue
Palo Alto, CA 94304

Dear Dr. Howard:

Thank you for appearing before the Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." We appreciate the time and effort you gave as a witness before the subcommittee.

Under the Rules of the Committee on Energy and Commerce, the hearing record remains open to permit Members to submit additional questions to the witnesses. Attached are questions directed to you from a Member of the Committee. In preparing your answers to these questions, please address your response to the Member who has submitted the questions and include the text of the Member's question along with your response.

To facilitate the printing of the hearing record, your responses to these questions should be received no later than the close of business on **Monday, September 17, 2007**. Your written responses should be delivered to **2125 Rayburn House Office Building** and faxed to **(202) 225-2899** to the attention of Rachel Bleshman. An electronic version of your response should also be sent by e-mail to Ms. Bleshman, at **rachel.bleshman@mail.house.gov**. Please send your response in a single Word formatted document.

Michael Howard, Ph.D.
Page 2

Thank you for your prompt attention to this request. If you need additional information or have other questions, please contact Rachel Bleshman at (202) 225-2927.

Sincerely,

JOHN D. DINGELL
CHAIRMAN

Attachment

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

MICHAEL W. HOWARD, PH.D., P.E.
Senior Vice President
Research and Development

September 11, 2007

The Honorable Michael C. Burgess
U.S. House of Representatives
2125 Rayburn House Office Building
Washington, DC 20515-6115

Dear Congressman Burgess:

Thank you for your follow-up questions from the May 3, 2007 hearing entitled "Facilitating the Transition to a Smart Electric Grid." I am pleased to provide my responses below:

Question 1:

On Tuesday, we held a hearing in this subcommittee on appliance efficiency standards. The Smart Grid technologies we are discussing today require advanced appliances that can communicate with the grid. One of our witnesses mentioned the need for increased efficiency standards for appliances, but won't these advanced appliances require additional electricity to power their communications features? We wouldn't want to set efficiency standards that inadvertently prevent the introduction of new technologies that may help the grid save energy. How would you recommend we set efficiency standards to allow flexibility so that these smart appliances of the future will comply with the energy efficiency standard?

EPRI Response to Question 1:

The smart grid technologies will require appliances to communicate with the grid. However, the power consumption for the communication interface for the appliances will be orders of magnitude less compared to the power consumption of the appliance itself. For example the incremental power consumption to make a thermostat receive a price signal from a smart grid is in a few watts range compared to the thousands of watts power consumption of an air conditioner that is controlled by the smart thermostat. To ensure a "smart appliance" is also an efficient appliance, the test protocol to measure energy consumption of an appliance to qualify for an 'Energy Star' rating should be the total power consumption which include measuring stand-by and active power consumption of an appliance.

1300 West W.T. Harris Boulevard, Charlotte, NC 28262-8550 USA • 704.595.2031 • Fax 704.595.2860 • mhoward@epri.com

The Honorable Michael Burgess
September 11, 2007
Page 2

Question 2:

In states that deregulated their electric markets, many resident customers, including myself, did not switch suppliers. What can be done to foster public support for smart grid and encourage people to use it? One demand reduction strategy discussed is allowing the electric grid to determine when individual air conditioners will turn on and off. How do we convince customers that this is not "big brother" or a loss of personal freedom?

EPRI Response to Question 2:

Using the smart grid does not depend on customers switching suppliers. The utility or service provider can provide access to energy usage and cost information to the customer devices which can be programmed to make smart energy choices. The information can be relayed to the customer in many ways, including via the Internet, an energy management system, or an advanced meter. Information to the customer/customer devices could include price or grid stability, congestion, or other information. Control by the utility or a service provider could be done through an agreement with the customer.

If EPRI can provide any further information, please feel free to contact Barbara Tyran, Director, Washington Relations, at 202-293-7513 or at btyran@epri.com.

Sincerely,

Michael W. Howard, Ph.D., P.E.
Sr. Vice President, R&D

cc: The Honorable John D. Dingell, Chairman
Committee on Energy and Commerce

The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

ONE HUNDRED TENTH CONGRESS

U.S. House of Representatives
Committee on Energy and Commerce
Washington, DC 20515–6115

JOHN D. DINGELL, MICHIGAN
CHAIRMAN

August 31, 2007

The Honorable Kevin Kolevar
Director
Office of Energy Delivery &
Electricity Reliability
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Mr. Kolevar:

Thank you for appearing before the Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." We appreciate the time and effort you gave as a witness before the subcommittee.

Under the Rules of the Committee on Energy and Commerce, the hearing record remains open to permit Members to submit additional questions to the witnesses. Attached are questions directed to you from a Member of the Committee. In preparing your answers to these questions, please address your response to the Member who has submitted the questions and include the text of the Member's question along with your response.

To facilitate the printing of the hearing record, your responses to these questions should be received no later than the close of business on **Monday, September 17, 2007.** Your written responses should be delivered to **2125 Rayburn House Office Building** and faxed to **(202) 225-2899** to the attention of Rachel Bleshman. An electronic version of your response should also be sent by e-mail to Ms. Bleshman, at **rachel.bleshman@mail.house.gov**. Please send your response in a single Word formatted document.

The Honorable Kevin Kolevar
Page 2

Thank you for your prompt attention to this request. If you need additional information or have other questions, please contact Rachel Bleshman at (202) 225-2927.

