SMART GRID: Creating Green Jobs

1. What is Smart Grid?
2. The Next President Wants Smart Grid for America
3. Federal Smart Grid Law (summary & text)
4. Smart Grid City (Xcel Energy, news release & white paper)
5. Smart Grid & Homeland Security
6. EPRI Study: $2 Trillion/yr additional U.S. GDP by 2020
7. Smart Grid is “Future Proof”
   - “Sustainable Future Requires Electrical Smart Grid” (Sacramento Bee)
   - “Smart Meters May Soon Be Outdated” (LA Times)
   - AMI without Smart Grid, a Negative Net Present Value
A “Smart Grid” Enhances Energy Independence, Reduces CO2 & Creates Jobs

- Smart Grid transforms the aging electricity grid to reduce energy consumption
- Fundamental design of today’s electric system is nearly a century old
- Over next decade U.S. electric demand will increase 19%, while supply increases only 6%
- 10% to 20% of energy is lost before it reaches the end user
- Power saved is better than new power generation – no new waste, pollutants or CO2
- Regulators should reward efficiency enhancements, rather than just sale of more energy

What is a Smart Grid?  A power transmission and distribution network that can incorporate millions of sensors all connected through an advanced, two-way communications and data acquisition system to provide real-time monitoring, diagnosis and control that enables more efficient use of electricity and measurement and verification of CO2-reduction efforts.

- Electricity grid produces 40% of all C02 emissions, more than the entire U.S. vehicle fleet
- Smart Grid can reduce consumption by 10% and grid-C02 emissions by 25% (EPRI)

Smart Grid Capabilities: Enable & Maximize Impact of Renewable Resources

- Smart Grid will facilitate grid-integration of renewables and maximize their impact
- Enable more efficient, reliable and secure energy service – grid carries megabits, not just megawatts
- Reduce need for new generation plants that can cost consumers billions in higher rates
- Save consumers billions each year lost due to power outages ($50B in savings by 2025)
- Homeland Security enhanced through critical infrastructure protection
- Government, business and consumers become partners in global warming mitigation
- Promote alternative energy sources:
  - Monitoring & control capabilities optimize use of dispersed renewable sources
  - Enables distributed generation based on real-time, accurate market signals (antiquated “advanced metering” and past-tense net metering do not)
- Make utilities more efficient by enabling them to –
  - Identify the nature and location of power losses or threats to critical infrastructure
  - Improve efficiency via services such as automated control and load balancing
  - Identify and prevent theft and tampering
  - Improve diagnostics, predictive maintenance based on rich data streams never before available
- Helps energy consumers
  - Enhanced demand-side management lowers costs & CO2 emissions (less generation needed)
  - Real-time pricing and information about energy use gives consumers better control of bills, lets market forces influence usage patterns, and lowers overall energy costs
  - Providing new, facilities-based alternatives for broadband Internet access and other communications services
- Critical infrastructure for plug-in electric vehicles
  - DOE study found the grid today could support most cars and light trucks running on electricity (approx. $1 per gallon equivalent), but Smart Grid is needed to keep plug-in vehicles from requiring new generation plants to meet increased electricity demand.
What is a Smart Grid?

“. . . 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.” (EPRI, emphasis added)
Over the last several years, utility executives and regulators have become increasingly concerned about multiple issues that can only be addressed through an enterprise-wide smart grid solution.

### Cost and Uncertainty about New Generation and Transmission
- Peak shaving through demand side management programs
  - Enhance point load control and TOU programs with real-time verification and measurement
  - Enable smart home with intelligence appliances
- Inherent robust and ubiquitous HAN network

### Increasing Requirements for the use of Renewables and Distributed Generation
- Improving CAIDI, SAIDI, and SAIFI
- Customer service and field maintenance labor reduction and improved productivity
- Improved revenue assurance and receivables
- Conservation Voltage/Var control
- Vegetation management
- Regulatory compliance
- Reduced cost of insurance (outage related)

### Environmental Impact
- Aging workforce

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<th>Smart Grid Enterprise Solution</th>
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<td>▪ Optimized data collection and system planning</td>
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<td>▪ Transformer, Capacitor bank and substation equipment automation and management</td>
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<td>▪ Asset life extension and failure avoidance</td>
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<td>▪ Reduced cost of URD cable replacement</td>
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<th>Smart Grid Enterprise Solution</th>
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<td>▪ Plug-in Electric Hybrid Vehicles (PHEVs)</td>
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<td>- Demand response, load shedding/shifting capability</td>
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<td>▪ Management of distributed generation (including PHEV)</td>
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<td>▪ Differentiated service offerings</td>
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The federal Energy Independence and Security Act of 2007 calls the implementation of Smart Grid systems a “Policy of the United States”

**Recognition that the requirements of the Energy Policy Act of 2005 which called for advanced metering were not enough**

- Calls for utilities to invest in Smart Grids to improve the efficiency, reliability and security of the electric distribution system
- Provides for loans and federal contributions
- Authorizes $100M each year from 2008 through 2012 to be divided between 5 smart grid demonstration projects throughout nation, and matching funds for up to 20% of cost of actual deployments of smart grid technology.
- Directs DOE to report within 1 year on status of smart grid deployments and identify any regulatory or government obstacles.
- Directs states to consider various incentives to encourage smart grid
CURRENT Smart Grid
Energy Efficiency

Smart Grid can improve energy efficiency and reliability

“If we could make the electric grid even 5 percent more efficient, we would save more than 50 gigawatts of energy” (the equivalent of production from 50 large coal-fired power plants” (Commissioner Wellinghof, U.S. Federal Energy Regulatory Commission, February 2008)

“A peer-reviewed analysis of 11 studies in 2004 indicated a median achievable economic potential (savings from the intelligent air conditioner and similar devices), of 24% of total U.S. electricity demand . . . 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.” (Michael Howard of EPRI testifying to U.S. Congress, May 2007)

The grid is going to have to be updated to handle 20-30% of renewables that many state renewable portfolio standards are calling for . . . That can be challenging with intermittent resources such as wind. . . . Turbines have to shut down to protect themselves when wind hits 60 mph and if wind blows at night the Danes often have to shut off other generators. (EPRI President Dr. Steven Specker presenting at the 2007 Deloitte Energy Conference)
Smart Grid City
Collaborating to Create the Next Generation Utility

Smart Grid City Details
- Approximately 100,000 residents (Boulder, CO)
- Fully interconnected city using Smart Grid technologies
- Phase I expected to be in place as early as August 2008

Benefits for Evaluation
- Lower bills
- Smarter energy management
- Better grid reliability
- Improved energy efficiency and reliability options
- Reduce environmental impact by Increased use of renewable resources
- Support for plug-in electric hybrids and intelligent home appliances

Smart Grid Consortium
- Xcel
- CURRENT Group
- Schweitzer Engineering Laboratories (intelligent substation)
- Ventyx (service delivery management)
- Accenture

“The fundamental component for making the smart grid work will be a robust and dynamic communications network; providing the utility the ability for real-time, two-way communications throughout the grid and enabling interaction with each component from fuel source to end use”

(Xcel Smart Grid White Paper)
**TRANSIENT SECONDARY FAULT**

- This is a 37.5 KVA, 120/240v transformer with 2/0 copper conductor connecting it to the secondary bus.
- One conductor had rubbed against the cooling fin of the transformer and burned the conductor for ~10” back to the secondary bushing of the transformer.
- Oncor was able to repair before a customer call.

- **Result – Outage and potential safety issue avoided**
Advanced sensors distributed throughout the network and a high speed, symmetrical communications network are key to the Smart Grid.
CURRENT® Smart Grid installation

- Aerial
- Underground
CURRENT Smart Grid Services
Home Area Network (HAN) Architecture

- High speed connectivity to and beyond each electrical outlet through open IP based standard
- Gateway can be self-installed and remotely managed
- Ability to add / adapt to evolving standards by replacing inexpensive gateway inside of home
- Eliminates need to choose the in-home standard now when buying meters

High-speed connectivity to each electrical outlet
CURRENT Smart Grid was designed to maximize flexibility and interoperability for the life of the system

| Meter and Device Agnostic | - CURRENT Smart Grid is designed independent of specific end-point devices  
|                          | - CURRENT has and can partner with any meter or in-home customer control device manufacturer preferred, present day or in the future  
|                          | - Utility maintains meter/control device vendor choices for the life of the system |
| Open Standards Network   | - IP based network can interconnect with multiple devices and software applications  
|                          | - Connects to any Ethernet enabled device anywhere on the grid  
|                          | - Leverages BPL, fiber optics and other communications technologies as appropriate  
|                          | - Leverages advances in Internet security/technology |
| Utility Compatible       | - Software systems that fit into Utility’s IT infrastructure  
|                          | - Oracle and SQL databases  
|                          | - Open APIs to interface with existing utility software systems  
|                          | - Built-in enterprise level security |
## CURRENT Smart Grid Summary

### Best-In-Class AMI and Smart Grid Solution
- Exceeds the guideline requirements of present AMI mandates
- High speed, low latency two-way communications to meet present/future needs
- Embedded advanced sensors provide Actionable intelligence, and software analytics
- Open IP-based standards to reduce costs, simplify integration and ensure future upgradeability
- Real-time, two-way, verifiable and targeted demand response capabilities

### Addresses Market Requirements
- Demand-Supply imbalance
  - Greatly reduces operational inefficiencies and line loss
  - Enables peak saving through robust demand response capabilities
  - Enables the monitoring, coordination and control necessary to manage distributed, renewable generation
- Aging Infrastructure and grid reliability
  - Allows the real-time monitoring and proactive maintenance of distribution infrastructure
  - Enables faster and targeted outage detection and restoration
- Environmental impact
  - Functions as a clean, renewable energy source, reducing the need for additional CO₂ emitting generation sources

### Accelerating Adoption
- Advanced discussions with Utilities worldwide
- Increasing Political and Regulatory Support as means to solve Demand/Supply issues as well as to reduce Greenhouse Gas
- Future proofed enterprise wide network reduces risk of stranding point AMI solutions
- Improved reliability, efficiency, customer service and asset management
- Flexible business model offering upside by enabling consumer broadband services
A CURRENT Smart Grid enables real-time monitoring wherever the electric distribution grid reaches

- Real-time video monitoring of critical infrastructure – substations, State and local government facilities, etc.
- Networked sensors designed to detect specific hazards, such as radiation or biological agents
John McCain

Thank you. I appreciate the invitation to talk with you about a great and urgent challenge - breaking our nation's critical dependence on foreign sources of oil, and making America safer, stronger and more prosperous by modernizing the way we generate and employ energy. . . . Energy efficiency by using improved technology and practicing sensible habits in our homes, businesses and automobiles is a big part of the answer, and is something we can achieve right now. . . . smart grid technology can help homeowners and businesses lower their energy use, and breakthroughs in high tech materials can greatly improve fuel efficiency in the transportation sector. We need to dispel the image of conservation that entails shivering in cold rooms, reading by candlelight, and lower productivity. Americans have it in their power today to contribute to our national security, prosperity and a cleaner environment.

“Speech on Energy Policy,” (April 23, 2007) online at:  
http://www.johnmccain.com/Informing/News/NewsReleases/5097be0c-e4db-4c6d-9949-21d8d177947f.htm

Hillary Clinton: “Our electricity grid is antiquated, resulting in costly blackouts, the overbuilding of generation capacity, and large losses in energy during transmission. We need to move aggressively toward a smart grid -- a web-enabled, digitally controlled, intelligent power delivery system that efficiently distributes electricity and protects against blackouts, brown-outs and excess energy use. With smarter two-way communications, utilities and consumers can get more control over consumption and save money. A recent study found that using demand reduction programs, which would be greatly facilitated by an interactive smart grid, can reduce "peak demand" by 5 percent and save $35 billion in energy costs over a 10-year period. Other potential "smart grid" benefits include: more efficient power plants; smaller transmission infrastructure needs; more control and better incentives for consumers to save energy; net metering for solar and other distributed renewables; and the ability for consumers to sell power back into the grid.” .... “Funding 10 ‘Smart Grid Cities.’ These public-private partnerships between states, cities, utilities, automakers and battery makers will deploy smart grid technology and plug-in hybrid vehicles on a large scale, as well as encourage other technological options to discourage consumption during peak cost periods like time of use meters and pricing, real time demand response, visual price meters, and "prepaid" service models. The projects will enable testing and refinement of advanced capabilities, such as the ability of plug-in hybrid vehicles to communicate with the smart grid to sell power back to utilities when utilities most need the power. Some experts believe that providing such "vehicle to grid" power at times when the utilities need it most could be worth $2,000-4,000 dollars per vehicle per year, slashing the cost of owning a plug-in hybrid…”  

Barack Obama: Invest in a Digital Smart Grid: Like other pieces of infrastructure, such as roads and bridges our energy grid is outdated and inefficient, resulting in $50-100 billion dollar losses to the U.S. economy each year. The 2003 East Coast blackout alone resulted in a $10 billion economic loss. Like President Eisenhower did with the interstate highway system, Barack Obama will pursue a major investment in our national utility grid to enable a tremendous increase in renewable generation and accommodate 21st century energy requirements, such as reliability, smart metering, and distributed storage. Obama will invest federal money to leverage additional state and private sector funds to help create a digitally connected power grid. Creating a smart grid will also help insulate against terrorism concerns because our grid today is virtually unprotected from terrorists. Installing a smart grid will help consumers produce electricity at home through solar panels or wind turbines, and be able to sell electricity back through the grid for other consumers, and help consumers reduce their energy use during peak hours when electricity is more expensive. Obama will direct federal resources to the most vulnerable and congested areas and rural areas where significant renewable energy sources are located, as well as work toward national transformation of our energy grid in partnership with states and utilities.  
Source: http://www.barackobama.com/issues/energy/
SMART GRID: Other Presidential Candidates

Mitt Romney

**Invest In Research.** Dramatically increase federal spending on research, development, and demonstration projects that hold promise for diversifying our energy supply and increasing our energy efficiency, such as:

- Basic research in key technologies like improved energy storage
- Bringing clean energy technology to market through commercialization of large-scale renewables and advanced nuclear technologies
- Improved **smart-grid technology** for power distribution
- Clean, efficient uses of existing fossil fuels, e.g. clean coal, coal-to-liquids, carbon sequestration

http://www.mittromney.com/Issues/ending-energy-dependence

John Edwards

**“Expand Smart Meters and Smart Grids to Use Energy More Wisely:** By simultaneously displaying energy use and price, smart meters encourage consumers to use less energy and to use energy when it can be generated less expensively. Utilities can also use information technology to monitor electricity demand, allowing them to plan their production more efficiently.”


