ENERGY AND THE ENVIRONMENT

CHAPTER 12

AMERICA DEPENDS ON RELIABLE AND AFFORDABLE access to diverse sources of energy. The $1.2 trillion U.S. energy industry powers the rest of the economy, making possible a good quality of life and strong economic productivity.[1]

U.S. prosperity and national security, as well as the health of the planet, require a national transition to a low-carbon economy and reduced dependence on foreign oil. Congress has demonstrated significant resolve in jump-starting this transition, devoting more than $80 billion in the American Recovery and Reinvestment Act of 2009 (Recovery Act) to clean energy and efficiency investments.[2] Americans have mounted solar panels on their roofs, weatherized their homes, installed efficient light bulbs and traded their "clunkers" for vehicles that get higher gas mileage. But the U.S. economy still runs mostly on domestic fossil fuels and imported oil.

Broadband and advanced communications infrastructure will play an important role in achieving national goals of energy independence and efficiency. Broadband-connected smart homes and businesses will be able to automatically manage lights, thermostats and appliances to simultaneously maximize comfort and minimize customer bills. New companies will emerge to help manage energy use and environmental impact over the Internet, creating industries and jobs. Televisions, computers and other devices in the home will consume just a fraction of the power they use today, drawing energy only when needed. Large data centers, built and managed to leading energy efficiency standards, will be located near affordable and clean energy sources. Finally, broadband connectivity in vehicles will power the next generation of navigation, safety, information and efficiency applications while minimizing driver distraction. Next-generation safety systems will alert drivers to hazards, helping to avoid accidents and saving lives. In the process, broadband and information and communication technologies (ICT) can collectively prevent more than a billion metric tons of carbon emissions per year by 2020.[3]

The path to reliable, affordable and clean energy will require ingenuity and hard work from legions of scientists, entrepreneurs and green-collar workers, as well as the participation of every American. Consumers and businesses will need easy access to information about the type, amount and price of energy to make informed decisions about their consumption. The price of electricity will also have to better reflect the cost of providing power, which can skyrocket during critically hot days.

Broadband alone cannot solve the country's energy and environmental challenges, but it will be an important part of the solution.

This chapter is divided into four sections. The first two focus on how broadband and advanced communications can make the greatest impact on energy and the environment: as the foundation of a smarter electric grid and as a platform for innovation in smart homes and buildings, especially if utilities unlock energy data. The third section highlights how industry and the federal government can improve the energy efficiency and environmental impact of ICT usage. The fourth explores how broadband and advanced communications can make transportation safer, cleaner and more efficient.

RECOMMENDATIONS

Integrate broadband into the Smart Grid

- As outlined in Chapter 16, the Federal Communications Commission (FCC) should start a proceeding to explore the reliability and resiliency of commercial broadband communications networks.
- States should reduce impediments and financial disincentives to using commercial service providers for Smart Grid communications.
- The North American Electric Reliability Corporation (NERC) should clarify its Critical Infrastructure Protection (CIP) security requirements.
- Congress should consider amending the Communications Act to enable utilities to use the proposed public safety 700 MHz wireless broadband network.
- The National Telecommunications and Information Administration (NTIA) and the FCC should continue their joint efforts to identify new uses for federal spectrum and should consider the requirements of the Smart Grid.
- The U.S. Department of Energy (DOE), in collaboration with the FCC, should study the communications requirements of electric utilities to inform federal Smart Grid policy.