Sincerely,

JOHN D. DINGELL
CHAIRMAN

Attachment

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

Department of Energy
Washington, DC 20585

September 20, 2007

The Honorable John D. Dingell
Chairman
Committee on Energy and Commerce
U. S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

On May 3, 2007, Kevin Kolevar, Director, Office of Electricity Delivery and Energy Reliability, testified before the Subcommittee on Energy and Air Quality hearing entitled "Facilitating the Transition to a Smart Electric Grid."

Enclosed are the answers to two questions that were submitted by Representative Michael C. Burgess for the hearing record.

If we can be of further assistance, please have your staff contact our Congressional Hearing Coordinator, Lillian Owen, at (202) 586-2031.

Sincerely,

Lisa E. Epifani
Assistant Secretary
Congressional and Intergovernmental Affairs

Enclosures

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

QUESTIONS FROM REPRESENTATIVE MICHAEL E. BURGESS

Q1. On Tuesday, we held a hearing in this subcommittee on appliance efficiency standards. The Smart Grid technologies we are discussing today require advance appliances that can communicate with the grid. One of our witnesses mentioned the need for increased efficiency standards for appliances, but won't these advanced appliances require additional electricity to power their communication features? We wouldn't want to set efficiency standards that inadvertently prevent the introduction of new technologies that may help the grid save energy. How would you recommend we set efficiency standards to allow flexibility so that these smart appliances of the future will comply with the energy efficiency standard?"

A1. We believe that smart grid technology can be complementary to energy efficiency standards for appliances. Although the addition of smart grid devices to appliances could cause marginal increases in electricity use, the marginal consumption for these communications is estimated to be approximately one tenth of a watt, which is only 12 watt hours a day, or 8 kWh/yr. This adds up to less than one tenth of one percent of total household consumption (0.08% of a typical household that consumes 10,000 kWh/yr).

In general, a smart grid includes real-time visualization technologies on the transmission level and smart meter and communications technologies on the distribution level, which enable the advancement of demand response, distributed energy systems (generation, storage, thermal), consumer energy management systems, distributed automation systems, and smart appliances. Thus, any small increase in energy used by an energy efficient appliance due to a smart grid device would be negligible when compared to the overall energy savings to the electric system.

Certain smart grid devices do not use two-way communications and can be used by grid operators to turn off an appliance when the grid is experiencing stress. Other smart grid devices without communication circuitry do not consume any additional electricity than would otherwise be required to operate the appliance. In other cases where the smart appliance must communicate with the grid, it is expected that the "smart meter," which would actually communicate with the grid, would only consume a very small amount of power.

Currently there are smart grid appliances, such as electric water heaters and central air conditioners that receive control signals from the local electric utility via a radio receiver. Although the electricity consumed by this particular type of smart grid technology may be greater, an overall savings in energy is achieved when the appliance that is being controlled by the smart grid device is switched off.

However, your question does raise a good point, as appliance standards should take into account the energy consumption of any smart grid feature that is added to the appliance. Future appliance standards and updates to test procedures can be written to include the energy consumption of embedded devices required for smart grid communication. However, specific standards cannot be set until information on the specific smart grid devices and the nature of the communications between the device and the grid are determined. Sensing and dynamic response circuits would require more energy than a simple one-way communication toggle device. Appliance standards would also need to allow for appliance-specific requirements when setting minimum-allowed efficiency levels that are consistent with our statutory authorities.

Q2. In states that deregulated their electric markets, many resident customers, including myself, did not switch suppliers. What can be done to foster public support for the smart grid and encourage people to use it? One demand reduction strategy discussed is allowing the electric grid to determine when individual air conditioners will turn on and off. How do we convince customers that this is not "big brother" or a loss of personal freedom?

A2. There are a number of ways to cultivate public support for the development of a smart grid. The primary incentive for a customer to become engaged in a smart grid is pricing. By making time-varying (higher prices during times of high demand) electricity pricing plans available to customers, they could be motivated by economics to control their energy use with smart grid-equipped appliances and other devices. Customers are currently accustomed to altering their habits in response to time-varied pricing in telephone rates and airfares pricing, for example.

Incentives, typically monetary, can also be offered to customers who take a certain action to reduce their electricity use or change demand. Some utilities currently pay $5-10 per month to customers who allow the utility to cycle their central air conditioner if there are times when the electric grid is stressed.

Customers can also be given the choice to opt-out of a smart grid entirely or to override smart grid controls, when necessary, by using a "manual control" button on a smart grid appliance.

Grid modernization is a major undertaking for our Nation and it will only be realized through the dedicated involvement and cooperation of Federal and state governments and other partners. Section 1252 of the Energy Policy Act of 2005, for example, which requires states to consider whether to require their jurisdictional electric utilities to offer time-varying pricing plans, is a step in the right direction. Ultimately, if a smart grid system is implemented using these methods, the customer will actually be more empowered to control their energy use.

ONE HUNDRED TENTH CONGRESS

U.S. House of Representatives

Committee on Energy and Commerce

Washington, DC 20515–6115

JOHN D. DINGELL, MICHIGAN
CHAIRMAN

August 31, 2007

Mr. Dan Delurey
Executive Director
Demand Response and
Advanced Metering Coalition
1615 M Street, N.W.
Washington, D.C. 20036

Dear Mr. Delurey:

Thank you for appearing before the Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." We appreciate the time and effort you gave as a witness before the subcommittee.