Rudolph Giuliani

**“Securing, Renewing, And Expanding Our Energy Infrastructure:** We must ensure the security and reliability of America's energy infrastructure. We need new oil refineries, nuclear reactors, transmission lines, and renewable energy facilities. Expanding our infrastructure and diversifying its geographic location directly impacts national security, economic stability, and job creation. Key steps include enhancing security, cutting red tape in the regulatory process, investing in a digital "**Smart Grid,**" and developing batteries to more effectively store energy.”

Source: “Rudy's Plan To Move Toward Energy Independence” (July 18, 2007),
On December 19, 2007, the President signed the Energy Independence and Security Act of 2007 (“the Act”), which contains a Title devoted entirely to Smart Grid. The smart grid provisions give the Department of Energy (DOE) the lead on all but two issues (Interoperability & State Consideration), but DOE must coordinate with the Federal Energy Regulatory Commission (FERC), the National Institute of Standards and Technology (NIST), the Department of Homeland Security, other federal agencies and the States.

Overview of the Act’s provisions on Smart Grid:

- **Statement of Policy.** The Smart Grid title begins with a “Statement of Policy on Modernization of the Electricity Grid” that lists 10 achievement goals “which together characterize a Smart Grid.” As DOE and the States interpret what this indirect definition of Smart Grid means, we plan to narrow their focus on the core smart grid functionality that CURRENT provides: a two-way, real-time, data-producing digital network that reaches behind the meter into the premises and in front of the meter onto the distribution network to provide many times more value than meter-focused approaches.

- **Report to Congress.** DOE must report in 1 year to Congress on smart grid deployment, and barriers to deployment, and to form both a DOE-Task Force and a Smart Grid Advisory Committee to advance develop and deploy smart grid and smart grid technologies. The Task Force and Committee must be formed by April 19, 2008.

- **Demonstration Projects ($500M).** The Act provides **$100M annually** from 2008 to 2012 for 5 smart grid regional “demonstration” projects that should seek to leverage existing deployments, and DOE may provide up to 50% of tech investment costs by a utility made to carry out demo projects. The 5 demos are to include rural areas, including at least one area where the majority of generation and transmission assets are controlled by a tax-exempt entity (e.g., public power systems).

- **Matching Grants.** The Act authorizes matching grants to reimburse up to **20% of the cost** of smart grid investments and directs DOE to issue rules for the grant program within 1 year of enactment.

- **Interoperability (NIST-led process).** One area where DOE does not have the lead is in coordinating the development of a smart grid “interoperability framework.” Here NIST must coordinate with DOE and stakeholders and start work within 60 days of enactment, with an initial progress report on interoperability due to Congress within 1 year of enactment. NIST is given authority to institute rules once there is “sufficient consensus.” The Act devotes $5M toward this purpose from 2008 through 2012.

- **State Consideration.** The Act amends the Public Utility Regulatory Policies Act (PURPA) of 1978 to direct the States to consider requiring that electric utilities, before investing in “non-advanced grid technologies,” consider investments in a “qualified smart grid system.” The term “qualified smart grid system” will have to be defined by DOE. States are also directed to consider smart grid incentives such as legislation or regulations on rate recovery and obsolete equipment. Consideration by each State regulatory authority (with respect to each electric utility for which it has ratemaking authority) and each non-regulated electric utility must start within 1 year of enactment (or a hearing date must be set by then) and the consideration must be completed within 2 years of enactment.

- **Smart Grid Information Mandates.** The Act also amends PURPA to give electricity purchasers direct access over the Internet to prices and customer usage in kWh offered at least daily (and hourly info and day-ahead projection info where available). Consumers must also be told the source of their power, including greenhouse gas emissions associated with the generation type.

- **Private Wires Laws impact on Combined Heat & Power.** The Act requires DOE to study and report to Congress within 1 year on laws affecting the siting of privately owned electric distribution wires on and across public rights-of-way.

- **Smart Grid Security.** The Act directs DOE to report to Congress within 18 months on security attributes of smart grid systems: how smart grid helps make the grid less vulnerable to attack; how smart grid helps in restoring grid integrity after disruptions; how smart grid facilitates “nationwide, interoperable emergency communications and control of the Nation’s electricity system” during emergencies.
An Act

To move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes.

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

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the “Energy Independence and Security Act of 2007”.

(b) TABLE OF CONTENTS.—The table of contents of this Act is as follows:

Sec. 1. Short title; table of contents.
Sec. 2. Definitions.
Sec. 3. Relationship to other law.

TITLE I—ENERGY SECURITY THROUGH IMPROVED VEHICLE FUEL ECONOMY

Subtitle A—Increased Corporate Average Fuel Economy Standards

Sec. 101. Short title.
Sec. 102. Average fuel economy standards for automobiles and certain other vehicles.
Sec. 103. Definitions.
Sec. 104. Credit trading program.
Sec. 105. Consumer information.
Sec. 106. Continued applicability of existing standards.
Sec. 108. National Academy of Sciences study of medium-duty and heavy-duty truck fuel economy.
Sec. 109. Extension of flexible fuel vehicle credit program.
Sec. 110. Periodic review of accuracy of fuel economy labeling procedures.
Sec. 111. Consumer tire information.
Sec. 112. Use of civil penalties for research and development.
Sec. 113. Exemption from separate calculation requirement.

Subtitle B—Improved Vehicle Technology

Sec. 131. Transportation electrification.
Sec. 132. Domestic manufacturing conversion grant program.
Sec. 134. Loan guarantees for fuel-efficient automobile parts manufacturers.
Sec. 135. Advanced battery loan guarantee program.
Sec. 136. Advanced technology vehicles manufacturing incentive program.

Subtitle C—Federal Vehicle Fleets

Sec. 141. Federal vehicle fleets.
Sec. 142. Federal fleet conservation requirements.
Sec. 222. Establishment and management of Foundation.
Sec. 223. Duties of Foundation.
Sec. 224. Annual report.
Sec. 225. Powers of the Foundation; related provisions.
Sec. 226. General personnel authorities.
Sec. 227. Authorization of appropriations.

Subtitle C—Miscellaneous Provisions
Sec. 311. Energy diplomacy and security within the Department of State.
Sec. 312. National Security Council reorganization.
Sec. 314. Annual national energy security strategy report.
Sec. 314. Convention on Supplementary Compensation for Nuclear Damage contingent cost allocation.
Sec. 315. Transparency in extractive industries resource payments.

TITLE X—GREEN JOBS
Sec. 1001. Short title.
Sec. 1002. Energy efficiency and renewable energy worker training program.

TITLE XI—ENERGY TRANSPORTATION AND INFRASTRUCTURE
Subtitle A—Department of Transportation
Sec. 1101. Office of Climate Change and Environment.
Subtitle B—Railroads
Sec. 1111. Advanced technology locomotive grant pilot program.
Sec. 1112. Capital grants for class II and class III railroads.
Subtitle C—Marine Transportation
Sec. 1121. Short sea transportation initiative.
Sec. 1122. Short sea shipping eligibility for capital construction fund.
Sec. 1123. Short sea transportation report.
Subtitle D—Highways
Sec. 1131. Increased Federal share for CMAQ projects.
Sec. 1132. Distribution of rescissions.
Sec. 1133. Sense of Congress regarding use of complete streets design techniques.

TITLE XII—SMALL BUSINESS ENERGY PROGRAMS
Sec. 1201. Express loans for renewable energy and energy efficiency.
Sec. 1202. Pilot program for reduced 7(a) fees for purchase of energy efficient technologies.
Sec. 1203. Small business energy efficiency.
Sec. 1204. Larger 504 loan limits to help business develop energy efficient technologies and purchases.
Sec. 1205. Energy saving debentures.
Sec. 1206. Investments in energy saving small businesses.
Sec. 1207. Renewable fuel capital investment company.
Sec. 1208. Study and report.

TITLE XIII—SMART Grid
Sec. 1301. Statement of policy on modernization of electricity grid.
Sec. 1302. Smart grid system report.
Sec. 1303. Smart grid advisory committee and smart grid task force.
Sec. 1304. Smart grid technology research, development, and demonstration.
Sec. 1305. Smart grid interoperability framework.
Sec. 1306. Federal matching fund for smart grid investment costs.
Sec. 1307. State consideration of smart grid.
Sec. 1308. Study of the effect of private wire laws on the development of combined heat and power facilities.
Sec. 1309. DOE study of security attributes of smart grid systems.

TITLE XIV—POOL AND SPA SAFETY
Sec. 1401. Short title.
Sec. 1402. Findings.
Sec. 1403. Definitions.
Sec. 1404. Federal swimming pool and spa drain cover standard.
Sec. 1405. State swimming pool safety grant program.
Sec. 1406. Minimum State law requirements.
Sec. 1407. Education program.
“(B) PAYMENT.—Any company against which the Administrator assesses costs under this paragraph shall pay such costs.

“(2) DEPOSIT OF FUNDS.—Funds collected under this section shall be deposited in the account for salaries and expenses of the Administration.

“SEC. 394. MISCELLANEOUS.

“To the extent such procedures are not inconsistent with the requirements of this part, the Administrator may take such action as set forth in sections 309, 311, 312, and 314 and an officer, director, employee, agent, or other participant in the management or conduct of the affairs of a Renewable Fuel Capital Investment company shall be subject to the requirements of such sections.

“SEC. 395. REMOVAL OR SUSPENSION OF DIRECTORS OR OFFICERS.

“Using the procedures for removing or suspending a director or an officer of a licensee set forth in section 313 (to the extent such procedures are not inconsistent with the requirements of this part), the Administrator may remove or suspend any director or officer of any Renewable Fuel Capital Investment company.

“SEC. 396. REGULATIONS.

“The Administrator may issue such regulations as the Administrator determines necessary to carry out the provisions of this part in accordance with its purposes.

“SEC. 397. AUTHORIZATIONS OF APPROPRIATIONS.

“(a) IN GENERAL.—Subject to the availability of appropriations, the Administrator is authorized to make $15,000,000 in operational assistance grants under section 389 for each of fiscal years 2008 and 2009.

“(b) FUNDS COLLECTED FOR EXAMINATIONS.—Funds deposited under section 393(c)(2) are authorized to be appropriated only for the costs of examinations under section 393 and for the costs of other oversight activities with respect to the program established under this part.

“SEC. 398. TERMINATION.

“The program under this part shall terminate at the end of the second full fiscal year after the date that the Administrator establishes the program under this part.”.

SEC. 1208. STUDY AND REPORT.

The Administrator of the Small Business Administration shall conduct a study of the Renewable Fuel Capital Investment Program under part C of title III of the Small Business Investment Act of 1958, as added by this Act. Not later than 3 years after the date of enactment of this Act, the Administrator shall complete the study under this section and submit to Congress a report regarding the results of the study.

TITLE XIII—SMART GRID

SEC. 1301. STATEMENT OF POLICY ON MODERNIZATION OF ELECTRICITY GRID.

It is the policy of the United States to support the modernization of the Nation’s electricity transmission and distribution system...
to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve each of the following, which together characterize a Smart Grid:

(1) Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.

(2) Dynamic optimization of grid operations and resources, with full cyber-security.

(3) Deployment and integration of distributed resources and generation, including renewable resources.

(4) Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.

(5) Deployment of “smart” technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.

(6) Integration of “smart” appliances and consumer devices.

(7) Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning.

(8) Provision to consumers of timely information and control options.

(9) Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.

(10) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.

SEC. 1302. SMART GRID SYSTEM REPORT.

The Secretary, acting through the Assistant Secretary of the Office of Electricity Delivery and Energy Reliability (referred to in this section as the “OEDER”) and through the Smart Grid Task Force established in section 1303, shall, after consulting with any interested individual or entity as appropriate, no later than 1 year after enactment, and every 2 years thereafter, report to Congress concerning the status of smart grid deployments nationwide and any regulatory or government barriers to continued deployment. The report shall provide the current status and prospects of smart grid development, including information on technology penetration, communications network capabilities, costs, and obstacles. It may include recommendations for State and Federal policies or actions helpful to facilitate the transition to a smart grid. To the extent appropriate, it should take a regional perspective. In preparing this report, the Secretary shall solicit advice and contributions from the Smart Grid Advisory Committee created in section 1303; from other involved Federal agencies including but not limited to the Federal Energy Regulatory Commission (“Commission”), the National Institute of Standards and Technology (“Institute”), and the Department of Homeland Security; and from other stakeholder groups not already represented on the Smart Grid Advisory Committee.

SEC. 1303. SMART GRID ADVISORY COMMITTEE AND SMART GRID TASK FORCE.

(a) Smart Grid Advisory Committee.—
(1) **ESTABLISHMENT.**—The Secretary shall establish, within 90 days of enactment of this Part, a Smart Grid Advisory Committee (either as an independent entity or as a designated sub-part of a larger advisory committee on electricity matters). The Smart Grid Advisory Committee shall include eight or more members appointed by the Secretary who have sufficient experience and expertise to represent the full range of smart grid technologies and services, to represent both private and non-Federal public sector stakeholders. One member shall be appointed by the Secretary to Chair the Smart Grid Advisory Committee.

(2) **MISSION.**—The mission of the Smart Grid Advisory Committee shall be to advise the Secretary, the Assistant Secretary, and other relevant Federal officials concerning the development of smart grid technologies, the progress of a national transition to the use of smart-grid technologies and services, the evolution of widely-accepted technical and practical standards and protocols to allow interoperability and inter-communication among smart-grid capable devices, and the optimum means of using Federal incentive authority to encourage such progress.

(3) **APPLICABILITY OF FEDERAL ADVISORY COMMITTEE ACT.**—The Federal Advisory Committee Act (5 U.S.C. App.) shall apply to the Smart Grid Advisory Committee.

(b) **SMART GRID TASK FORCE.**—

(1) **ESTABLISHMENT.**—The Assistant Secretary of the Office of Electricity Delivery and Energy Reliability shall establish, within 90 days of enactment of this Part, a Smart Grid Task Force composed of designated employees from the various divisions of that office who have responsibilities related to the transition to smart-grid technologies and practices. The Assistant Secretary or his designee shall be identified as the Director of the Smart Grid Task Force. The Chairman of the Federal Energy Regulatory Commission and the Director of the National Institute of Standards and Technology shall each designate at least one employee to participate on the Smart Grid Task Force. Other members may come from other agencies at the invitation of the Assistant Secretary or the nomination of the head of such other agency. The Smart Grid Task Force shall, without disrupting the work of the Divisions or Offices from which its members are drawn, provide an identifiable Federal entity to embody the Federal role in the national transition toward development and use of smart grid technologies.

(2) **MISSION.**—The mission of the Smart Grid Task Force shall be to insure awareness, coordination and integration of the diverse activities of the Office and elsewhere in the Federal Government related to smart-grid technologies and practices, including but not limited to: smart grid research and development; development of widely accepted smart-grid standards and protocols; the relationship of smart-grid technologies and practices to electric utility regulation; the relationship of smart-grid technologies and practices to infrastructure development, system reliability and security; and the relationship of smart-grid technologies and practices to other facets of electricity supply, demand, transmission, distribution, and policy. The Smart Grid Task Force shall collaborate with the Smart Grid Advisory Committee and other Federal agencies and offices.
The Smart Grid Task Force shall meet at the call of its Director as necessary to accomplish its mission.