Unleash innovation in smart homes and smart buildings

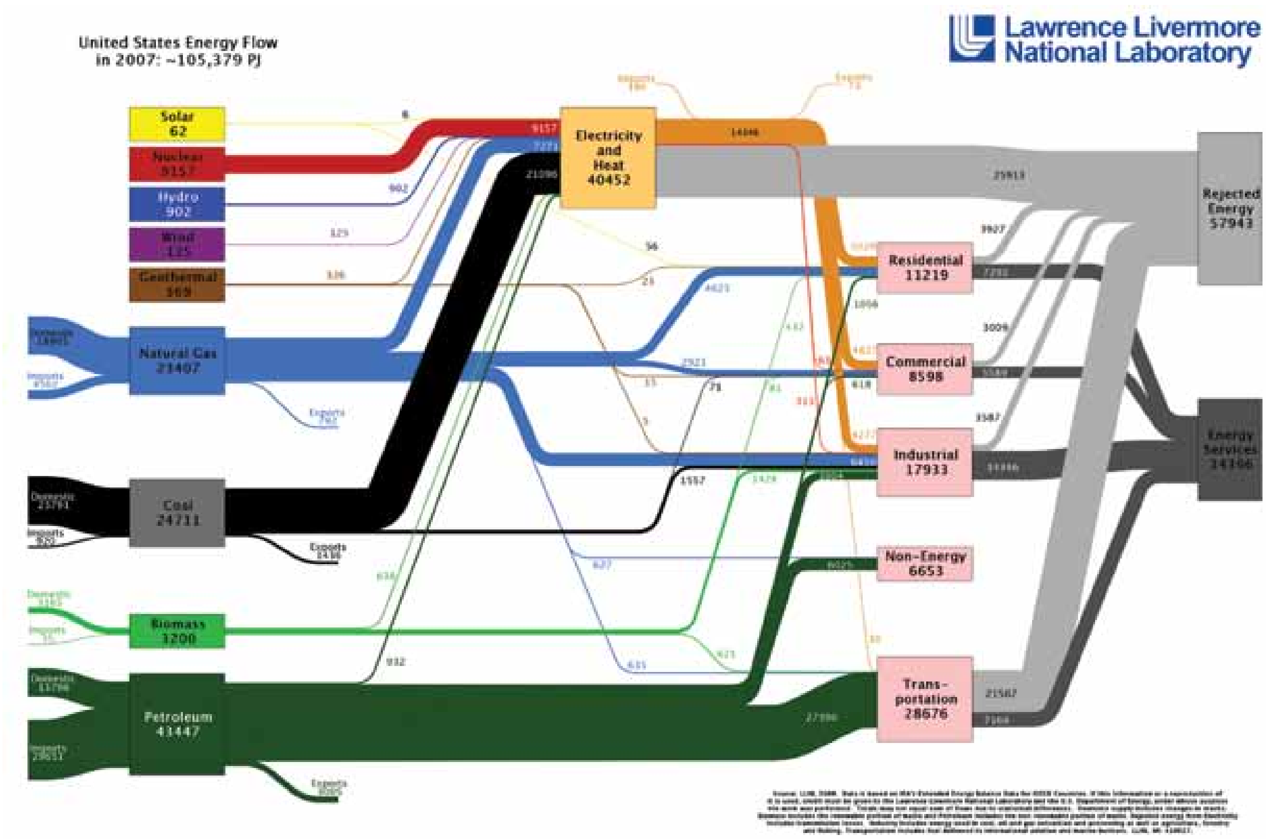
- States should require electric utilities to provide consumers access to, and control of, their own digital energy information, including real-time information from smart meters and historical consumption, price and bill data over the Internet. If states fail to develop reasonable policies over the next 18 months, Congress should consider national legislation to cover consumer privacy and the accessibility of energy data.

- The Federal Energy Regulatory Commission (FERC) should adopt consumer digital data accessibility and control standards as a model for states.
- DOE should consider consumer data accessibility policies when evaluating Smart Grid grant applications, report on the states' progress toward enacting consumer data accessibility and develop best practices guidance for states.
- The Rural Utilities Services (RUS) should make Smart Grid loans to rural electric cooperatives a priority, including integrated Smart Grid-broadband projects. RUS should favor Smart Grid projects from states and utilities with strong consumer data accessibility policies.

Accelerate sustainable ICT

- The FCC should start a proceeding to improve the energy efficiency and environmental impact of the communications industry.
- The federal government should take a leadership role in improving the energy efficiency of its data centers.

BOX 12-1:



United States Energy Flow (Petajoules, 2007)[9]

The national energy balance sheet reveals a number of pertinent facts. First, coal-fired power plants generate almost half of our electricity and are responsible for nearly two billion metric tons of greenhouse gas emissions per year—equivalent to the emissions of the entire transportation industry.[10] Greenhouse gas emissions from coal, and to a lesser extent natural gas and oil, explain why the electric power industry is the single largest contributor to U.S. greenhouse gas emissions.[11] Second, although there has been explosive growth in solar, wind and biomass power in recent years, renewable generation still provides a small amount of our generating capacity. Third, the current electricity system, from generation to end-user, wastes vast sums of energy; for example, a light bulb receives less than half of the energy contained in a piece of coal. Finally, the U.S. transportation sector is almost wholly reliant on oil, more than half of which is imported.