Under the Rules of the Committee on Energy and Commerce, the hearing record remains open to permit Members to submit additional questions to the witnesses. Attached are questions directed to you from a Member of the Committee. In preparing your answers to these questions, please address your response to the Member who has submitted the questions and include the text of the Member's question along with your response.

To facilitate the printing of the hearing record, your responses to these questions should be received no later than the close of business on **Monday, September 17, 2007.** Your written responses should be delivered to **2125 Rayburn House Office Building** and faxed to **(202) 225-2899** to the attention of Rachel Bleshman. An electronic version of your response should also be sent by e-mail to Ms. Bleshman, at **rachel.bleshman@mail.house.gov**. Please send your response in a single Word formatted document.

Thank you for your prompt attention to this request. If you need additional information or have other questions, please contact Rachel Bleshman at (202) 225-2927.

Sincerely,

JOHN D. DINGELL
CHAIRMAN

Attachment

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

Supplemental Testimony

Of

Demand Response and Advanced Metering Coalition (DRAM)

Before the

House Energy and Air Quality Subcommittee

September 14, 2007

In response to the following questions put forth by the Honorable Michael C. Burgess, DRAM provides the following comments:

Question 1

> On Tuesday, we held a hearing in this subcommittee on appliance efficiency standards. The Smart Grid technologies we are discussing today require advanced appliances that can communicate with the grid. One of our witnesses mentioned the need for increased efficiency standards for appliances, but won't these advanced appliances require additional electricity to power their communications features? We wouldn't want to set efficiency standards that inadvertently prevent the introduction of new technologies that may help the grid save energy. How would you recommend we set efficiency standards to allow flexibility so that these smart appliances of the future will comply with the energy efficiency standard?

DRAM Comments:

It is the case that deployment of electricity consuming appliances and other equipment in American homes and businesses is on the rise. The average home has more electricity consuming items than in the past due to the introduction of computers and other personal electronics. Also, some new electronic items consumer more electricity than the items that they have replaced (e.g. a plasma television on average uses more electricity than a conventional set).

Key to reducing electricity use and its associated environmental impacts is to make electricity consuming appliances and equipment more energy efficient, i.e. to have them use the lowest amount of energy possible to produce the same benefit to the user. From a policy standpoint, this has been the impetus for appliance efficiency standards, which require that all appliances sold meet a certain level of energy efficiency.

In DRAM's testimony, we attempted to speak to another type or level of efficiency – the dynamic efficiency of the way the electricity system operates. Communication, control and information technology available today allows the electricity system to be transformed into a smart system whereby it is not simply one based on continued injection of new generating capacity to meet ever rising demand. It is possible now to use smart technology to create a smart grid which can seamlessly and dynamically (and painlessly from the standpoint of consumers and business) modify electricity demand by shifting use to different periods of the day – or even by shifting usage within a shorter period of time.

This concept of "optimizing" the electricity system is what is behind the new business and policy area of Demand Response. Demand Response refers to using technology as well as time-dependent price signals to optimize the overall operation of the grid and the electricity system, with the result being less electricity being needed, less emissions generated and less need for new generating facilities.

As part of this vision of a smart grid, electrical appliances would ideally be such that they were tied into the electricity grid via communications and controls that would allow the appliances to (with the customer's permission) automatically respond to price signals and grid fluctuations by reducing, shifting or otherwise modifying demand.

In DRAM's testimony, we recommended that in addition to the standard type of appliance efficiency standards, i.e. lower electricity used for the same benefit, that appliance standards in the future should include a requirement that the appliances be equipped with the necessary technology to be capable of being part of the smart grid. The result would be standards that addressed efficiency within the appliance as well as the overall efficiency of the entire electricity system.

Question 2

> In states that deregulated their electric markets, many resident customers, including myself, did not switch suppliers. What can be done to foster public support for the smart grid and encourage people to use it?

One demand reduction strategy discussed is allowing the electric grid to determine when individual air conditioners will turn on and off. How do we convince customers that this is not "big brother" or a loss of personal freedom?

DRAM Comments:

Several issues are raised in this question.

First, it is DRAM's position that deployment of demand response, smart meters and the smart grid is not a question of whether a state has deregulated or not. These technologies, programs and pricing can be offered successfully in open, competitive markets as well as under traditional regulation.

In the case of a competitive market, it is still the regulated wires companies that will be the vehicle for the development and deployment of smart meters and other smart grid technologies. The deployment of such in these markets can provide a foundation for these markets to grow. For example, in the case of smart meters, they provide increased accuracy, new and useful information, and speedier settlement of transactions – all necessary ingredients for a successful market.

In the case of a traditional regulated system, not only will the utilities be the vehicle for deployment of the technologies that form the foundation of the smart grid, they can also be the entities that can offer time-based electricity rates and pricing to their customers. Such rates and pricing are not solely dependent on competitive retail markets. Even in the case of a traditional vertically integrated utility, the costs of generating and providing electricity vary by time of day, and that can be reflected in prices and programs which offer customers a new choice within a regulated market.

Second is the question of what can be done to foster public support. This is a major issue for the nascent smart technology and demand response industry and community. While the concepts of smart meters, smart grid, dynamic pricing, etc are conceptually comfortable to most, they still represent new ideas in the energy arena that must compete with higher profile areas like energy efficiency, renewable energy and many others which have firmly established advocacy infrastructures and which benefit from substantial government support. While growing steadily, the number of parties engaged in advocacy and awareness building on demand response and smart technologies is still very small, and government funding to support education and awareness of these new options is for the most part non-existent. What would help is government support for a National Action Plan for Demand Response and the Smart Grid which would develop and implement a coordinated campaign to build awareness and support for the those areas.