(c) AUTHORIZATION.—There are authorized to be appropriated for the purposes of this section such sums as are necessary to the Secretary to support the operations of the Smart Grid Advisory Committee and Smart Grid Task Force for each of fiscal years 2008 through 2020.

SEC. 1304. SMART GRID TECHNOLOGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION.

(a) POWER GRID DIGITAL INFORMATION TECHNOLOGY.—The Secretary, in consultation with the Federal Energy Regulatory Commission and other appropriate agencies, electric utilities, the States, and other stakeholders, shall carry out a program—

(1) to develop advanced techniques for measuring peak load reductions and energy-efficiency savings from smart metering, demand response, distributed generation, and electricity storage systems;

(2) to investigate means for demand response, distributed generation, and storage to provide ancillary services;

(3) to conduct research to advance the use of wide-area measurement and control networks, including data mining, visualization, advanced computing, and secure and dependable communications in a highly-distributed environment;

(4) to test new reliability technologies, including those concerning communications network capabilities, in a grid control room environment against a representative set of local outage and wide area blackout scenarios;

(5) to identify communications network capacity needed to implement advanced technologies.

(6) to investigate the feasibility of a transition to time-of-use and real-time electricity pricing;

(7) to develop algorithms for use in electric transmission system software applications;

(8) to promote the use of underutilized electricity generation capacity in any substitution of electricity for liquid fuels in the transportation system of the United States; and

(9) in consultation with the Federal Energy Regulatory Commission, to propose interconnection protocols to enable electric utilities to access electricity stored in vehicles to help meet peak demand loads.

(b) SMART GRID REGIONAL DEMONSTRATION INITIATIVE.—

(1) IN GENERAL.—The Secretary shall establish a smart grid regional demonstration initiative (referred to in this subsection as the “Initiative”) composed of demonstration projects specifically focused on advanced technologies for use in power grid sensing, communications, analysis, and power flow control. The Secretary shall seek to leverage existing smart grid deployments.

(2) GOALS.—The goals of the Initiative shall be—

(A) to demonstrate the potential benefits of concentrated investments in advanced grid technologies on a regional grid;

(B) to facilitate the commercial transition from the current power transmission and distribution system technologies to advanced technologies;
(C) to facilitate the integration of advanced technologies in existing electric networks to improve system performance, power flow control, and reliability;

(D) to demonstrate protocols and standards that allow for the measurement and validation of the energy savings and fossil fuel emission reductions associated with the installation and use of energy efficiency and demand response technologies and practices; and

(E) to investigate differences in each region and regulatory environment regarding best practices in implementing smart grid technologies.

(3) DEMONSTRATION PROJECTS.—

(A) IN GENERAL.—In carrying out the initiative, the Secretary shall carry out smart grid demonstration projects in up to 5 electricity control areas, including rural areas and at least 1 area in which the majority of generation and transmission assets are controlled by a tax-exempt entity.

(B) COOPERATION.—A demonstration project under subparagraph (A) shall be carried out in cooperation with the electric utility that owns the grid facilities in the electricity control area in which the demonstration project is carried out.

(C) FEDERAL SHARE OF COST OF TECHNOLOGY INVESTMENTS.—The Secretary shall provide to an electric utility described in subparagraph (B) financial assistance for use in paying an amount equal to not more than 50 percent of the cost of qualifying advanced grid technology investments made by the electric utility to carry out a demonstration project.

(D) INELIGIBILITY FOR GRANTS.—No person or entity participating in any demonstration project conducted under this subsection shall be eligible for grants under section 1306 for otherwise qualifying investments made as part of that demonstration project.

(c) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated—

(1) to carry out subsection (a), such sums as are necessary for each of fiscal years 2008 through 2012; and

(2) to carry out subsection (b), $100,000,000 for each of fiscal years 2008 through 2012.

SEC. 1305. SMART GRID INTEROPERABILITY FRAMEWORK.

(a) INTEROPERABILITY FRAMEWORK.—The Director of the National Institute of Standards and Technology shall have primary responsibility to coordinate the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems. Such protocols and standards shall further align policy, business, and technology approaches in a manner that would enable all electric resources, including demand-side resources, to contribute to an efficient, reliable electricity network. In developing such protocols and standards—

(1) the Director shall seek input and cooperation from the Commission, OEDER and its Smart Grid Task Force, the Smart Grid Advisory Committee, other relevant Federal and State agencies; and
(2) the Director shall also solicit input and cooperation from private entities interested in such protocols and standards, including but not limited to the Gridwise Architecture Council, the International Electrical and Electronics Engineers, the National Electric Reliability Organization recognized by the Federal Energy Regulatory Commission, and National Electrical Manufacturer's Association.

(b) **SCOPE OF FRAMEWORK.—**The framework developed under subsection (a) shall be flexible, uniform and technology neutral, including but not limited to technologies for managing smart grid information, and designed—

(1) to accommodate traditional, centralized generation and transmission resources and consumer distributed resources, including distributed generation, renewable generation, energy storage, energy efficiency, and demand response and enabling devices and systems;

(2) to be flexible to incorporate—
   (A) regional and organizational differences; and
   (B) technological innovations;

(3) to consider the use of voluntary uniform standards for certain classes of mass-produced electric appliances and equipment for homes and businesses that enable customers, at their election and consistent with applicable State and Federal laws, and are manufactured with the ability to respond to electric grid emergencies and demand response signals by curtailing all, or a portion of, the electrical power consumed by the appliances or equipment in response to an emergency or demand response signal, including through—
   (A) load reduction to reduce total electrical demand;
   (B) adjustment of load to provide grid ancillary services; and
   (C) in the event of a reliability crisis that threatens an outage, short-term load shedding to help preserve the stability of the grid; and

(4) such voluntary standards should incorporate appropriate manufacturer lead time.

(c) **TIMING OF FRAMEWORK DEVELOPMENT.**—The Institute shall begin work pursuant to this section within 60 days of enactment. The Institute shall provide and publish an initial report on progress toward recommended or consensus standards and protocols within 1 year after enactment, further reports at such times as developments warrant in the judgment of the Institute, and a final report when the Institute determines that the work is completed or that a Federal role is no longer necessary.

(d) **STANDARDS FOR INTEROPERABILITY IN FEDERAL JURISDICTION.**—At any time after the Institute's work has led to sufficient consensus in the Commission's judgment, the Commission shall institute a rulemaking proceeding to adopt such standards and protocols as may be necessary to insure smart-grid functionality and interoperability in interstate transmission of electric power, and regional and wholesale electricity markets.

(e) **AUTHORIZATION.**—There are authorized to be appropriated for the purposes of this section $5,000,000 to the Institute to support the activities required by this subsection for each of fiscal years 2008 through 2012.
SEC. 1306. FEDERAL MATCHING FUND FOR SMART GRID INVESTMENT COSTS.

(a) MATCHING FUND.—The Secretary shall establish a Smart Grid Investment Matching Grant Program to provide reimbursement of one-fifth (20 percent) of qualifying Smart Grid investments.

(b) QUALIFYING INVESTMENTS.—Qualifying Smart Grid investments may include any of the following made on or after the date of enactment of this Act:

(1) In the case of appliances covered for purposes of establishing energy conservation standards under part B of title III of the Energy Policy and Conservation Act of 1975 (42 U.S.C. 6291 et seq.), the documented expenditures incurred by a manufacturer of such appliances associated with purchasing or designing, creating the ability to manufacture, and manufacturing and installing for one calendar year, internal devices that allow the appliance to engage in Smart Grid functions.

(2) In the case of specialized electricity-using equipment, including motors and drivers, installed in industrial or commercial applications, the documented expenditures incurred by its owner or its manufacturer of installing devices or modifying that equipment to engage in Smart Grid functions.

(3) In the case of transmission and distribution equipment fitted with monitoring and communications devices to enable smart grid functions, the documented expenditures incurred by the electric utility to purchase and install such monitoring and communications devices.

(4) In the case of metering devices, sensors, control devices, and other devices integrated with and attached to an electric utility system or retail distributor or marketer of electricity that are capable of engaging in Smart Grid functions, the documented expenditures incurred by the electric utility, distributor, or marketer and its customers to purchase and install such devices.

(5) In the case of software that enables devices or computers to engage in Smart Grid functions, the documented purchase costs of the software.

(6) In the case of entities that operate or coordinate operations of regional electric grids, the documented expenditures for purchasing and installing such equipment that allows Smart Grid functions to operate and be combined or coordinated among multiple electric utilities and between that region and other regions.

(7) In the case of persons or entities other than electric utilities owning and operating a distributed electricity generator, the documented expenditures of enabling that generator to be monitored, controlled, or otherwise integrated into grid operations and electricity flows on the grid utilizing Smart Grid functions.

(8) In the case of electric or hybrid-electric vehicles, the documented expenses for devices that allow the vehicle to engage in Smart Grid functions (but not the costs of electricity storage for the vehicle).

(9) The documented expenditures related to purchasing and implementing Smart Grid functions in such other cases as the Secretary shall identify. In making such grants, the Secretary shall seek to reward innovation and early adaptation,
even if success is not complete, rather than deployment of proven and commercially viable technologies.

(c) INVESTMENTS NOT INCLUDED.—Qualifying Smart Grid investments do not include any of the following:

(1) Investments or expenditures for Smart Grid technologies, devices, or equipment that are eligible for specific tax credits or deductions under the Internal Revenue Code, as amended.

(2) Expenditures for electricity generation, transmission, or distribution infrastructure or equipment not directly related to enabling Smart Grid functions.

(3) After the final date for State consideration of the Smart Grid Information Standard under section 1307 (paragraph (17) of section 111(d) of the Public Utility Regulatory Policies Act of 1978), an investment that is not in compliance with such standard.

(4) After the development and publication by the Institute of protocols and model standards for interoperability of smart grid devices and technologies, an investment that fails to incorporate any of such protocols or model standards.

(5) Expenditures for physical interconnection of generators or other devices to the grid except those that are directly related to enabling Smart Grid functions.

(6) Expenditures for ongoing salaries, benefits, or personnel costs not incurred in the initial installation, training, or start up of smart grid functions.

(7) Expenditures for travel, lodging, meals or other personal costs.

(8) Ongoing or routine operation, billing, customer relations, security, and maintenance expenditures.

(9) Such other expenditures that the Secretary determines not to be Qualifying Smart Grid Investments by reason of the lack of the ability to perform Smart Grid functions or lack of direct relationship to Smart Grid functions.

(d) SMART GRID FUNCTIONS.—The term “smart grid functions” means any of the following:

(1) The ability to develop, store, send and receive digital information concerning electricity use, costs, prices, time of use, nature of use, storage, or other information relevant to device, grid, or utility operations, to or from or by means of the electric utility system, through one or a combination of devices and technologies.

(2) The ability to develop, store, send and receive digital information concerning electricity use, costs, prices, time of use, nature of use, storage, or other information relevant to device, grid, or utility operations to or from a computer or other control device.

(3) The ability to measure or monitor electricity use as a function of time of day, power quality characteristics such as voltage level, current, cycles per second, or source or type of generation and to store, synthesize or report that information by digital means.

(4) The ability to sense and localize disruptions or changes in power flows on the grid and communicate such information instantaneously and automatically for purposes of enabling automatic protective responses to sustain reliability and security of grid operations.
(5) The ability to detect, prevent, communicate with regard to, respond to, or recover from system security threats, including cyber-security threats and terrorism, using digital information, media, and devices.

(6) The ability of any appliance or machine to respond to such signals, measurements, or communications automatically or in a manner programmed by its owner or operator without independent human intervention.

(7) The ability to use digital information to operate functionalities on the electric utility grid that were previously electro-mechanical or manual.

(8) The ability to use digital controls to manage and modify electricity demand, enable congestion management, assist in voltage control, provide operating reserves, and provide frequency regulation.

(9) Such other functions as the Secretary may identify as being necessary or useful to the operation of a Smart Grid.

(e) The Secretary shall—

(1) establish and publish in the Federal Register, within 1 year after the enactment of this Act procedures by which applicants who have made qualifying Smart Grid investments can seek and obtain reimbursement of one-fifth of their documented expenditures;

(2) establish procedures to ensure that there is no duplication or multiple reimbursement for the same investment or costs, that the reimbursement goes to the party making the actual expenditures for Qualifying Smart Grid Investments, and that the grants made have significant effect in encouraging and facilitating the development of a smart grid;

(3) maintain public records of reimbursements made, recipients, and qualifying Smart Grid investments which have received reimbursements;

(4) establish procedures to provide, in cases deemed by the Secretary to be warranted, advance payment of moneys up to the full amount of the projected eventual reimbursement, to creditworthy applicants whose ability to make Qualifying Smart Grid Investments may be hindered by lack of initial capital, in lieu of any later reimbursement for which that applicant qualifies, and subject to full return of the advance payment in the event that the Qualifying Smart Grid investment is not made; and

(5) have and exercise the discretion to deny grants for investments that do not qualify in the reasonable judgment of the Secretary.

(f) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary such sums as are necessary for the administration of this section and the grants to be made pursuant to this section for fiscal years 2008 through 2012.

SEC. 1307. STATE CONSIDERATION OF SMART GRID.

(a) Section 111(d) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2621(d)) is amended by adding at the end the following:

"(16) CONSIDERATION OF SMART GRID INVESTMENTS.—"

"(A) IN GENERAL.—Each State shall consider requiring that, prior to undertaking investments in nonadvanced grid technologies, an electric utility of the State demonstrate
to the State that the electric utility considered an investment in a qualified smart grid system based on appropriate factors, including—

“(i) total costs;
“(ii) cost-effectiveness;
“(iii) improved reliability;
“(iv) security;
“(v) system performance; and
“(vi) societal benefit.

“(B) RATE RECOVERY.—Each State shall consider authorizing each electric utility of the State to recover from ratepayers any capital, operating expenditure, or other costs of the electric utility relating to the deployment of a qualified smart grid system, including a reasonable rate of return on the capital expenditures of the electric utility for the deployment of the qualified smart grid system.

“(C) OBSOLETE EQUIPMENT.—Each State shall consider authorizing any electric utility or other party of the State to deploy a qualified smart grid system to recover in a timely manner the remaining book-value costs of any equipment rendered obsolete by the deployment of the qualified smart grid system, based on the remaining depreciable life of the obsolete equipment.

“(17) SMART GRID INFORMATION.—

“(A) STANDARD.—All electricity purchasers shall be provided direct access, in written or electronic machine-readable form as appropriate, to information from their electricity provider as provided in subparagraph (B).