12.1 BROADBAND AND THE SMART GRID

The United States is undertaking a massive communications and information technology buildout to produce the Smart Grid, which the National Institute of Standards and Technology (NIST) defines as the "two-way flow of electricity and information to create an automated, widely distributed energy delivery network."[4]

The vision is to build a modern grid that enables energy efficiency and the widespread use of both renewable power and plug-in electric vehicles, reducing the country's dependence on fossil fuels and foreign oil. This grid will intelligently detect problems and automatically route power around localized outages, making the energy system more resilient to natural disasters and terrorist attacks. It will keep bills low and minimize greenhouse gas emissions.

Realizing the promise of the Smart Grid will require the addition of two-way communications, sensors and software to the electrical system, both in the grid and in the home. Communications are fundamental to all aspects of the Smart Grid, including generation, transmission, distribution and consumption.

The Energy Independence and Security Act of 2007 (EISA) made modernizing the grid national policy, and the Recovery Act devoted $4.5 billion to accelerating standardization and deployment of the Smart Grid. The Electric Power Research Institute estimates that the U.S. will spend $165 billion over the next 20 years building the Smart Grid.[5]

The Smart Grid is a national priority for several reasons. It will increase the reliability of the electric grid, more efficiently integrate renewable generation, reduce peak demand and support the widespread adoption of electric vehicles.

First, as the current patchwork grid has become more interconnected and complex, reliability has become more critical. Power blackouts cost the nation as much as $164 billion per year.[6] The Smart Grid could prevent many blackouts by sensing problems and routing power around them (see the story of the 2003 blackout in Box 12-2).

Second, to combat climate change, national and state energy policies increasingly encourage the development of generation assets—such as solar, wind and nuclear—that emit fewer greenhouse gases. But renewable power can be intermittent; clouds can mask the sun and wind can stop blowing without warning. The country will need greater intelligence in the grid and viable energy-storage solutions in order to meaningfully displace fossil fuel generation. Renewable power and distributed

BOX 12-2:

The 2003 Northeast Blackout and Synchrophasors

On Aug. 14, 2003, a high-voltage power line in Ohio failed after contact with an overgrown tree. When a grid alarm system also failed, a cascading set of faults traveled throughout eight northeastern states and southeastern Canada over the next two hours, as transmission system operators tried to determine the cause and full extent of the problem. In total, more than 50 million people lost power, trapping some in elevators and leaving vulnerable populations at home without air conditioning.

According to Secretary of Energy Steven Chu, a smarter grid could have prevented the blackout, which cost the nation an estimated $6-10 billion.[18]

A key finding of the U.S.-Canada Power System Outage Task Force was that network operators did not have the right data and tools in place to view, analyze and control grid events as they quickly deteriorated. First, each operator only had visibility in his or her own control area. The grid, however, is heavily interconnected across regions and so operators must be able to see the status of the grid beyond their area to make appropriate adjustments in response to grid events. Second, only limited real-time, time-coded, synchronized energy data was available in 2003, preventing operators from quickly seeing the cascading events even within their own areas.

Advanced grid sensors, called synchrophasors, would have given those grid operators sufficient visibility to prevent the spread of the blackout. Synchrophasors measure voltage, current and frequency 30 times or more per second, compared with once every four seconds for legacy systems. Given higher bandwidth and low latency requirements, these advanced sensors are often connected with utility fiber networks. Synchrophasors improve wide-area visibility and control, allowing grid operators to track real-time grid conditions, observe emerging problems and take actions to protect system reliability. The high granularity of the data can also facilitate: 1) better post-disturbance analysis, 2) improved system utilization, and 3) better analysis of the integration of renewable power into the grid.