Third is the question of "big brother" type control over consumers via smart technologies. This will not be the case as these technologies are introduced. A key stipulation set forth by policy makers to date, particularly at the state level, is that demand response, smart meters, etc provide consumers with more information, more control and more choices and options. This has been accepted by the demand response and smart grid industry as one of the design requirements. That said, one of the choices for customers will be to either a) grant their utility or another third party the ability to moderate the customers electricity appliances and equipment, or b) install appliances and equipment that automatically modify their operation in response to prices and other signals – without the active intervention of the customer or any other party.

In the case of (a), even if a consumer grants another party control, the consumer will have the option to override that control at any time that the customers chooses. In the case of both (a) and (b) a major issue as technologies and the overall grid get "smarter" is the use of customer information that is generated. Privacy protections should be part of policy developed in this area.

ONE HUNDRED TENTH CONGRESS

U.S. House of Representatives

Committee on Energy and Commerce

Washington, DC 20515–6115

JOHN D. DINGELL, MICHIGAN
CHAIRMAN

August 31, 2007

Mr. Brad Gammons
Vice President
IBM Global Energy and Utilities Industry
3505 Danbury Drive
Amarillo, TX 79109

Dear Mr. Gammons:

Thank you for appearing before the Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." We appreciate the time and effort you gave as a witness before the subcommittee.

Under the Rules of the Committee on Energy and Commerce, the hearing record remains open to permit Members to submit additional questions to the witnesses. Attached are questions directed to you from a Member of the Committee. In preparing your answers to these questions, please address your response to the Member who has submitted the questions and include the text of the Member's question along with your response.

To facilitate the printing of the hearing record, your responses to these questions should be received no later than the close of business on **Monday, September 17, 2007.** Your written responses should be delivered to **2125 Rayburn House Office Building** and faxed to **(202) 225-2899** to the attention of Rachel Bleshman. An electronic version of your response should also be sent by e-mail to Ms. Bleshman, at **rachel.bleshman@mail.house.gov**. Please send your response in a single Word formatted document.

Mr. Brad Gammons
Page 2

Thank you for your prompt attention to this request. If you need additional information or have other questions, please contact Rachel Bleshman at (202) 225-2927.

Sincerely,

JOHN D. DINGELL
CHAIRMAN

Attachment

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

Subcommittee on Energy and Air Quality

Hearing on Tuesday, May 3, 2007

Additional Questions

Mr. Brad Gammons

Vice President

IBM Global Energy and Utilities Industry

The Honorable Michael Burgess (TX-26)

One of our witnesses mentioned the need for increased efficiency standards for appliances, but won't these advanced appliances require additional electricity to power their communications features?

Many current appliances already have the ability to communicate if a mechanism is available. Also, there have been numerous pilots run of this type of technology and communication. From an energy consumption point of view, technology is very light weight and would not have material effect against other efficiency gains.

We wouldn't want to set efficiency standards that inadvertently prevent the introduction of new technologies that may help the grid save energy. How would you recommend we set efficiency standards to allow flexibility so that these smart appliances of the future will comply with the energy efficiency standard?

Smart appliance should be able to aid in achieving efficiency objectives, auditing achievement and attributing benefits. While setting efficiency standards, it would be beneficial if complimentary technology standards are recommended and supported. This would make the achievement and efficiency objectives more possible, verifiable and attributable.

In states that deregulated their electric markets, many resident customers, including myself, did not switch suppliers. What can be done to foster public support for the smart grid and encourage people to use it?

Smart grid is composed of both Automated Meter Infrastructure (AMI) and Distribution/Transmission Automation. AMI has the highest touch to residential customers and is supported by the most recent PUC ruling in Texas. AMI provides bidirectional communication with the meter allowing for a more real-time view of energy consumption, remote disconnect/connect, communication with demand control devices (examples -- smart thermostat, pool pump) and the ability to measure voltage and power quality. All this new information will and can be made available to both the consumers, energy retailers and energy delivery utilities such as CenterPoint (Houston, TX). This new information allows consumers to better understand their energy costs, environmental impact and usage patterns. A better informed consumer can make better choices and decisions on who provides them energy and how they will use it. In the end, this creates acceptance of smart grid technology and retail market adoption. The same information can be used by retailers to design custom contracts and programs for consumers to meet their economic and social agenda making a retail market more successful and liquid. The distribution utilities use the same information to better manage the assets that deliver the energy. This allows for more rapid switching between retail energy providers and better visibility and restoration during outage situations.

One demand reduction strategy discussed is allowing the electric grid to determine when individual air conditioners will turn on and off. How do we convince customers that this is not "big brother" or a loss of personal freedom?

As it relates to energy consumption, choice must be left to the customer on the level of control they turn over. With better information on customer consumption patterns, programs can be designed with appropriate awards and penalties to incent the behavior needed to affect the demand response objectives desired, but with the customer always having the ability to override if desired. Demand Side program tests have proved that enough consumers will opt into these programs to make them successful and beneficial if rolled out on a large scale.