“(B) INFORMATION.—Information provided under this section, to the extent practicable, shall include:

“(i) PRICES.—Purchasers and other interested persons shall be provided with information on—

“(I) time-based electricity prices in the wholesale electricity market; and

“(II) time-based electricity retail prices or rates that are available to the purchasers.

“(ii) USAGE.—Purchasers shall be provided with the number of electricity units, expressed in kwh, purchased by them.

“(iii) INTERVALS AND PROJECTIONS.—Updates of information on prices and usage shall be offered on not less than a daily basis, shall include hourly price and use information, where available, and shall include a day-ahead projection of such price information to the extent available.

“(iv) SOURCES.—Purchasers and other interested persons shall be provided annually with written information on the sources of the power provided by the utility, to the extent it can be determined, by type of generation, including greenhouse gas emissions associated with each type of generation, for intervals during which such information is available on a cost-effective basis.

“(C) ACCESS.—Purchasers shall be able to access their own information at any time through the Internet and on other means of communication elected by that utility.
for Smart Grid applications. Other interested persons shall be able to access information not specific to any purchaser through the Internet. Information specific to any purchaser shall be provided solely to that purchaser.”.

(b) **COMPLIANCE.—**

(1) **TIME LIMITATIONS.—**Section 112(b) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2622(b)) is amended by adding the following at the end thereof:

“(6)(A) Not later than 1 year after the enactment of this paragraph, each State regulatory authority (with respect to each electric utility for which it has ratemaking authority) and each nonregulated utility shall commence the consideration referred to in section 111, or set a hearing date for consideration, with respect to the standards established by paragraphs (17) through (18) of section 111(d).

“(B) Not later than 2 years after the date of the enactment of this paragraph, each State regulatory authority (with respect to each electric utility for which it has ratemaking authority), and each nonregulated electric utility, shall complete the consideration, and shall make the determination, referred to in section 111 with respect to each standard established by paragraphs (17) through (18) of section 111(d).”.

(2) **FAILURE TO COMPLY.—**Section 112(c) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2622(c)) is amended by adding the following at the end:

“In the case of the standards established by paragraphs (16) through (19) of section 111(d), the reference contained in this subsection to the date of enactment of this Act shall be deemed to be a reference to the date of enactment of such paragraphs.”.

(3) **PRIOR STATE ACTIONS.—**Section 112(d) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2622(d)) is amended by inserting “and paragraphs (17) through (18)” before “of section 111(d)”.

**SEC. 1308. STUDY OF THE EFFECT OF PRIVATE WIRE LAWS ON THE DEVELOPMENT OF COMBINED HEAT AND POWER FACILITIES.**

(a) **STUDY.—**

(1) **IN GENERAL.—**The Secretary, in consultation with the States and other appropriate entities, shall conduct a study of the laws (including regulations) affecting the siting of privately owned electric distribution wires on and across public rights-of-way.

(2) **REQUIREMENTS.—**The study under paragraph (1) shall include—

(A) an evaluation of—

(i) the purposes of the laws; and

(ii) the effect the laws have on the development of combined heat and power facilities;

(B) a determination of whether a change in the laws would have any operating, reliability, cost, or other impacts on electric utilities and the customers of the electric utilities; and

(C) an assessment of—

(i) whether privately owned electric distribution wires would result in duplicative facilities; and
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(ii) whether duplicative facilities are necessary or desirable.

(b) REPORT.—Not later than 1 year after the date of enactment of this Act, the Secretary shall submit to Congress a report that describes the results of the study conducted under subsection (a).

SEC. 1309. DOE STUDY OF SECURITY ATTRIBUTES OF SMART GRID SYSTEMS.

(a) DOE STUDY.—The Secretary shall, within 18 months after the date of enactment of this Act, submit a report to Congress that provides a quantitative assessment and determination of the existing and potential impacts of the deployment of Smart Grid systems on improving the security of the Nation’s electricity infrastructure and operating capability. The report shall include but not be limited to specific recommendations on each of the following:

(1) How smart grid systems can help in making the Nation’s electricity system less vulnerable to disruptions due to intentional acts against the system.

(2) How smart grid systems can help in restoring the integrity of the Nation’s electricity system subsequent to disruptions.

(3) How smart grid systems can facilitate nationwide, interoperable emergency communications and control of the Nation’s electricity system during times of localized, regional, or nationwide emergency.

(4) What risks must be taken into account that smart grid systems may, if not carefully created and managed, create vulnerability to security threats of any sort, and how such risks may be mitigated.

(b) CONSULTATION.—The Secretary shall consult with other Federal agencies in the development of the report under this section, including but not limited to the Secretary of Homeland Security, the Federal Energy Regulatory Commission, and the Electric Reliability Organization certified by the Commission under section 215(c) of the Federal Power Act (16 U.S.C. 824o) as added by section 1211 of the Energy Policy Act of 2005 (Public Law 109–58; 119 Stat. 941).

TITLE XIV—POOL AND SPA SAFETY

SEC. 1401. SHORT TITLE.

This title may be cited as the “Virginia Graeme Baker Pool and Spa Safety Act”.

SEC. 1402. FINDINGS.

Congress finds the following:

(1) Of injury-related deaths, drowning is the second leading cause of death in children aged 1 to 14 in the United States.

(2) In 2004, 761 children aged 14 and under died as a result of unintentional drowning.

(3) Adult supervision at all aquatic venues is a critical safety factor in preventing children from drowning.

(4) Research studies show that the installation and proper use of barriers or fencing, as well as additional layers of protection, could substantially reduce the number of childhood residential swimming pool drownings and near drownings.
DENVER – Xcel Energy announced today it will put in motion its vision to make Boulder, Colo. the nation’s first fully integrated Smart Grid City.

The advanced, smart grid system – when fully implemented over the next few years – will provide customers with a portfolio of smart grid technologies designed to provide environmental, financial and operational benefits. Xcel Energy anticipates funding only a portion of the project, and plans to leverage other sources including government grants for the remainder of what could be up to a $100 million effort.

“Smart Grid City is the first step toward building the grid of the future,” said Dick Kelly, Xcel Energy chairman, president and CEO. "In Boulder, we’ll collaborate with others to integrate all aspects of our smart grid vision and evaluate the benefits. The work we’re doing will benefit not only Boulder, but also customers throughout our eight-state service territory. We’re pleased to partner with the city and our Boulder customers as we begin this journey.”

In December 2007, Xcel Energy established the Smart Grid Consortium, bringing together leading technologists, engineering firms, business leaders and IT experts. Consortium members include Accenture, Current Group, Schweitzer Engineering Laboratories and Ventyx. The group will provide guidance, products and services needed to bring Xcel Energy’s smart grid vision to life.

In addition to its geographic concentration, ideal size and access to all grid components, Boulder was selected as the Smart Grid City because it is home to the University of Colorado and several federal institutions, including the National Institute of Standards and Technology, which already is involved in smart grid efforts for the federal government.

Smart Grid City could feature a number of infrastructure upgrades and customer offerings – for the first time fully integrated through the partnership’s efforts in Boulder – including:

- Transformation of existing metering infrastructure to a robust, dynamic electric system communications network, providing real-time, high-speed, two-way communication throughout the distribution grid;
- Conversion of substations to “smart” substations capable of remote monitoring, near real-time data and optimized performance;
- At the customer’s invitation, installation of programmable in-home control devices and the necessary systems to fully automate home energy use; and
- Integration of infrastructure to support easily dispatched distributed generation technologies (such as plug-in hybrid electric vehicles with vehicle-to-grid technology; battery systems; wind turbines; and solar panels).

The potential benefits of the Smart Grid City include operational savings, customer-choice energy management, better grid reliability, greater energy efficiency and conservation options, increased use of renewable energy sources, and support for plug-in hybrid electric vehicles and intelligent-home appliances.

With the city now selected, Xcel Energy and its Smart Grid Consortium will spend the next four weeks to six weeks studying the city’s electricity infrastructure to develop a scope and preliminary design plan for implementing the changes. Work would start soon after, but system changes will take place over the next few years.

The first phase of Smart Grid City is expected to be in place by as early as August 2008, with implementation throughout the city continuing through 2009. Beginning in 2009, the consortium also expects to begin an initial assessment of the technologies.

After initial implementation and assessment, Xcel Energy will use the results from this effort to talk with state, federal and regulatory officials about a larger deployment throughout the company’s eight-state service territory.

Xcel Energy also unveiled a Smart Grid Consortium web site today, www.xcelenergy.com/smartgrid, which has graphics and educational materials explaining its Smart Grid vision.

Xcel Energy (NYSE: XEL) is a major U.S. electricity and natural gas company with regulated operations in eight Western and Midwestern states. Xcel Energy provides a comprehensive portfolio of energy-related products and services to 3.3 million electricity customers and 1.8 million natural gas customers through its regulated operating companies. Company headquarters are located in Minneapolis. More information is available at xcelenergy.com.
The Smart Grid City

Xcel Energy’s Smart Grid Consortium is working towards a future when our energy grid can predict its problems and strengths while optimizing available resources.

The Consortium has announced plans to build Smart Grid City, a community that combines traditional and emerging technology to move the energy grid into the digital age.

This next-generation grid will allow customers and utilities to collaboratively manage power generation, delivery and energy consumption. Smart Grid City will boast a fully inter-connected energy system capable of managing the various parts of the grid involved in producing power and delivering it to consumers.

Key components of Smart Grid City include:
- A dynamic system rich in information technology
- High-speed, real-time, two-way communications
- Sensors throughout the grid enabling rapid diagnosis and corrections
- Decision-making data and support for peak efficiency
- Distributed generation technologies (such as wind turbines, solar panels, and plug-in hybrid electric vehicles)
- Automated “smart substations”
- In-home energy control devices
- Automated home energy use
The Smart House

Xcel Energy’s Smart Grid Consortium is imagining a future that would allow you to communicate your energy choices to the power grid and automatically receive electricity based on your personal needs.

The potential benefits:
- Lower cost of power
- Cleaner power
- A more efficient and resilient grid
- Improved system reliability
- Increased conservation and energy efficiency

Plug-in Hybrid Electric Car

Xcel Energy is studying how plug-in electric vehicles can store energy, act as backup generators for homes and supplement the grid during peak hours.

Smart Meter

Real-time pricing signals create increased options for consumers.

Smart Appliances

Smart appliances contain on-board intelligence that “talks” to the grid, senses grid conditions and automatically turns devices on and off as needed.

Smart Thermostat

Customers can opt to use a smart thermostat, which can communicate with the grid and adjust device settings to help optimize load management. Other “smart devices” could control your air conditioner or pool pump.

High-Speed Connections

Advanced sensors distributed throughout the grid and a high-speed communications network tie the entire system together.

Customer Choice

Customers may be offered an opportunity to choose the type and amount of energy they’d like to receive with just the click of a mouse on their computer.

100 percent green power? A mix of sources? The cheapest priced source? In Smart Grid City, it could be up to you.
Xcel Energy Smart Grid
A White Paper

INTRODUCTION

“He’s been dead more than 75 years, but Thomas Edison—hailed as the father of the light bulb—probably could run the nation’s modern-day electric grid. It just hasn’t changed that much.”

Denver Business Journal
March 30, 2007

Xcel Energy’s business strategy has multiple components, including a focus on our customers, people and communities. Our strategy of delivering reliable energy is complimented by our commitment to find the most environmentally feasible methods of meeting the energy demands of our customers. One area of opportunity revolves around the concept of a smart grid. While the industry has various definitions of a smart grid and there are multiple efforts underway that are called “smart grid,” we believe the opportunity to develop a fully inter-connected system allowing customers to automatically manage their energy consumption and enabling Xcel Energy to reliably produce and deliver that energy through real-time, automated controls is now available.

Xcel Energy’s vision of a smart grid includes a fully network-connected system that identifies all aspects of the power grid and communicates its status and the impact of consumption decisions (including economic, environmental and reliability impacts) to automated decision-making systems on that network. This vision leverages the multitude of vertical system solutions currently available and deploys a horizontal integration of these systems into a real-time, automated “neural network” that will manage all of the variables involved in delivering energy to the consumer. We believe this vision of an advanced decision-making system will allow Xcel Energy to more efficiently deliver energy while providing consumers with valuable information for better decisions on when, where and how to consume energy. The impact will be a greatly improved delivery system that optimizes the impact on the environment, ensures the most efficient delivery, and maximizes reliability.

Xcel Energy has been recognized in the past for its ability to drive transformation, in addition to its ability to bring partners to the table for leveraged development. Our past successes combined with a continued commitment of transformation presents us with a unique position to be one of the leaders in Smart Grid development and deployment within the industry. We are excited to establish this industry leadership with Xcel Energy’s vision of the smart grid.

The purpose of this white paper is to dive into the details of Xcel Energy’s Smart Grid, offer insight into related industry activity, and explain the steps we are taking to bring this smart grid vision to life through the implementation of a Smart Grid City. By doing so, we will validate our vision and demonstrate to the marketplace the possibilities.

What is a Smart Grid?

The fundamental method of operating the nation’s power grid has not changed much in the past 100 years. It has remained essentially the same, although the number of customers and their needs have grown exponentially. Utilities across the nation—and indeed, around the world—are trying to figure out how to bring their networks into the 21st century and the digital age. This effort to make the power grid more
intelligent is generally referred to as creating a “smart grid.” The industry sees this transformation to a smart grid improving the methods of delivery as well as consumption. Xcel Energy not only sees it as improving our energy security issue, but is the first utility to view smart grid as an environmental solution, helping solve the more pressing global issue of climate change.

While details vary greatly, the general definition of a smart grid is an intelligent, auto-balancing, self-monitoring power grid that accepts any source of fuel (coal, sun, wind) and transforms it into a consumer’s end use (heat, light, warm water) with minimal human intervention. It is a system that will allow society to optimize the use of renewable energy sources and minimize our collective environmental footprint. It is a grid that has the ability to sense when a part of its system is overloaded and reroute power to reduce that overload and prevent a potential outage situation; a grid that enables real-time communication between the consumer and utility allowing us to optimize a consumer’s energy usage based on environmental and/or price preferences.

**What Does Smart Grid Mean to Xcel Energy?**

Our vision of smart grid covers the entire value chain—“wind to light,” or “coal to cool air”—and sees smart grid as a continuing organic evolution that includes multiple layers of functional intelligence leading to real-time analytics, decision-making, and action.

We plan on partnering with key industry leaders to jointly fund the design and deployment of a complete smart grid model to a city within Xcel Energy’s service territory. The deployment of a working model will allow us to test and prove the value assumptions directly with our customers and regulators. By collaborating with industry leaders, we will spread the cost and associated risk across multiple players, thereby allowing a fully deployed smart grid system that can demonstrate the capabilities of technology to reform the industry.

