# Testimony

# Facilitating the Transition to a Smart Electric Grid

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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 20$^{th}$ century – become a vulnerable low-tech legacy by the dawn of the 21$^{st}$ century? The declining cost commodity business model which successfully enabled the 20$^{th}$ 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 21$^{st}$ 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, 21$^{st}$ 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 provisions that encourage utilities to provide consumers with advanced net metering systems, enabling access to real-time electricity pricing and demand response opportunities.

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

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

One such prototype application is the transformation of the Illinois Institute of Technology (IIT) Chicago campus electrical system into a smart microgrid. This smart transformation is being conducted by a team consisting principally of IIT, Endurant Energy and Commonwealth Edison. The 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.