ONE HUNDRED TENTH CONGRESS

U.S. House of Representatives

Committee on Energy and Commerce

Washington, DC 20515–6115

JOHN D. DINGELL, MICHIGAN
CHAIRMAN

August 31, 2007

Mr. Kurt Yeager
Galvin Electricity Initiative
3412 Hillview Avenue
Palo Alto, CA 94304

Dear Mr. Yeager:

Thank you for appearing before the Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." We appreciate the time and effort you gave as a witness before the subcommittee.

Under the Rules of the Committee on Energy and Commerce, the hearing record remains open to permit Members to submit additional questions to the witnesses. Attached are questions directed to you from a Member of the Committee. In preparing your answers to these questions, please address your response to the Member who has submitted the questions and include the text of the Member's question along with your response.

To facilitate the printing of the hearing record, your responses to these questions should be received no later than the close of business on **Monday, September 17, 2007**. Your written responses should be delivered to **2125 Rayburn House Office Building** and faxed to **(202) 225-2899** to the attention of Rachel Bleshman. An electronic version of your response should also be sent by e-mail to Ms. Bleshman, at **rachel.bleshman@mail.house.gov**. Please send your response in a single Word formatted document.

Mr. Kurt Yeager
Page 2

Thank you for your prompt attention to this request. If you need additional information or have other questions, please contact Rachel Bleshman at (202) 225-2927.

Sincerely,

JOHN D. DINGELL
CHAIRMAN

Attachment

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

GALVIN ELECTRICITY INITIATIVE

Sponsored by The Galvin Project, Inc.

Galvin Electricity Initiative
3412 Hillview Avenue
Palo Alto, CA 94304 USA
tel 650.855.2400
fax 650.855.1040
www.galvinelectricity.org

DATE: September 14, 2007

TO: The Honorable Michael C. Burgess

VIA: Attention of Rachel Bleshman rachel.bleshman@mail.house.gov

FROM: Kurt Yeager

SUBJECT: Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007

Dear Congressman Burgess:

Thank you for the opportunity to respond to your questions following up on my testimony before the Sub Committee on Energy and Air Quality on May 3, 2007, at the hearing entitled, "Facilitating the Transition to a Smart Electric Grid".

Question One:

On Tuesday, we held a hearing in this sub-committee on appliance efficiency standards. The Smart Grid technologies we are discussing today require advanced appliances that can communicate with the grid. On of our witnesses mentioned the need for increased efficiency standards for appliances, but won't these advanced appliances require additional electricity to power their communication features? We wouldn't want to set efficiency standards that inadvertently prevent the introduction of new technology that may help the grid save energy. How would you recommend we set efficiency standards to allow flexibility so that these smart appliances of the future will comply with the energy efficiency standard?

Response:

In fact, the amount of electricity that advanced appliances will need to power their communications features is a very minor part of their energy consumption. DOE's appliance efficiency standards have been fundamental to the approximately 1% per year in electric utilization efficiency improvement which is currently being realized in the country. These standards should be enhanced and expanded. However, the next step function increase in utilization efficiency will need "Dynamic Systems". Dynamic systems enable the real-time exchange of data between the power system, consumer's buildings and then appliances and devices within buildings. Unfortunately the electric power systems in the U.S. employs 152 different communications standards and the buildings industry employs another 28 different standards. And none of the 152 line up with the 28. As a result, we have the potential for having segments of the dynamic system infrastructure as not being "interoperable" – that is various devices on the power system and the consumer's buildings and the consumer's appliances may not be able to" talk" or communicate with one another.

We believe that solving this conflict through mandates runs the risk of setting a standard which then blocks further improvement and expansion. The solution for this issue is to allow the electric utility industry to continue the efforts it has begun to develop its own consensus standards. Two efforts have been underway in that regard for more than 12 years. First, through the development of the "Utility Communications Architecture" or UCA, which has now been largely adopted by the International Electrotechnical Council (IEC) and has resulted in several standards for compatibility in utility applications including substations. The second is the development of an "Integrated Utility – Communications Architecture" called the IntelliGrid. The IntelliGrid is a publicly available architecture which provides the methods, tools, best practices and recommendations for specifying "intelligent" systems in such a way as to promote interoperability, flexibility, and effective security and data & system management. It is an open, standards-based architecture for integrating the data communications networks and intelligent equipment needed to support the Power Delivery System of the Future. Utilities already putting **IntelliGrid Architecture** to work include:

- **Southern California Edison** – *applying the IntelliGrid Architecture to their $1 billion advanced metering infrastructure project*
- ***TXU*** *– applying the IntelliGrid Architecture to their $400 million automated meter reading project*
- **Salt River Project** – *applying the IntelliGrid Architecture for substation data integration*
- **Long Island Power Authority, Electricite de France** and **Alliant Energy** are also applying the IntelliGrid Architecture on projects

This is a strong industry – led effort that has a strong chance of succeeding and address the issues with regard to deployment of dynamic systems. We do not believe that it is necessary for the Federal Government to become involved in promulgating standards in this area.

Question Two:

In states that deregulated their electric markets, many resident customers, including myself, did not switch suppliers. What can be done to foster public support for the Smart Grid and encourage people to use it? One demand reduction strategy discussed is allowing the electric grid to determine when individual air conditioners will turn on and off. How do we convince customers that this is non "big brother" or a loss of personal freedom?