Our vision of smart grid includes the optimization of all investment, operational expenditures, and environmental impact in coordination with consumer choices and by better managing supply (both central and distributed generation) and consumption. It allows consumers to become dynamically engaged in making intelligent and automated energy choices based on their own individual priorities, effectively balancing cost, reliability, and environmental impact on an individual customer basis; ensuring full application integration leading to the transformation of data and knowledge into real-time decisions and actions; and resulting in measurable value for all stakeholders across the entire value chain.

Concerns about climate change, environmental impact and sustainable energy solutions, along with a renewed personal sense of responsibility for limiting our carbon footprint, are key reasons consumers are pushing for cleaner, more efficient energy solutions. An integrated smart grid allows customers to better plan and manage their energy consumption while optimizing the grid through real-time generation and distribution control management.
The smart grid will create the ability to optimize traditional fuel sources and integration of renewable sources and distributed generation to reduce the impact we have on the environment, while still meeting our consumers’ growing energy demands. We believe the smart grid will result in:

- Positive environmental impact
- Customer choice from products to services
- Enhanced system reliability
- Increased efficiency of power delivery
- Extended asset life

We expect the smart grid to provide tangible and intangible benefits to all stakeholders, including consumers, shareholders, and regulators. It will bring environmental benefits that impact all of us today, as well as our future generations. Customers will have options and choices when it comes to the amount and type of power they use, and when to use those energy resources. Our systems will be more reliable, creating a reduced need for building additional capacity, and allowing us to better manage energy demand with the resources available and create higher returns. Utility operating costs will be lower as a result of automation and better visibility into operational aspects of the grid, leading to more efficient and effective use of resources.

**SITUATION ANALYSIS**

“Peak demand for electricity is projected to...grow by 19% over the next decade; ...currently committed capacity is projected to grow only by six percent.”

The Brattle Group, May 2007

The drive to pursue status as a “Next Generation” utility is based on the realities of a rapidly changing market dynamic that requires a balance among the environment, energy security, customer choices and energy concerns.

**Environment** – Concerns over environmental impacts of utility operations are at all-time high. Awareness of issues involving greenhouse gases and the promotion of “green power” has never before been at such a high level in the public consciousness. Utilities are pressured on many fronts to adopt business practices that respond to global environmental concerns. According to a study conducted by the National Renewable Energy Lab, if we do nothing, U.S. carbon emissions are expected to rise from 1700 million tons of carbon (Mtc) per year today to 2300 Mtc by the year 2030. In that same study, they demonstrate that utilities, through implementation of energy efficiency programs and use of renewable energy sources, could not only displace that growth, but actually have the opportunity to reduce the carbon output to below 1,000 Mtc by 2030.

To that end, Xcel Energy supported the legislative requirements in both our Colorado and Minnesota jurisdictions for increasing the renewable aspects of our portfolio. We have committed to the following renewable energy benchmarks:

- In Colorado, by 2020, 20% of annual retail electricity sales
- In Minnesota, by 2025, 30% of annual retail electricity sales, 25% of which will be derived from wind energy
**Energy Security** – Our nation has never seen threats like we have over the past several years. General societal threats can cascade over to industry reliability threats. In addition, our nation’s electric system is vulnerable and is critical to our way of life. Smart grid technologies can expand capabilities to effectively minimize and manage both concerns.

**Customer Choices** – The requirements of customers to be offered choices has also never been as high as they are today, and the demands of customers are expected to rise even further in the years ahead. Larger houses, exponentially larger amounts of electric usage, and higher expectations for choices and options for services in a digital economy have given rise to the need to provide more flexibility in how energy is provided to customers.

**Energy Concerns** – Given the global political climate and unstable foreign energy markets, the energy sector has been asked to respond to energy issues by adopting business practices that provide assurances that energy can be delivered to end-users reliably, continuously, and cost-effectively. With concerns over rising energy costs, many utilities are actively seeking ways to modify long-term strategies by ensuring that fail-safe provisions are accounted for.

Together these elements will lead to the most significant transformation of the energy market in a century. The migration of many disjointed energy markets into one has begun.

**Smart Grid Capabilities**

We believe a Smart Grid will provide new capabilities to customers, utilities and the overall energy market. Consumers will have the opportunity for choices not just with the type of energy they receive but also with the ability to manage their own consumption habits through in home automation. They will have visibility into how energy is used within their home, how much that usage costs them, and what kind of impact that usage has on the environment. They will have the option of self-managing that usage interactively, or setting preferences allowing the utility to automatically make adjustments based on those choices. We believe the smart grid will also open up opportunities for new consumer services, energy management offerings and products not currently possible with today’s infrastructure. We believe smart grid will allow utilities to intelligently respond to supply availability and demand.

Utilities can expect to enhance and refine their distribution and generation management with the help of real-time system information. As a result, they will be able to respond to peak demand loads more efficiently; identify outages and their related causes more precisely (enabling faster restoration); dispatch a more cost-effective mix of fuel sources (while minimizing environment impacts); and automatically re-route energy as needed to meet consumer demands and avoid unnecessary strain on the power grid.

Smart grid capabilities will enable marketers to have a real-time view of the demand on various aspects of the grid and manage the market accordingly.

With smart grid concepts continuing to evolve and emerge, we believe additional capabilities will be realized related to the integration of real-time data analytics and decision-making throughout all the components of a smart grid. These will become more apparent as the smart grid is implemented and matures.
Smart Grid Technologies

The fundamental component for making the smart grid work will be a robust and dynamic communications network; providing the utility the ability for real-time, two-way communications throughout the grid and enabling interaction with each component from fuel source to end use. Other key components for bringing the smart grid to life are utility devices (monitors, switches, fuses, etc.) for communication throughout the grid infrastructure and devices at consumers’ premises (meters, monitors, device / appliance controls, logic) for communications with the customer. Finally, there must be integration logic that brings all of this information together into a manageable, understandable format through the use of data management tools and neural networks.

Smart Grid Benefits

While we can identify several quantifiable benefits the smart grid will bring today, we believe many other significant benefits exist that will not become apparent until the smart grid begins to be implemented. Specifically, we believe there is compelling evidence that supports the following long-term benefit assumptions:

• Significant reductions in residential peak demand energy consumption achieved by providing real-time price and environmental signals in conjunction with advanced in-home technologies
• Additional reductions in residential peak demand by fully integrating the utility system with distributed generation technologies (scalable for mass penetration)
• Up to 30% reduction in distribution losses from optimal power factor performance and system balancing
• Potential carbon footprint reduction as a result of lowered residential peak demand and energy consumption, improved distribution losses and increased conservation options
• Possible reductions in the number of customer minutes out as a result of improved abilities to predict and/or prevent potential outages, and more effective responses to outages and restoration
• Expected deferral of capital spends for distribution and transmission projects based on improved load estimates and reduction in peak load from enhanced demand management
• Potential utility cost savings from remote and automated disconnects and reconnects, elimination of unneeded field trips and reduced customer outage and high-bill calls through home automation
THE MARKET

The Department of Energy has defined a smart grid road map intended to help guide utilities in developing future strategies. It includes:

- Smart meters enabled with two-way communication
- Intelligent home and smart appliances
- Demand side management and distributed generation
- Automatic correction for voltage, frequency and power factor issues
- Superconducting cables for long distance transmission
- Access to affordable pollution-free, low-carbon electricity generation
- Affordable energy storage devices available to anyone

Xcel Energy is not the only utility considering smart grid strategies. However, many of our peer’s efforts involve implementation of significant smart meter initiatives—and they refer to those implementations as “smart grid” initiatives. As a result, the terms smart metering and smart grid are often used synonymously. Up to a year ago, no one identified a discrete definition of “smart grid.” To address this and related problems, Xcel Energy worked with various stakeholders to develop a coherent vision of the smart grid by establishing a working group, called the Smart Grid Forum, to engage technology companies, public officials, policy experts, environmental advocates, and other participants in an effort to define what the smart grid means for our company, and to determine how stakeholders can help realize that vision.

As a result of the Smart Grid Forum, Xcel Energy has a more expansive conception of the smart grid than that of others in the industry. We are looking at the integration of the fuel source to the end-use consumer and all touch points in between. We believe that everything from a piece of coal or a breeze of wind to the thermostat has to be part of the smart grid and that it must include integration among all of the components. Very few, if any, of our peer utilities have a documented smart grid vision that encompasses the entire horizontal utility value chain like Xcel Energy does, nor do they tout the horizontal integration of various smart grid components as the key to the success. Xcel Energy has further set itself apart by identifying smart grid as one component to help meet the environmental challenges facing our industry and the world.

Because of our comprehensive smart grid vision and our incorporation of the environmental aspects into smart grid, many organizations in the marketplace have identified Xcel Energy as a leader in this space. However, as concerns for climate change and environmental impacts continue to increase, and consumers increasingly become aware of and educated about these issues, more and more utilities are doing things to help move the industry forward in relation to smart grid. While those things continue to only focus on specific components of the smart grid and not the end-to-end horizontal value chain that Xcel Energy has identified, it will likely not be long before others recognize the need for the broader, environmental focus, and perhaps overtake our hard-earned leadership position. If we act quickly, we can solidify our leadership position and be a significant influencer for moving our industry forward.
What Others are Doing

Southern California Edison

- Smart Meters — replacement of 5 million meters; field testing in 2007; final vendor selection by year-end; full deployment in 2009 (subject to PUC approval)
- Infrastructure expansion — $5 billion in last 5 years; plans for $9 billion during the next five years (Neighborhood power distribution circuits and on/off routing switches)
- PHEVs — Announced a partnership with Ford in July to explore this technology

Pacific Gas & Electric — Partnering with Tesla Motors on PHEVs and vehicle to grid technology

American Electric Power — Deploying advanced metering and an enhanced infrastructure; expected in place by 2010, fully deployed by 2015 to its 5M+ customer base

Others — Several states have AMI initiatives in place or plans for one in the future

Regulatory Strategies

To date, there has been regulatory approval for significant amounts of funding targeted at smart metering and a few cases of funding for various types of energy storage initiatives. However, while metering and energy storage are key components to a smart grid, the real risk in a true coal-to-cool-air, wind-to-light implementation of the smart grid is that these technologies that transform conservation and efficiency efforts can lead to degradation of the regulated return and uncompensated demand destruction. Mitigation of that risk requires efforts of both the utility, as well as the regulators. Utilities will need to focus on the creation of new products and services, transforming from a product model to a service model, and offering customers more options. Regulators will need to be partners in establishing different pricing regimens; ones which create incentives for utilities to earn revenue in ways that aren’t entirely linked to additional sales. The focus needs to be on the total customer bill, with an eye toward rewarding both the utility and the customer for conservation.

One of the design principles that will be applied in Xcel Energy’s approach to the smart grid, as demonstrated in the following paragraphs, will be focused on gaining consumer, regulatory, and legislative support for these efforts and a recognition that there needs to be some innovation in how utilities are compensated and allowed to make a return on their shareholders investment.
Xcel Energy’s Approach to the Smart Grid

As mentioned previously, Xcel Energy’s approach was to first convene a Smart Grid Forum to help define our vision for the smart grid. Once that was defined, a video was created to encapsulate the vision and then a high-level implementation plan developed. Our approach to smart grid implementation follows our Utility Innovations business model, the objectives of which are to:

- Collaborate with influential partners to craft a clear and understandable smart grid vision and identify a well-defined approach to smart grid deployment, aligned with our corporate objectives
- Develop a public policy strategy that manages expectations; addresses the long-term vision and current technical capabilities; and ensures return on investment
- Test smart grid components to measure and prove benefit; manage risk; and determine specific deployment strategies

Consistent with our model, our Smart Grid implementation involves a three-phased approach comprised of:

(I) Quick-hit projects
(II) Smart Grid City
(III) Xcel-wide deployment of proven technologies.

Phase I is in progress today. Phase II is planned for deployment in 2008 – 2010. Phase III will be dependent on the learnings from the first two phases.
Phase I – Quick-Hit Projects

In order to show action and quickly demonstrate smart grid concepts within each component of our utility value chain, engage partners with tangible investment opportunities, continue to publicize and communicate our vision of smart grid, and develop momentum and buy-in internally for the smart grid concept, seven quick-hit projects were identified to test various technologies that could be used to build intelligence into the power grid.

**Wind Power Storage:** This project tests a one-megawatt battery energy storage system connected directly to a wind turbine at the MinnWind wind farm in southwest Minnesota in an effort to store wind energy and return it to the grid. It is expected to demonstrate long-term emission reductions from increased availability of wind; help reduce impacts of wind variability; and allow us to meet Renewable Energy Standard legislation requirements. It will also help us test the technology to make wind power dispatchable on a utility scale.

**Neural Networks:** This project creates a state-of-the-art system that helps reduce coal slagging and fouling (build up of hard mineral in the boiler). Slagging results in several million dollars in lost revenue each year. Boiler sensors plug directly into the Distribution Control. Neural networks will model the slagging/fouling by using historical data to “learn” boiler behavior. The system also captures and incorporates knowledge directly from the plant engineers and operators – effectively capturing, modeling, and using hundreds of years of collective experience. Smart grid technologies will also help solve the impending demographic challenge all companies face.

**Smart Substation:** This project is retrofitting an existing substation (Merriam Park) with cutting-edge technology for remote monitoring of critical and non-critical operating data. Includes developing an analytics engine that processes massive amounts of data for near real-time decision-making and automated actions. The team will monitor breakers, transformers, batteries and substation environmental factors (such as ambient temperatures, variable wind speeds, security cameras, etc.) This project will help prove our ability to optimize power factor performance and obtain a significant reduction in distribution losses leading to a reduction in our carbon footprint. Expected operational benefits include reduced maintenance and installation costs; improved employee safety and equipment life; faster restoration times; and increased system reliability. This system will also test and demonstrate newly developed security technology.

**Smart Distribution Assets:** This project tests existing meter communication equipment that can automatically notify Xcel Energy of outages and help the utility restore outages more quickly. By using this Advanced Meter Technology, our Control Center will be able to detect isolated outages in advance of customer calls and dispatch crews to the correct location faster.

**Smart Outage Management:** This project tests diagnostic software that uses statistics on eight factors, including equipment maintenance, real-time weather and history to predict problems in the power distribution system (an Outage Cause Model). A Substation Feeder Analysis system can detect cable and device failures on monitored substation banks (a Cable Fail Predictor.) Success means responding to outages faster, with properly equipped crews—and possibly even preventing the problem—and detecting outages well before a customer’s first call.
Plug-in Hybrid Electric Vehicles: This project builds upon our previous impact study and takes it a step further by testing Plug-in Hybrid EVs in the field. The team is equipping six Ford Escape Hybrids with vehicle-to-grid technology, which will allow them to charge from and discharge energy to the grid, in one of the nation’s first field tests of this emerging technology. This project will help prove the significant environmental benefits associated with the dual value (transportation and electric energy storage) inherent in PHEVs by demonstrating to what degree the variable nature of renewable sources can be eliminated by utilizing massive amounts of storage devices connected to the grid and available to be dispatched. This project will move us closer to better understanding the energy security benefit of PHEVs by helping quantify the percentage of the vehicle fuel market that potentially can be moved to domestic electric energy sources. In addition, it serves as a testing and validation opportunity for other types of distributed generation, related to how they can be managed and how the energy from distributed generation can be put back onto the grid when needed.