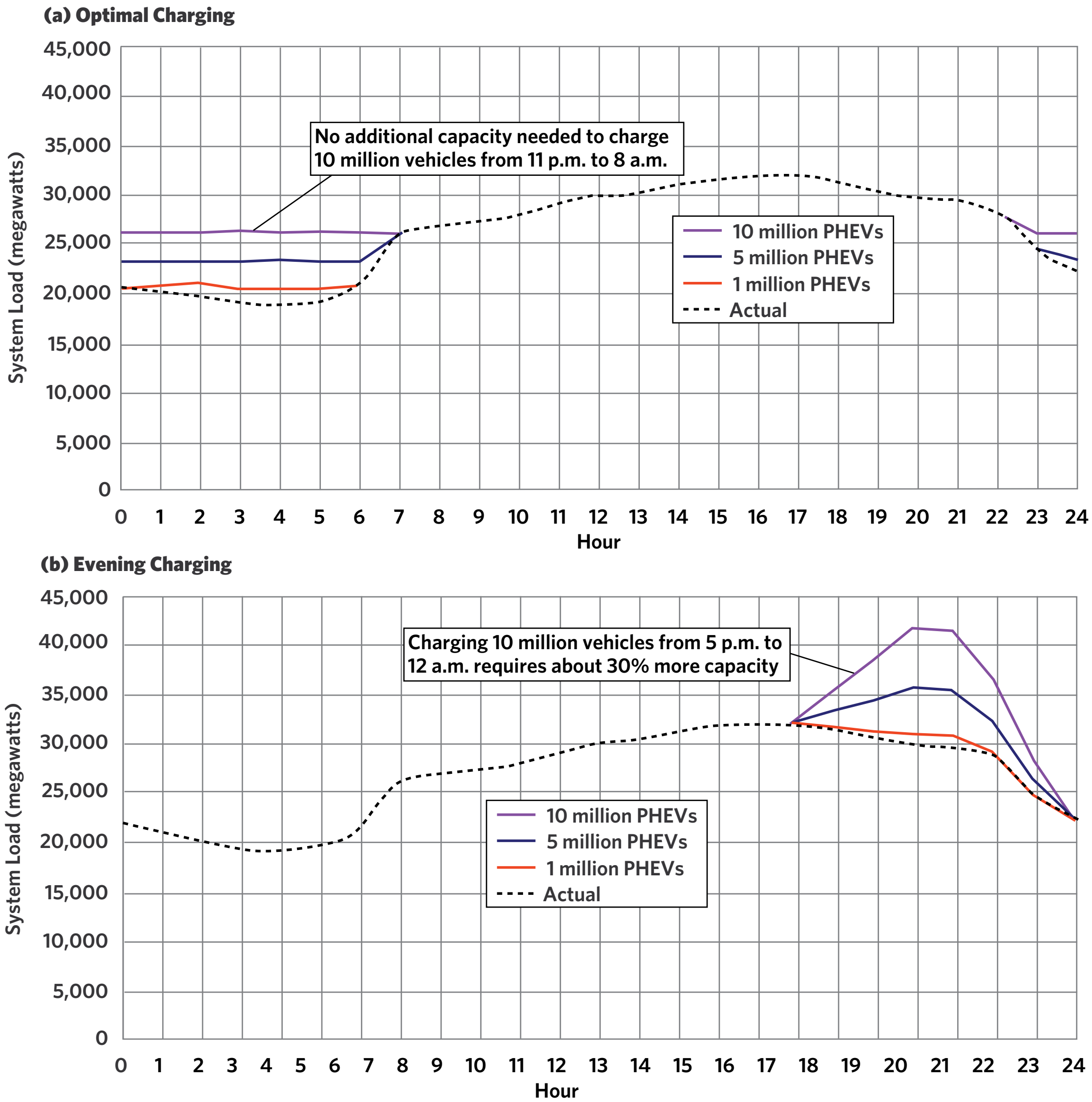
Along with industry, the Recovery Act is funding the deployment of synchrophasors across the country's electric transmission system. The funds will help pay for the installation of nearly 900 synchrophasors, improving reliability, security and visibility of the entire electric transmission system.[19] In the future, synchrophasors will extend throughout the distribution grid, transmitting data over wide-area broadband networks.[20]

generation will also drive the need for greater communication because they will transform the one-way power system into a sophisticated two-way system, where homes, vehicles and buildings sometimes draw power from the grid and sometimes contribute power to it.[7] A recent study by the Pacific Northwest National Laboratory estimates the Smart Grid can reduce greenhouse gas emissions from electricity generation by as much as 12% by 2030, which is equivalent to taking 65 million of today's cars off the road.[8]