Response:

There are signs that consumers are becoming more sensitive to issues regarding energy. This is in part driven by media reports on global warming and the higher pump prices and electric bills they see. The price tag for the Smart Grid transformation is significant, but not out of the question. By one estimate, we could completely modernize the grid for the cost of about a pizza pie per month for the average household. For example – the California Public Utilities Commission has approved a Pacific Gas and Electric (PG&E) Company request to spend $2.2 billion to install an advanced metering infrastructure with 5.1 million meters over the periods of 2007 to 2011. Thereafter, the operating savings from that system will be $160 million/year. That system will reduce the peak demand for electricity by 448 MW. Customer bills will increase only $0.49 - $0.99/month for the first five years and decrease annually thereafter. One survey I was involved with touched 700 business and industries – half of whom indicated they would support and encourage the rate increases needed to modernize the power system.

We believe that the solution is not to mandate restrictions on consumers, but to require smart metering infrastructures like PG&E's which give consumers the dynamic electricity price signals which allow them to make prudent use decisions. The Energy Policy Act of 1992 encouraged the states to do this but most have ignored the message. Clearly, a stronger Congressional signal is needed. The opportunity to control costs, significantly improve efficiency and reduce the need for new infrastructure through smart technologies like advanced metering is one which consumers will quickly grasp. This has been proved in states as diverse as Georgia, California and Florida. Finally, breaking the link between utility electricity sales and profits, and basing utility earnings on efficiency and reliability will serve to establish the dynamic partnership between utilities and their customers. This transformation in other regulated industries has spawned incredible waves of innovation, private investment and economic development benefiting all consumers, suppliers and the prosperity of our nation alike.

Thank you.

Kurt

Kurt Yeager
Executive Director
Galvin Electricity Initiative
kyeager@epri.com
650/855-2400 (Tues. & Thurs)
831/786-9832 (home office)

ONE HUNDRED TENTH CONGRESS

U.S. House of Representatives

Committee on Energy and Commerce

Washington, DC 20515–6115

JOHN D. DINGELL, MICHIGAN
CHAIRMAN

August 31, 2007

Mr. Dean Kamen
President
DEKA Research and Development
340 Commercial Street
Manchester, NH 03101-1129

Dear Mr. Kamen:

Thank you for appearing before the Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." We appreciate the time and effort you gave as a witness before the subcommittee.

Under the Rules of the Committee on Energy and Commerce, the hearing record remains open to permit Members to submit additional questions to the witnesses. Attached are questions directed to you from a Member of the Committee. In preparing your answers to these questions, please address your response to the Member who has submitted the questions and include the text of the Member's question along with your response.

To facilitate the printing of the hearing record, your responses to these questions should be received no later than the close of business on **Monday, September 17, 2007.** Your written responses should be delivered to **2125 Rayburn House Office Building** and faxed to **(202) 225-2899** to the attention of Rachel Bleshman. An electronic version of your response should also be sent by e-mail to Ms. Bleshman, at **rachel.bleshman@mail.house.gov**. Please send your response in a single Word formatted document.

Mr. Dean Kamen
Page 2

Thank you for your prompt attention to this request. If you need additional information or have other questions, please contact Rachel Bleshman at (202) 225-2927.

Sincerely,

JOHN D. DINGELL
CHAIRMAN

Attachment

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

Dean Kamen Responses to Questions from the Honorable Michael C. Burgess Regarding Testimony at "Facilitating the Transition to a Smart Electric Grid," May 3, 2007.

1. **On Tuesday, we held a hearing in this subcommittee on appliance efficiency standards. The Smart Grid technologies we are discussing today require advanced appliances that can communicate with the grid. One of our witnesses mentioned the need for increased efficiency standards for appliances, but won't these advanced appliances require additional electricity to power their communications features? We wouldn't want to set efficiency standards that inadvertently prevent the introduction of new technologies that may help the grid save energy. How would you recommend we set efficiency standards to allow flexibility so that these smart appliances of the future will comply with the energy efficiency standard?**

Although advanced or "smart" appliances will require some communications features, the power required for these features should be very low, especially when compared to the power required to run the appliance.

Effective use of an advanced or "smart" appliance requires two things – an appliance that is able to communicate and a "control station" that communicates with the appliance and is connected to an infrastructure that provides information. The communications capability will require only a nominal amount of power, which can be minimized by having the appliance only communicate when it needs to (e.g. asking the control station if it can turn on). Even if "always on" communications are used, this can be done at very low power levels – much lower then the power used by the appliance when it is running. Since the power required for these communications features should be very low, the efficiency standards could probably incorporate the additional power required for these features without any significant impediment to the adoption of these new technologies.

2. **In states that deregulated their electric markets, many resident customers, including myself, did not switch suppliers. What can be done to foster public support for the smart grid and encourage people to use it? One demand reduction strategy discussed is allowing the electric grid to determine when individual air conditioners will turn on and off. How do we convince customers that this is not "big brother" or a loss of personal freedom?**

To garner consumer support for the smart grid, it must provide benefits to the consumer with little to no extra cost. The benefits to consumers can come from a number of areas: saving money on their monthly utility bills by either conserving energy or shifting energy use to off-peak periods, a sense that by conserving energy they are reducing environmental impacts, and knowing they are helping to avoid building new power generation or transmission infrastructure. There are demand response programs already in place throughout the country where consumers have signed on because of these benefits.