Consumer Web Portal: This project will allow customers to program or pre-set their own energy use and automatically control power consumption based on personal preferences based against both energy costs and environmental factors. The Web interface will give customers an opportunity to automatically control their energy. Customers will be able to choose to turn devices on or off from pre-selected preferences (for example, hourly price points or green energy signals sent from the Web.)

Each of these projects is at various stages of development/deployment ranging from requirements definition, through final testing and analysis stages. Partners, each willing to co-invest, have been identified for all of the projects. All projects are expected to be complete, with final reports available, by the end of 2008.

Phase II – Smart Grid City

The quick-hit projects from Phase I are focused on vertical aspects of the utility. As indicated previously, we believe the true value from a smart grid comes from the communications infrastructure and the integration of those various components. As such, we believe the next critical step in Xcel Energy’s smart grid deployment will be a comprehensive demonstration of our vision of smart grid, brought to life in a mid-sized metropolitan city within our service territory; a 100% deployment of all of the elements from our quick-hit projects in one location, including all premises and the monitoring and control of all resources on the grid.

This Smart Grid City (Phase II of our plan) will be a true coal-to-cool air/wind-to-light development test bed for integration of information between silos. It will be a proof-of-concept that validates or disproves the proposed environmental, financial, and operational benefits of our Smart Grid vision. In the end, our Smart Grid City will become an international showcase of the possibilities.
Deploying Smart Grid City

• Funding of Smart Grid City is designed as a shared-risk model with contributions from multiple partners, thereby significantly expanding the scope while limiting financial risk to any one company or investor. The initiative will be funded similar to our Utility Innovations funding model, using partner-based co-investment in which the partners provide funding for all or part of an initiative in return for a share of the intellectual property and enhancements to, or creation of, their products and services. We anticipate co-investment from five to seven primary strategic partnerships and several other secondary partners. This funding model is expected to leverage Xcel Energy’s investment of $15 million six to seven times for a total Smart Grid City investment of approximately $100 million.

• The technology will consist of converting existing metering infrastructure to true two-way architecture integrated with outage management and customer information systems. In addition, we will convert substations to “smart” substations; provide/install 10,000 in-home control devices and the necessary infrastructure to fully automate home energy use; and integrate 1,000 dispatchable distributed generation technologies (PHEVs, battery systems, vertical wind turbines, and solar panels) designed to minimize our carbon footprint by eliminating the inherent variable nature of renewable energy sources.

• The city selection process will ensure the necessary political and regulatory engagement needed for support of the demonstration effort but also for future deployments.

• The initiative will be overseen by a Smart Grid Advisory Board consisting of members from our strategic partnership companies that will provide direction for the effort.

Smart Grid City Characteristics

An ideal location for Smart Grid City would be one that:

• Is operationally well defined and located in a geographically concentrated area (Geographic isolation is preferred; however, not required)

• Contains, or has easy access to, components necessary to implement and validate the Smart Grid concept

• Is a medium-sized metropolitan area (Approximately 50,000 customers)

• Offers “friendly” regulatory and political support

• Is visible, somewhat recognized, community (Neither obscure or remote)

• Is home to environmentally conscious consumers (Open to PHEVs, alternative sources of energy, and variations of energy usage)

• Provides optimal economic development, political, public relations and branding opportunities

• Remains open to opportunities to provide new services to the city. (Examples include: customers energy use and carbon footprint information, reliability information on specific city facilities, traffic lights, city buildings, and other high priority customers. Ability for cities to set priorities for power restoration and ability for city to see power restoration progress)

• Offers regulatory and political incentives for change (Tariffs, return, etc.)
Smart Grid City Regulatory Strategy

One of the objectives of our Smart Grid City initiative is to demonstrate the possibilities that smart grid technologies have for the enhancement of the grid of the future as well as its impact on the environment. We are also anticipating significant involvement in the effort from regulators and legislators as well to help educate them on those possibilities. The goal will not be to request specific recovery on the dollars we invest in the Smart Grid City effort but rather set the stage and work with the regulators on how recovery should be sought in the future. Because of the potential for rate return degradation and uncompensated demand destruction that the smart grid will result in, we believe that regulatory structures will need to be significantly different in the future than they are today. Our hope is to use Smart Grid City to help bring awareness to these issues and enable regulators an opportunity to see the value of smart grid and be open to making changes; perhaps even provide that test ground to experiment with different regulatory scenarios.

Proposed Timeline

<table>
<thead>
<tr>
<th>Activity</th>
<th>Timeline</th>
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<tbody>
<tr>
<td>Partner alignment</td>
<td>End of 2007</td>
</tr>
<tr>
<td>Scope and design</td>
<td>End of Q1 2008</td>
</tr>
<tr>
<td>Build out</td>
<td>April 2008 through March 2009</td>
</tr>
<tr>
<td>Benefit assessment</td>
<td>Beginning Q4 2008 through Q4 2009</td>
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During the initial partner alignment, we expect to finalize timelines and resource commitments from partners. We will also start discussions around intellectual property ownership between collaborators and ensure knowledge sharing occurs among this industry leadership group. Last, we will identify additional partners and thought leadership necessary to guarantee program success.
SUMMARY

The utility industry today is faced with not only supplying resources to accommodate the projected growth in demand for energy, but also minimizing and reducing the impact we have on the environment from producing that energy. Xcel Energy believes the smart grid provides a solution to this challenge. The benefits and payoffs are numerous.

For consumers, a smart grid means they can use electricity more wisely and save money by setting “smart” appliances that slow down or shut down on a hot, sunny day when demand for power and its corresponding cost are high. It means having many different options for using energy, and it means having a much better understanding of their overall energy use. For environmentalists, a smart grid means using technology to help solve climate change by conserving energy and using it more wisely. It also means better integration of renewable resources into standard operations, avoiding the creation of more carbon gases that have been linked to global warming. For investors, it provides additional revenue opportunities, will lead to the deferral of significant capital infrastructure investments, and will provide the ability to dramatically upgrade systems. It also means significantly improving reliability and increasing customer satisfaction.

The utility industry has reached a critical tipping point and our market is poised for change. The time for action is now—and perhaps more importantly, we can’t afford not to. Smart grid is the vehicle to move us away from Edison’s grid and move us towards both carbon neutrality and a fully secure energy future.
Smart Grid Enhances Homeland Security

Electric outages can have dire consequences for public safety. The 2006 Queens, New York blackout impacted 100,000 citizens and lasted for 10 days because power crews forced to rely on antiquated “Paul Revere” method of finding problem. The 2003 blackout shut down entire cities across the Northeast impacting 1/7th of the Nation’s population – and that was unintentional. Simply put,

PROLONGED OUTAGES = LIVES AT RISK

Smart grid can help, as follows:

Outage management

- power crews know where to go to repair downed and damaged wires
- power crews expedite power to customers through remote management of switches and other utility infrastructure
- restoration is verified sooner, so first responders know which areas are returning to normal conditions
- priority restoration possible for hospitals, police stations, National guard

Infrastructure protection

- high bandwidth gives direct data link to critical infrastructure and assets
- real-time sensor monitoring of substations prevents sabotage
- real-time sensor monitoring of government facilities (hospitals, State legislatures, military bases) and community centers (schools, universities)
- real-time control of non-utility critical infrastructure, like traffic signal system (to direct evacuation traffic flow)

Day to day savings: Homeland security assets reap same benefits of energy efficiency as others linked to a smart grid. The money saved can be devoted to primary mission instead of less-than-efficient power requirements.
“Technologies currently exist that would dramatically improve the performance of the Consolidated Edison distribution grid, providing a range of economic, environmental, and energy security benefits. The Task Force recognizes that the modernization of the grid to 21st century standards is a massive undertaking, requiring careful planning and major commitment of resources. Nonetheless, the magnitude of effort can no longer serve as a justification for inaction, or for Con Edison’s continued piecemeal “patching up” of the current system.”

“[T]he Task Force recommends that Con Edison launch a $20 million “Network of the Future” pilot program for the Long Island City network to demonstrate the advantages of “smart grid” technologies on both the customer and utility side of the meter, and that the costs of such a pilot program not be passed through to the rate-payers.”

“The ‘smart grid’ enhances the traditional elements of the grid with cutting-edge power engineering including distributed generation, sophisticated sensing and monitoring technology, information technology, and communications in order to provide better grid performance, enhanced security and seamless integration of additional services to consumers. Real-time information, delivered through high-speed networks, provides the critical linkage…."

“Similar to the nervous system in a living organism, the Smart Grid enables devices at all levels within the grid – from utility to consumer – to independently sense, anticipate, and respond to real-time conditions by accessing, sharing and acting on real-time information.”

EPRI / DOE Study:

**ELECTRICITY SECTOR FRAMEWORK FOR THE FUTURE**
Achieving the 21st Century Transformation

Smart Grid deployment can lead to:

- up to 10% reduction in electricity needed to drive same (or higher) GDP: p. 41 & 42
- up to 25% reduction in CO2 emissions: p. 42
- reduction of cost of power disturbances by 87%, saving billions of dollars: p. 40 & 42
- creation of $2 trillion/yr additional GDP by 2020: p. 43
5

VALUE OF THE 21ST CENTURY TRANSFORMATION

The value of the 21st Century Transformation goes well beyond the opportunities it opens for the electricity sector. In fact, its greatest value arises from the opportunities it opens for society as a whole. A transformed electricity sector has the potential to enhance economic productivity, improve energy efficiency and resource utilization, and generate substantial additional wealth to meet the growing societal needs of the 21st Century.

In this chapter, the value of the ESFF vision will be looked at in two ways: First, in terms of its ability to stem the large and growing costs of power reliability and power disturbances. This economic loss is largely hidden, elusive in nature, and is typically underestimated. Second, on the positive side, is the economic gain to be realized by properly supporting the rapid shift to the use of digital technologies by both business and industry. Preceding these two assessments is some background material on the demographic realities that underscore the urgency of striving for higher productivity growth targets, and the particular promise and vulnerability of using digital technology to achieve these growth targets.

The Demographic Challenge

Why are productivity improvements so important? One reason is that society is facing an uncomfortable choice in supporting aging baby boomers as they enter retirement years. In the simplest terms, the nation can ultimately either double the tax rate on those remaining in the labor force, or double their productivity. This means the U.S. needs to again find ways to maintain increased productivity growth rates across the board, as it did in the 1950s and 1960s. Fundamental technology change, built upon the platform of a revitalized electricity infrastructure, is the soundest way of ensuring that the nation has the economic resources to support an aging population. Failure to do so could easily result in intergenerational conflict, social upheaval, and a declining quality of life for all.

More specifically, within 30 years the U.S. dependency ratio (non-working to working population) is projected to increase by 75%. Under business-as-usual projections, this demographic change will require an expected increase in federal outlays for the Human Resources portion of the federal budget from 12% of GDP to 18%—a percentage equal to that of the total federal budget today. Even assuming no percentage increases in other budget categories such as Defense, this alone would require a 40% increase in taxes and would result in a higher fraction of GDP devoted to the federal budget than at any time since the peak of World War II. As federal revenues are more and more unable to keep pace with expenses, mounting and persistent deficits become increasingly unavoidable—leading to a potential scenario of higher interest rates and threatening the prospects for longer-term economic growth. This underscores the importance of accelerating productivity to stimulate faster economic growth. In constant 2000 dollars, this will mean sustaining a national productivity growth rate of at least 2.5% per
year over this period and beyond. This rate of growth was achieved during the latter half of the 1990s, but it is more than twice the rate sustained over the period of 1970 to 1995.

Figure 5-1

**Federal Revenues & Outlays, 1950 - 2030**

Expanding Use of Information Technology

The key to the accelerated productivity growth achieved since 1995 has been the rapidly expanding use of networked digital information and communications technologies (ICT). Their advantage is reflected in labor productivity, capital deepening and total factor productivity (TFP) gains. The productivity advantage achieved through ICT is most dramatic in liberalized markets where network improvements in information and communication can significantly enhance operational efficiency, expedite the matching of consumers and suppliers, and more closely align job requirements and worker skills. These advantages are applicable to all markets—product, capital and labor—and are proportional to the square of the number of network nodes that can be instantaneously linked. The diffusion of these ICT advantages is, however, still in its infancy in terms of the fraction of the potential markets engaged. This suggests that the economy has only scratched the surface in terms of exploiting the longer-run productivity gains that are likely to result from the creative use of digital ICT.

Infrastructure Implications

Despite the promise of digital technology for boosting U.S. productivity growth rates, it remains a “thoroughbred technology,” given its speed and fragility. It is highly sensitive to even the slightest disruption in power (an outage of less than a fraction of a single cycle can create a crash), as well as to variations in power quality due to transients, harmonics, voltage sags, etc.
Digital-quality power, with sufficient reliability and quality to serve these growing digital loads, now represents less than 10% of total electrical load in the U.S. It may reach 30% by 2020 under business-as-usual conditions, and as much as 50% under optimum conditions where the power system is revitalized with new all-electronic switches and controls.

In contrast, the electricity supply infrastructure has changed very little, and is making almost no provision to meet the changing needs of the economy. In fact, the investment needed to upgrade the infrastructure has reached new lows. As shown in Figure 5-2, capital expenditures by U.S. electricity providers were only about 12% of revenues during the 1990s, less than one-half of historic minimum levels and even below the level reached only briefly during the Depression.

In particular, the delivery system is not keeping up with the demands of digital technology. The transmission and distribution systems were designed for the industrial era of the 1950s and 1960s, when mechanical switching and radial network design were adequate. Annual investment in the transmission system has been cut in half since 1975. Despite increased demands placed on the system, capital expenditure plans announced by utility companies suggest that the under-funding trend is not being reversed. Figure 5-3 shows that projected expansion of the transmission system is roughly one-quarter of the projected growth in demand. As a result, line congestion is growing as indicated by the near doubling of requests for transmission line relief (TLR) between 1998 and 2002, also shown in Figure 5-3.

The key concern is that a large gap is opening between the economy and the infrastructure that supports it. Without substantial investment, the electricity supply system will almost certainly become a drag on future U.S. productivity growth rates.

**Figure 5-2**

![Capital Invested as % of Electricity Revenues](image)

Signposts of Trouble

There are already signposts of trouble. The power supply system is growing increasingly vulnerable in several regions. In some parts of the country, electricity consumers already suffer from inadequate generation or from transmission congestion during periods of high demand. This process is often exacerbated by historically low patterns of investment in infrastructure. Capacity limitations on the supply side, coupled with power interferences and disturbances on the consumer side, can sometimes lead to economic loss that cascades through the value chain, leading to losses sustained by industrial consumers and their suppliers alike. Although the losses to consumers are large and varied, there have been very little data to document and quantify the current situation comprehensively. Most estimates begin and end with the momentary impact at the point of disturbance.

On the contrary, losses are often quite varied in nature, and go well beyond immediate point of impact. For example, a nearly imperceptible one-second sag in voltage in one of the microprocessors running a paint gun in an auto plant could destroy the finish on one or more cars, and disrupt part of the assembly process. Similarly, a momentary disruption at a semiconductor-fabrication plant producing microprocessors could ruin an entire 30-day batch, and possibly the equipment itself. Further, in the tightly integrated supply lines typical of today’s just-in-time production, a small disruption can cascade upstream to hundreds of local suppliers, compounding the economic loss. In general, economic loss can include downtime, loss of raw material, damaged product, damaged equipment, disruption of supply chains, and even bankruptcy. In a few industries, such as information and financial services, the concerns over power reliability have now become “bet-the-company” investment decisions. At one new NASDAQ center in Connecticut, for example, the cost of power conditioning accounted for nearly two-thirds the cost of the entire facility. A similar ratio of power conditioning to total facility cost (68%) was found at a new Internet facility in Miami. These are anecdotal figures but they do point to the fact that the cost of power disturbances has risen dramatically in the last few years.

Figure 5-3

Transmission Grid Constraints

<table>
<thead>
<tr>
<th>Percent Change</th>
<th>Number of TLRs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>250</td>
</tr>
<tr>
<td>18</td>
<td></td>
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<tr>
<td>16</td>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

98-'07 Demand Growth
91-00 Trans. Expansion
98-'07 Trans. Expansion

*Calls for Level 2 or Higher Transmission Relief

2003
2002
1999

Month
In an effort to get a better handle on the economic loss from power reliability and power quality problems of all types, EPRI extensively surveyed some key industries in 2000 and extrapolated the results (see the sidebar, “Estimating the Costs of Power Disturbances”). The survey results were substantially higher than historic estimates, and the subsequent analyses indicated that the aggregate economic loss to the nation has climbed to more than $100 billion/year, or more than 1% of U.S. GDP. These results have been met with skepticism by some stakeholders, and certainly warrant further confirmation, but they are not out of line with the literally total reliance of business, industry and commerce on electricity. The costs of these power disturbances are parasitic in nature, and go largely unreported. They are passed on by businesses to all types to consumers in the cost of goods and services. Such costs are almost certain to climb in the years ahead unless action is taken to improve power reliability and quality.

There are other troubling signs of problems with the current power infrastructure. Serious incidents reflecting constrained capacity, often accompanied by price spiking and questionable financial dealings, have occurred in six of the last seven years. These problems have affected the Northeast and Midwest, in addition to California. Most observers conclude that the problems experienced during the last two years would have been even worse had it not been for the economic downturn and resulting drop in electricity demand.

Other problems arise from the threat of terrorist acts and sabotage that would compromise the security of the power system. The electricity system is a large and inviting target, and disruption of the grid would cause loss of human life and losses to society that extend far beyond the power system itself.

A final area of grid vulnerability is its growing inability to support the needs of competitive markets for electricity and related products and services. A massive transformation is needed to provide the grid with the policies, protocols, and technologies needed to support markets.

**Short-Term and Long-Term Responses**

The electricity supply system is in need of modernization, not just expansion. The nation finds itself in the awkward position of trying to use a system that still depends upon obsolete mechanical switches to power a 21st Century economy built upon billions of microprocessors operating at the speed of light. The grid is becoming incompatible with the nation’s economy.

Responses to the growing need for improved power quality are both short term and long term. Many of the short-term responses lie on the consumer side of the meter, where businesses with the need for “perfect power,” such as financial institutions and high-tech manufacturing, will be able to gain higher levels of reliability through the use of redundant power supply and power conditioning systems. The demand for uninterruptible power supplies on or close to the consumer premises is growing rapidly, and some high-tech firms and industrial parks have begun to plan for their own microgrids—small islands of digital-quality power in a sea of traditional power.

Some short-term solutions, however, are upstream of the meter. Activities such as improving maintenance practices, monitoring the “health” of critical equipment, and better preparations for outage recovery can materially reduce productivity losses. One reason that these and other fixes have not been implemented on a wide scale is the mismatch between who gains and who pays—in this case the electricity end-user realizes the benefits, while the distribution company incurs
Estimating the Costs of Power Disturbances

Data on the economic impact of power outages and disturbances are difficult to obtain. In nearly all cases, costs are passed on to the consumer, who neither sees them nor understands their impact. To obtain more reliable information on these costs, EPRI conducted a survey of 985 firms in three sectors of the economy with high sensitivity to power reliability. The firms surveyed were in the Digital Economy sector (data storage, financial and online services, etc.), the Continuous Process Manufacturing sector, and the Fabrication and Essential Services sector. The detailed survey asked respondents to estimate their costs arising from a series of power-quality and reliability events, based upon their recent experience. Data were collected and analyzed using the methods described below.

The estimated annual losses totaled $52 billion for the three sectors surveyed. Out of a total of 12 million business establishments in the U.S., about 2 million, or 17%, are represented by these three sectors. The average loss per business was estimated at $26,700 per year. Next, the researchers estimated the losses for sectors that they did not survey. They used two bounding assumptions to reflect the fact that the non-surveyed businesses would have a lower sensitivity to power outages than the surveyed sectors. In the first case, they assumed that the non-surveyed establishments suffered half the loss of the surveyed establishments. In numerical terms, the average loss per establishment was assumed to be $13,350/year for each of 10 million firms. In this case, the loss was estimated at $133.5 billion for the non-surveyed firms, plus $52 billion for the surveyed businesses, for a total of $186 billion. In the second case, the loss per establishment for non-surveyed companies was assumed to be 1/4 of the loss for surveyed companies. This leads to an estimated total economic loss of $120 billion.

Alternative approaches were also used to estimate losses for non-surveyed firms by looking at average revenues. This method assumes that the larger companies in three surveyed sectors would experience greater losses than smaller companies (on average) in the non-surveyed sectors. The three sectors surveyed constitute about 40% of GDP, or $4 trillion per year (U.S. GDP is approximately $10 trillion per year). Since there are 2 million such establishments, the average revenue per company is about $2 million per year. With economic losses estimated at $26,700 per company, losses in the surveyed sector equal roughly 1.3% of revenues. For the establishments not surveyed, the share of GDP is 60%. So the average revenue per company is $6 trillion divided by 10 million companies = $600,000 per company. For the case in which the losses at the non-surveyed companies are assumed to be 1/4 of the losses at the surveyed companies, the loss per company is $600,000, divided by the average revenue of $600,000, or 1.1% of revenue. The loss estimates are thus in the range of 1% of GDP, or $100 billion per year.

Finally, the researchers estimated the effect of scaling the losses by the GDP contribution of the sectors. This is what several reviewers of the report had suggested. In this case, the losses are $72 billion if the sensitivity of non-surveyed establishments is 1/4 of surveyed establishments and $91 billion if the sensitivity is 1/2.

All of the analytical methods and assumptions lead to economic losses that are in the ballpark of $100B per year, validating the thesis that the losses due to U.S. power system disturbances are much higher than expected, and have become the source of a significant loss to the U.S. economy. The loss represents an additional cost of about 50 cents for every dollar spent for electricity.

Technologies are now available that can reduce the frequency of disturbances and the damage they cause. Implementing these technologies over the next two decades should conservatively reduce outage costs by about half. However, failure to take action to reduce power disturbances will result in further degradation of the infrastructure, leading to an increase in costs, perhaps by as much as an additional $100 billion per year over a twenty-year period.

In addition to the direct costs of disturbances, some high-technology and information-based companies need essentially "perfect power." Increasingly, these companies are installing on-site equipment to meet their specialized needs. In a growing number of cases, the cost of installing power conditioning equipment in buildings has begun to dominate the cost of construction. So far, only anecdotal data are available to support this apparent trend. However, it's important to note that these preventive costs are not included in the estimated costs of disturbances.

EPRI is encouraging further research into the cost of power outages. Comprehensive assessments will require that researchers get into the field to get closer to the reality of how the costs of power disturbances emanate from the source. Refined estimates of the source and magnitude of power system losses will prove valuable as a means of determining how best to improve power system reliability and quality.
the costs. Moreover, the costs of unreliability are usually internalized by the commercial end-user, who passes the costs on to its consumers—a mechanism typically not available to the distribution companies. Some stakeholders believe that as awareness of the problem and the potential investment benefits grows, rate recovery will be allowed.

Longer term, it is crucial that the supporting power supply infrastructure be able to keep pace with the growing digitization of the economy. The rigor and pace of global competition, now impacting virtually every business in the U.S., are major drivers in the move to digitally controlled electricity use. It is hard to imagine any major industrial process, manufacturing facility, or commercial business in 2020 that would not be fully utilizing digital control and interactive links to its consumers through the “energy web.” As described in Wired Magazine (July 2001), the energy web will become a national system in which “every node in the power network is awake, responsive, adaptive, price-smart, eco-sensitive, real-time, flexible, and interconnected with everything else.”

**Vision of a More Productive U.S. Electricity System**

Table 5-1 summarizes some of the benefits of the 21st Century Transformation over the next 20 years. The table presents a current baseline plus two different projections of the future in 2020. The scenario shown in the table’s second data column is taken largely from DOE Energy Information Administration (EIA) extrapolations. We use those EIA forecasts to define a “business as usual” (BAU) case. The BAU case reflects elements of the Reliance on Regulation and the Blended Approaches Pathways.

The second view is an alternative, referred to in the table as the “enhanced productivity” scenario, which corresponds to the economic benefits of the 21st Century Transformation. This vision embodies the potential for creating a more efficient and reliable electric power system through the accelerated implementation of innovative technologies and architectures. It is important to note that the “enhanced productivity” case is not a forecast in the traditional sense. Instead, this scenario represents a set of highly challenging yet achievable “stretch goals” made possible by an enhanced electricity infrastructure. These reflect the opportunities that may be afforded by accelerating the fundamental technological changes underway in the U.S. economy and society. The enhanced productivity case incorporates analysis conducted as part of EPRI’s Electricity Technology Roadmap, as well as other sources, including the recently published report by the Energy Future Coalition, *Challenge and Opportunity: Creating a New Energy Future*.

**The Payoff of the 21st Century Transformation**

The “enhanced productivity” scenario of the 21st Century Transformation is based on the potential for further economic and environmental improvements through accelerated technological efforts. The deployment of more energy-efficient technologies has the potential for reducing the growth in bulk electricity consumption to about 1.3% per year over the next twenty years, compared with the 1.8% annual increase anticipated for the business-as-usual case. As shown in Table 5-1, this could result in an increase in electricity demand by 2020 of less than 30% above today’s level, rather than the 40% anticipated in the business-as-usual case. This means that 5-10% less electricity will be required to drive the same (or higher) GDP than under business-as-usual conditions. As a result, energy intensity is envisioned to be reduced by
about 40% in the enhanced productivity case vs. 20% in the business-as-usual case, a net improvement of 20%.

These are much more ambitious goals for energy savings than are typically forecasted or advocated today. However, similar instances of sharp reductions in energy intensity have occurred in the past both for total energy and for electricity. U.S. energy intensity declined by this same fraction from 1973 to 1999. In addition, since the oil embargo of 1973, the U.S. has gained nearly three times the energy from efficiency savings as it has from the net expansion of all domestic supplies combined. Moreover, the electricity intensity targets of the “enhanced productivity” scenario would allow the U.S. to achieve the energy efficiency levels of Japan and Germany, which have the lowest electricity intensities in the developed world.

Table 5-1: Potential Benefits of 21st Century Transformation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2000 Baseline</th>
<th>2020 Business As Usual</th>
<th>2020 Enhanced Productivity</th>
<th>Improvement of Enhanced Productivity Over BAU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Consumption (billion kWh)</td>
<td>3,800</td>
<td>5,400</td>
<td>4,900- 5,200</td>
<td>5 – 10% reduction</td>
</tr>
<tr>
<td>Delivered Electricity Intensity (kWh/$GDP)</td>
<td>0.41</td>
<td>0.33</td>
<td>0.27</td>
<td>20% reduction</td>
</tr>
<tr>
<td>Carbon Dioxide Emissions (million metric tons of C)</td>
<td>590</td>
<td>790</td>
<td>590 - 690</td>
<td>13 – 25% reduction</td>
</tr>
<tr>
<td>Worker Productivity Growth Rate (%/year)</td>
<td>2.5</td>
<td>2.0</td>
<td>2.5</td>
<td>25% increase</td>
</tr>
<tr>
<td>Real GDP ($billion 1996)</td>
<td>9,200</td>
<td>16,500</td>
<td>18,300</td>
<td>10% increase</td>
</tr>
<tr>
<td>Cost of Power Disturbances to Businesses ($billion 1996)</td>
<td>100</td>
<td>200</td>
<td>25</td>
<td>87% reduction</td>
</tr>
</tbody>
</table>

Source: EPRI, Energy Future Coalition

1. These specifications are primarily based on DOE-EIA projections and largely represent extrapolations of current trends.


Table 5-1 summarizes the payoff to society of rapidly developing and deploying the technology of the 21st Century Transformation, one that is fully capable of supporting the demands of digital technology. In this enhanced scenario, productivity growth rates are higher and the economy expands more rapidly, while energy intensity and carbon emissions are substantially reduced.

Worker productivity growth rate, for example, sustains the level of 2.5% achieved in the latter half of the 1990s (see discussion below on “Worker Productivity in the Digital Society”) as opposed to the 2% rate of the BAU case. The higher productivity rates can be sustained in the future because the highly reliable digital power infrastructure means that workers can perform existing and completely new functions quickly, accurately and efficiently. In this sense, transformed power reliability and quality become enabling agents —they are necessary for unleashing and streamlining the digital economy. The payoff from this economic progress is the
potential for creating nearly **$2 trillion per year** in additional GDP that would be available to both the private and public sectors by 2020.

One critical issue not covered in the table is the security of the power system. It is clear that national security would benefit from the improved electricity infrastructure envisioned in the 21st Century Transformation. A more reliable, self-healing electricity system that is better able to meet the demands of a digital economy would certainly contribute to national, energy-system security. Given the critical nature of electricity service to the nation’s economy and welfare, any significant interruption could be disastrous. While infrastructure security is critically important, it is not readily quantifiable. Uncertainties surrounding the business model for enhancing security (public sector financing versus market-based approaches, for example) further contribute to the difficulties in enabling security improvements today.