One way of avoiding the "big brother" mentality is by ensuring the consumer they can be removed from the program at any time with no cost to them. Another potential way is to allow consumers to override the signals being sent from the utility. Consumers would be less likely to do this in a real-time dynamic pricing environment, because they would be paying premium prices for their electricity. Also, utilities can exempt participants from the program during weekends and holidays (as some currently do) since these are typically not peak demand periods.

ONE HUNDRED TENTH CONGRESS

U.S. House of Representatives

Committee on Energy and Commerce

Washington, DC 20515–6115

JOHN D. DINGELL, MICHIGAN
CHAIRMAN

August 31, 2007

The Honorable Robert F. Lieberman
Commissioner
Illinois Commerce Commission
455 West Washington Boulevard
Oak Park, Illinois 60302

Dear Mr. Lieberman:

Thank you for appearing before the Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." We appreciate the time and effort you gave as a witness before the subcommittee.

Under the Rules of the Committee on Energy and Commerce, the hearing record remains open to permit Members to submit additional questions to the witnesses. Attached are questions directed to you from certain Members of the Committee. In preparing your answers to these questions, please address your response to the Member who has submitted the questions and include the text of the Member's question along with your response.

To facilitate the printing of the hearing record, your responses to these questions should be received no later than the close of business on **Monday, September 17, 2007.** Your written responses should be delivered to **2125 Rayburn House Office Building** and faxed to **(202) 225-2899** to the attention of Rachel Bleshman. An electronic version of your response should also be sent by e-mail to Ms. Bleshman, at **rachel.bleshman@mail.house.gov**. Please send your response in a single Word formatted document.

The Honorable Robert F. Lieberman
Page 2

Thank you for your prompt attention to this request. If you need additional information or have other questions, please contact Rachel Bleshman at (202) 225-2927.

Sincerely,

JOHN D. DINGELL
CHAIRMAN

Attachment

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

The Honorable Fred Upton, Member
Subcommittee on Energy and Air Quality

STATE OF ILLINOIS

ILLINOIS COMMERCE COMMISSION

The Honorable John D. Dingell
U.S. House of Representatives
Sub-Committee on Energy and Commerce
c/o Ms. Rachel Bleshman
2125 Rayburn House Office Building
Washington, D.C. 20515

VIA FAX: 202-225-2899
VIA EMAIL: rachel.bleshman@mail.house.gov

September 17, 2007

Dear Honorable John Dingell:

On August 31, 2007, I received a letter requesting additional information about testimony I presented to the House Sub-Committee on Energy and Commerce on May 3, 2007 at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." Attached please find my responses to the questions submitted by The Honorable Michael C. Burgess and The Honorable John Upton.

If you need additional information or have questions, feel free to contact me at 312-814-7254.

Sincerely yours,

Robert F. Lieberman
Commissioner with the Illinois Commerce Commission

160 North LaSalle Street, Suite C-800, Chicago, Illinois 60601-3104
Telephone [312] 814-4790 Fax [312] 814-1818 TDD ("V/TTY") [312] 814-5845

Responses to questions from The Honorable Michael C. Burgess

1. Have you sought input from appliance manufacturers who have done research or pilot work in this area?

Answer: We have largely worked thru GridWise and the other national organizations to understand the nature of the work that has already been done by appliance manufacturers. Our dilemma is the classic chicken and the egg – if the smart grid isn't in place, the appliance manufacturers have no market for their new technology.

2. What role should the appliance role play in a smart grid? How closely are you working with the appliance industry?

Answer: As I said above, we have a simultaneity problem. If the states and local distribution utilities don't invest in the smart grid, the manufacturers won't have a market. And conversely, if the technology on the appliance side doesn't exist, the smart grid will be less valuable. I should also note, however, that the value of the smart grid is not limited to the ability of appliances to respond to price signals.

I personally have not worked particularly closely with the appliance industry but I understand that the national "smart grid" organizations have.

160 North LaSalle Street, Suite C-800, Chicago, Illinois 60601-3104
Telephone [312] 814-4790 Fax [312] 814-1818 TDD ("V/TTY") [312] 814-5845

Responses to questions from The Honorable Richard Upton

1. Mr. Commissioner, you say that the smart grid has "Unknown or unknowable benefits: The benefits are uncertain and hard to calculate" and that ". . . the inability to predict the behavior of some critical variable vastly complicates the regulator's job and in large part stymies the analytic tools regulators and their staff's have at their disposal." Yet the other witnesses claim huge and seemingly knowable benefits.

   What is this variable that you mention?

Answer: The discrepancy isn't really as great as it may seem. I was arguing that – historically – regulatory agencies have made investment decisions by assuming away uncertainty inherent in their decisions ("if demand for electricity keeps growing at this rate, we will need to build a nuclear power plant") and thus moving forward, committing ratepayer monies on the basis of what could be called a "deterministic" analysis. The dilemma, today, is that the uncertainty in these investment decisions is much more difficult to assume away – ("will customers respond to price signals by reducing their consumption when prices are high and what affect will that have on a dynamic wholesale power market?") and by the very definition of markets, we are faced with an "indeterministic" model. Commissions are, as I said, perhaps reasonably nervous about investing real dollars today for indeterminate benefits tomorrow. It violates their culture, history and – in many cases – state legislative policy.

I personally have no argument with the other people on the panels who were certain the benefits would occur. I generally agree with their analysis. The problem is getting a (purposely) conservative and backwards-looking regulatory framework to acknowledge that it is worth investing current ratepayer dollars to create a circumstance sometime in the future when benefits **may** occur at an indeterminate rate. That's the tough sell.