**Worker Productivity in the Digital Society**

During the latter half of the 1990s, the U.S. economy experienced a sharp increase in labor productivity, as reported by the Conference Board, Gordon, Roberts, and the Congressional Budget Office. Dale Jorgenson and others attribute this productivity “boomlet” to the efficiency gains of an increasingly digital economy. Knowledge workers are using computers not just to do old tasks more quickly, but also to perform unique and previously unimagined functions. Given this recent experience, it is important to assess whether these high productivity levels are sustainable.

Jorgenson believes that the sustainability of high productivity may be related to the life cycle of microprocessor generations. Historically, the life cycle has been about three years. However, the life cycle dropped to about two years in the latter 1990s. Jorgenson suggests that if the life cycle remains at two years, the productivity growth rate could be sustained at 2.5% per year. Sustaining this productivity growth rate indicates that GDP growth will be 3.5% over the same period. As shown in Table 5-1 on, real GDP nearly doubles every twenty years under these circumstances.

However, if life cycles return to their historical average, the labor productivity growth rate could decline to less than 1.5% per year and GDP growth would be only 2.5% over the same period. Although this analysis seems reasonable, the overall economic health will determine the demand for increased microprocesser speed and therefore the life cycle of chips.

Finally, returning to the enabling effect of reliable electric power on productivity and the economy, the 1% loss in GDP currently ascribed to power disruptions is a near-term opportunity to improve productivity. Success in developing and deploying the technology of an enhanced electricity infrastructure could support sustained GDP growth of 3.5% per year by removing the losses from power disruptions and the brake on future growth of the digital economy. In particular, the two-way flow of communication and power through an energy/information portal would allow faster and deeper penetration of productivity-enhancing technology in all sectors of the economy.

**Conclusion**

Electricity has had a long history of stimulating and sustaining economic growth and improving the efficiencies of all factors of production. This is particularly true for the productivity of labor
and energy. Now, the self-healing grid and the energy/information portal will drive a new wave of productivity growth. Combined with the development of advanced end-use electro-technologies, the 21st Century Transformation of the electricity sector will introduce new efficiencies into the use of energy, labor, and capital for industry, business, and homes.

Improving worker productivity is particularly important as we look toward the demographic challenges of the new century. Birth rates are declining in most developed countries. In some countries, notably Italy and Japan, birthrates are below the replacement level, and populations are declining. Although these effects are currently less pronounced in developed countries with large immigrant populations—such as the U.S., Canada, and Australia—the growing social needs of an aging population will ultimately affect all countries, developed and developing. Worker productivity will have to increase substantially to meet the social costs of a growing retired population.

Realizing the 21st Century Transformation will be critically important to boosting productivity growth rates, and enabling trillions of dollars of additional revenue for use by both the private and public sectors. Figure 5-4 portrays the combined potential benefits enabled by a transformed electricity infrastructure, both in terms of stemming power-disturbance costs and taking the brakes off economic growth. Given the innovative opportunities that are emerging, it is likely that this projection only scratches the surface of what will be enabled for our economy and quality of life.

Most stakeholders have found the potential payoff of this vision sufficiently compelling to warrant concerted action by the electricity sector as a whole. The next chapter outlines some possible action pathways. Above all, the stakeholders emphasized their desire for continuing dialogue among those with diverse interests to achieve mutual understanding, trust, and resolution of the actions needed to expedite progress toward the transformed electricity sector.

Figure 5-4
Sustainable future requires electrical smart grid

By Jared Blumenfeld - Special to The Bee

When it comes to global warming, the future is rapidly approaching. Electricity generation and distribution produces 40 percent of all the carbon dioxide emissions in the United States.

Despite a great deal of talk about climate change, the electric power industry's nationwide CO2 emissions have risen 5.9 percent since 2002 and a whopping 11.7 percent since 1997. We need energy solutions – and we need them now.

California has taken the bold step of requiring that 20 percent of all our electricity come from renewable sources by 2010 and is now looking at increasing that target to 33 percent renewable energy mix by 2030. This is excellent news. However, the grid that transports energy is itself part of the problem.

In the last two decades our society has been transformed by the processing power of computers and yet the energy-delivery system that feeds these technologies has not been modernized since its inception a century ago. Instead, more and more demand has been thrust upon an antiquated electrical grid. Today, 10 percent or more of all electricity distributed by utilities is lost from grid inefficiency – never reaching the consumer. It's like trying to run your iTunes software off the Commodore 64 in the garage. At some point you need to upgrade.

Information and communications technologies are becoming an essential driver of productivity improvements and innovation for the 21st century that will enable green innovations in buildings, energy production and use, and transportation.

Potential rewards of investing in real-time communications are significant. For example, a recent study sponsored by the U.S. Department of Energy demonstrated significant results from new "smart grid" technologies to monitor and adjust home energy consumption, reducing average household consumption by 10 percent. Proactive management of home energy use by consumers using this technology could reduce peak loads on utility grids up to 15 percent annually. In addition, the grid itself can be optimized to reduce overall power consumption by several percent without any change in consumer behavior.

The Electric Power Research Institute has defined a smart grid as "a power system that can incorporate millions of sensors all connected through an advanced communication and data acquisition system." This real-time analysis will enable predictive responses allowing utilities to "manage their load." Thus only electricity that is needed will be generated and distributed.

As more of us put solar panels on our homes and businesses, a smart grid is needed so the utility can integrate these renewable resources into the electric grid. Customers could be rewarded for producing renewable energy when it is most needed, or encouraged to
reduce consumption at times when renewable energy supply is low, saving both costs and environmental impact. These types of integrated solutions can reduce CO2 emissions from the electricity grid by up to 25 percent. If precise, real-time management of the electricity load were in place, it could even eliminate the need for the controversial practice of utilities firing up costly, dirty peaker plants.

In a similar manner, as plug-in hybrid vehicles become more available (San Francisco just received its first three) a smart grid will help drivers charge their cars when energy is cheap and then be able to transfer excess energy back onto the electricity grid at peak hours (at a profit).

During the 2006 heat wave in California, hundreds of transformers failed. The outage affected about 80,000 customers over six days. Smart-grid technology would help utilities monitor key pieces of equipment such as transformers and provide the capability to take proactive action such as reducing load to prevent failures. It would also speed restoration of service by detecting outages and their underlying causes. This system of constant monitoring would allow proactive action to reduce the likelihood and impact of blackouts.

By making the electric grid just 5 percent more efficient nationwide, we would prevent emission of more than 275 million tons of CO2. This equates to taking 42 large coal-fired power plants off line, or 53 million cars off the road – forever.

Not surprisingly, the Energy Independence and Security Act, signed into law five months ago sets the implementation of a smart grid as the policy of the United States. And yet, California's three largest utilities – PG&E, Southern California Edison and San Diego Gas & Electric – are about to spend $4.2 billion to install meters with limited communications capabilities that are not compatible with the requirements of a smart grid.

California urgently needs to adopt a policy that requires any new meter and communications network installed to be capable of the two-way, real-time communications necessary for the smart grid. Otherwise, we will be wasting money on old technologies and foreclosing the possibility of a smart grid in California for the next decade.

Texas, Ohio, Maryland, Spain, Italy and Brazil were not cradles of the Internet or renewable energy, but they are all deploying smart-grid networks today. Combating climate change will require investing in infrastructure. A smart grid platform is a critical next step in getting to a more sustainable future. California cannot afford to be left in the dark.

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'Smart meters' may soon be outdated

Instead of broadband, utilities opt for cheaper, lower-speed connections.
April 20, 2008

California's three biggest utilities are charging customers nearly $4.6 billion to install millions of "smart meters" at homes and businesses. These newfangled meters, the utilities promise, will revolutionize energy usage by giving consumers far greater control over how much they pay for power.

Unfortunately, the meters could be outdated before they're even operational.

Instead of installing meters capable of receiving high-speed broadband Internet signals, Southern California Edison, San Diego Gas & Electric and Pacific Gas & Electric have opted for cheaper, lower-speed connections.

Yet the utilities are also laying the groundwork for advanced "smart grid" networks that will use broadband technology for managing power supplies and distribution.

The upshot: smart grids and smart meters that, in essence, won't speak the same language.

"Relative to the meters you have now, the new ones are pretty smart," said Kurt Yeager, executive director of the Galvin Electricity Initiative, a nonprofit group focused on improving the national power infrastructure. "Relative to the meters they should be installing, they're pretty stupid."

The utilities insist that lower-speed meters will function fine with a high-speed grid, and that ratepayers shouldn't be concerned about being sold a pig in a poke.

"The two-way communication is the key component," said Paul De Martini, director of Edison's "SmartConnect" program, which includes the utility's $1.7-billion rollout of 5.3 million new meters from 2009 to 2012. "Whether it's narrow-band or broadband is a secondary consideration."

Perhaps for the moment. The real question is how smart grids will be used five or 10 years from now.

Nobody could have known a decade ago that high-bandwidth services like YouTube and video downloads would one day dominate the Internet. Nowadays, you'd be crazy to access the Net with the slowpoke technology available back then.

The lower-speed meters will cost ratepayers about $100 each. Broadband meters would cost as much as five times more.

The utilities know that what customers get from smart grids today could be very different from what they'll expect in a few years. But they've decided to place short-term economic considerations ahead
of long-term technological prospects.

This runs contrary to federal and state policy.

In December, President Bush signed into law the Energy Independence and Security Act, which, among other things, promoted creation of smart grids to better manage the country's power supply.

California regulators directed state utilities to pursue smart-grid technology several years ago to give consumers more control over their energy usage.

The idea is that interactive connections would give utility customers real-time information about energy rates and let them plan their activities accordingly. Instead of doing the laundry in the afternoon when power is expensive, you'd be able to see when rates are lower and save money by doing the wash then.

More intriguingly, a new generation of appliances could be programmed to automatically pick times when energy prices are lower, or when renewable energy such as wind or solar power is more plentiful.

Consumers also would be able to access months of usage and billing records, and run programs to help them determine the best ways to economize.

Meanwhile, grid managers would be able to quickly pinpoint troubles during outages and allocate resources accordingly.

That's the idea anyway. The reality, at least as far as California utilities are concerned, is that the coming smart meters will do little more than save the companies money by allowing them to read customers' meters remotely -- thus enabling them to fire their meter readers.

The new meters also will allow utilities to connect or disconnect service remotely, saving them the expense of sending a technician to your home.

Experts say it's unlikely that the utilities would be able to provide real-time pricing info to millions of customers without broadband connections.

They also say that lower-speed meters could clog existing bandwidth with trouble reports during an outage, preventing utilities from getting an accurate fix on the scope of a problem or where to send repair crews.

The utilities counter that customers will be able to enjoy full smart-grid capabilities as long as they have a separate broadband Internet connection. For those who don't, sorry.

"We think this is the best way to serve our customers," said Anne Shen Smith, senior vice president of customer service at San Diego Gas & Electric, which is spending $570 million to roll out 1.4 million new meters by 2011.

"We can put these meters in now and give you immediate benefits," she said. "Then we'll look at incremental benefits down the road and translate that into what it means for rates and costs."
In other words, SDG&E and the other utilities will upgrade or even replace their meters once they see how much consumers want all the capabilities that come with a broadband smart grid.

"It wouldn't surprise me if there isn't more functionality we want to install down the road," said Jana Corey, director of Pacific Gas & Electric's smart meter program. The San Francisco-based utility is spending $2.3 billion to install 10.3 million new meters by 2011.

Californians could end up having to pay twice to get to the smart-grid future that state and federal officials have already decreed to be our goal. This would be profitable for the utilities, which stand to gain additional revenue with each meter upgrade, but very expensive for ratepayers.

"Once you deploy these new meters, it will be very, very hard to upgrade them," said Robert Robinson, a vice president at consulting firm Booz Allen Hamilton who specializes in electric utilities.

"No one knows what all the futuristic applications will be," he said. "You want to be thinking about the endgame for all the things that will connect to the grid through your meter. All of that will require bandwidth."

It's possible, of course, that the cost of broadband meters will come down in the future, and that waiting to upgrade makes more economic sense. Similarly, not all ratepayers may want the full functionality of a broadband meter.

But if the growth of the Internet tells us anything, it's that it's better to be technologically prepared for all the bells and whistles that come with advanced data networks. Chances are, it'll be cheaper over the long run to bring consumers up to speed now, rather than waiting to upgrade their meters in the future.

Is it too late for the utilities to shift gears? No. Thousands of new meters have already been installed in pilot programs, but millions more have yet to make it to people's homes.

Terrie Prosper, a spokeswoman for the California Public Utilities Commission, said the new meters met performance standards set by regulators.

But she acknowledged that "to be cost-effective, the systems implemented by the utilities are less sophisticated and less expensive than a broadband system."

It seems incredibly shortsighted to build a high-speed network for utilities that consumers will be able to access only through lower-speed meters. State regulators need to take a closer look at this situation and determine what's best for the state as a whole, not just the utilities.

Otherwise, a few years from now, we could have the dumbest smart grid in the country.

Consumer Confidential runs Wednesdays and Sundays. Send your tips or feedback to david.lazarus@latimes.com.

http://www.latimes.com/business/la-fi-lazarus20apr20,0,4357622.column
The attached chart from a McKinsey study conducted for utility companies shows that utility Advanced Metering programs (AMI, "smart" meters, wireless mesh, etc) have a NEGATIVE NET PRESENT VALUE which is, of course, not in the best interests of ratepayers. Unless AMI is part of a Smart Grid, or ready to operate with a Smart Grid, AMI is not cost-effective.

AMI Cost/Benefit Analysis: *McKinsey Model*

**Results Summary ($Millions)**

<table>
<thead>
<tr>
<th>Deployment Costs</th>
<th>Electric</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital</td>
<td>$ Per Meter</td>
<td>Capital</td>
</tr>
<tr>
<td>Electric Meters with AMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meters per month</td>
<td>265</td>
<td>$120</td>
<td>247</td>
</tr>
<tr>
<td>Meters per year</td>
<td>115</td>
<td>52</td>
<td>115</td>
</tr>
<tr>
<td>Installation</td>
<td>98</td>
<td>45</td>
<td>92</td>
</tr>
<tr>
<td>IT Integration and Software</td>
<td>60</td>
<td>27</td>
<td>60</td>
</tr>
<tr>
<td><strong>Total Capital</strong></td>
<td>$538</td>
<td>$244</td>
<td>$514</td>
</tr>
</tbody>
</table>

| On-going Annual O&M Expense | $13 | $6 |

| Annual Benefits          | $21  | $9  | $20  | $9  |
| Distribution Operations  | 8    | 4   | 8    | 4   |
| Revenue Enhancement      | 9    | 4   | 8    | 4   |
| Avoided Capital          | 2    | 1   | 2    | 1   |
| **Total Benefits**       | $41  | $18 | $38  | $17 |

**NPV (20 yr)**

($198) ($199)

*Analysis does not include costs or benefits for an intelligent end, only AMI.*