The variable I mentioned was the behavior of households and businesses. Until now, the electricity business has never really thought about customer behavior. They assumed that electricity had an inelastic demand and therefore they simply had to build enough power plants to meet that demand. The problem is that the utilities and state regulatory commissions really have no experience or knowledge base to fall back on to even begin to think about how customers might respond to price signals and they are wary of assuming that price signals in the electric market (unlike elsewhere in the economy) will elicit the response that the members of the panel were predicting.

Again, this is not to say that it won't – there is beginning to be significant evidence that customers will respond to price signals, but most utilities and regulators are not yet comfortable with those findings.

ONE HUNDRED TENTH CONGRESS

U.S. House of Representatives

Committee on Energy and Commerce

Washington, DC 20515–6115

JOHN D. DINGELL, MICHIGAN
CHAIRMAN

August 31, 2007

The Honorable Jon Wellinghoff
Commissioner
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Dear Mr. Wellinghoff:

Thank you for appearing before the Subcommittee on Energy and Air Quality on Tuesday, May 3, 2007, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid." We appreciate the time and effort you gave as a witness before the subcommittee.

Under the Rules of the Committee on Energy and Commerce, the hearing record remains open to permit Members to submit additional questions to the witnesses. Attached are questions directed to you from a Member of the Committee. In preparing your answers to these questions, please address your response to the Member who has submitted the questions and include the text of the Member's question along with your response.

To facilitate the printing of the hearing record, your responses to these questions should be received no later than the close of business on **Monday, September 17, 2007**. Your written responses should be delivered to **2125 Rayburn House Office Building** and faxed to **(202) 225-2899** to the attention of Rachel Bleshman. An electronic version of your response should also be sent by e-mail to Ms. Bleshman, at **rachel.bleshman@mail.house.gov**. Please send your response in a single Word formatted document.

The Honorable Jon Wellinghoff
Page 2

Thank you for your prompt attention to this request. If you need additional information or have other questions, please contact Rachel Bleshman at (202) 225-2927.

Sincerely,

JOHN D. DINGELL
CHAIRMAN

Attachment

cc: The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Rick Boucher, Chairman
Subcommittee on Energy and Air Quality

The Honorable J. Dennis Hastert, Ranking Member
Subcommittee on Energy and Air Quality

The Honorable Michael C. Burgess, Member
Subcommittee on Energy and Air Quality

September 17, 2007

The Honorable Michael C. Burgess
Subcommittee on Energy and Air Quality
U.S. House of Representatives
Committee on Energy and Commerce
2125 Rayburn House Office Building
Washington DC 20515-6115

Dear Congressman Burgess:

The following information is provided in response to your additional questions dated August 31, 2007, regarding my May 3, 2007 testimony before the House Energy and Commerce Subcommittee on Energy and Air Quality, at the hearing entitled "Facilitating the Transition to a Smart Electric Grid".

Please do not hesitate to contact me if you have any further questions.

Sincerely,

Jon Wellinghoff
Commissioner

The Honorable Michael C. Burgess
Energy and Commerce Subcommittee on Energy and Air Quality
September 17, 2007
Page 2

Question:

1. On Tuesday, we held a hearing in this subcommittee on appliance efficiency standards. The Smart Grid technologies we are discussing today require advanced appliances that can communicate with the grid. One of our witnesses mentioned the need for increased efficiency standards for appliances, but won't these advanced appliances require additional electricity to power their communications features? We wouldn't want to set efficiency standards that inadvertently prevent the introduction of new technologies that may help the grid save energy. How would you recommend we set efficiency standards to allow flexibility so that these smart appliances of the future will comply with the energy efficiency standard?

Answer: I agree that efficiency standards should not inadvertently prevent the introduction of new technologies that may help to save energy. As a general matter, however, the communications hardware that enables appliances to communicate with a "smart" electric transmission grid requires a very small amount (literally microamps) of power. Therefore, the inclusion of such communications technology in appliances will not add substantially to their power requirements, and for that reason, it should not present a major additional consideration with regard to establishing appliance efficiency standards.

The Honorable Michael C. Burgess
Energy and Commerce Subcommittee on Energy and Air Quality
September 17, 2007
Page 3

Question:

2. In states that deregulated their electric markets, many resident customers, including myself, did not switch suppliers. What can be done to foster public support for the smart grid and encourage people to use it? One demand reduction strategy discussed is allowing the electric grid to determine when individual air conditioners will turn on and off. How do we convince customers that this is not "big brother" or a loss of personal freedom?

Answer: A "smart" electric transmission grid has the potential to empower consumers through advanced communications and control technologies that enable and utilize bidirectional flows of information.

For example, the Olympic Peninsula Distributed Resources Demonstration conducted by Pacific Northwest National Laboratory showed that residential, municipal, and commercial consumers equipped with automated control technology took advantage of a virtual real-time market in which they could see real monetary benefits to adjusting their consumption during times of peak demand. These consumers decided for themselves when to take advantage of the opportunities made possible by the availability of smart grid technologies. Rather than a loss of personal freedom, this initiative and others that will rely on a smart grid provide consumers with more choices.

As I stated in my testimony, we should not underestimate the power of consumers to drive smart-grid technologies. The more that consumers see economic benefits of such technologies, the more they will support investments in the smart grid.