Third, it is important to shift energy usage away from the cripplingly expensive times of peak demand. To meet those peaks, utilities build and maintain power plants that only run for hours per year. In New England, for example, 15% of the total generating capacity is needed less than 1% of the time—fewer than 90 hours per year.[12] As a result, state regulators are increasingly looking to change the structure of retail rates—which are mostly flat today—to time-varying or dynamic rates that better reflect the cost of supplying power. A smarter grid is necessary to communicate those prices to consumers and help them manage their energy use. According to a recent FERC report, dynamic pricing and better demand-side engagement can reduce peak demand by as much as 20% by 2019, limiting the need to build expensive new power plants.[13]

Fourth, a smarter grid is necessary if America wants to lead in the shift toward vehicle electrification. Almost all of the global automakers are developing plug-in hybrid electric or full electric vehicles, and, if successful in the market, these vehicles have the potential to reduce U.S. dependence on foreign oil by half and decrease greenhouse gas emissions of the light-duty vehicle fleet by 27%.[14] Without a Smart Grid, widespread

Exhibit 12-A:
California Independent System Operator (ISO) System Load Profiles in Various Plug-in Hybrid Electric Vehicle (PHEV) Deployment Scenarios[16]



adoption of electric vehicles would require the construction of many more power plants. A 2008 study illustrates the challenge: California's grid has enough spare capacity to charge a fleet of more than 10 million plug-in electric hybrids at night without requiring new plants. But if drivers plugged in the same 10 million vehicles at the end of the workday, California would require 10 gigawatts of new capacity (see Exhibit 12-A). According to a DOE study, the U.S. has enough existing capacity to power 73% of its light-duty vehicle fleet once a smarter grid is in place that can charge vehicles entirely at off-peak times.[15]

Smart meters, which are located at customers' homes and provide two-way communications with their utility, will play a major role in the Smart Grid. FERC estimates that the number of smart meters deployed will rise from eight million today to 80 million in 2019.[17]

Smart meters, however, are just one part of the effort to modernize the electric system. The Smart Grid also includes new and legacy applications in the generation, transmission and distribution systems, including Supervisory Control and Data Acquisition systems, outage management systems, energy management systems and a host of new sensing technologies, such as synchrophasors (see Box 12-2). These systems allow utilities to operate the grid more efficiently, safely and reliably. They also allow grid operators to detect, prevent and recover from faults, helping avoid blackouts. But they require communications networks capable of operation during and immediately following disasters.

Today, the more than 3,000 electric utilities in the United States use a variety of networks, including wired and wireless, licensed and unlicensed, private and commercial, fixed and mobile, broadband and narrowband. Traditionally, electric utilities build private networks to support applications with a high level of reliability, such as those for grid control and protection. These systems have operated separately from commercial networks, often utilizing privately owned, proprietary narrowband solutions.

However, current narrowband solutions are not able to support the growing number of endpoints requiring connectivity in the modern electric grid,[21] and many utilities believe that solutions using unlicensed spectrum will be suboptimal for mission-critical control applications.[22]

The amount of data moving across Smart Grid networks is modest today but is expected to grow significantly because the number of devices, frequency of communications and complexity of data transferred are all expected to increase.[23] Various parties have attempted to estimate bandwidth requirements; none expect existing narrowband communications will be sufficient. Sempra Energy has found that it will require "pervasive mobile coverage of at least 100 kbps to all utility assets and customer locations."[24] Similarly, DTE Energy believes it will require connectivity of 200-500 kbps to support pole-mounted distribution devices.[25] And, as Southern California Edison points out, "the history of new technology deployments shows that performance and bandwidth needs were underestimated at early stages."[26]

Commercial networks are not available in all areas where utilities have assets and provide service.[27] Commercial data networks are less commonly used for mission-critical control applications, in part because they have historically been unable to ensure service continuity during emergency situations, which is a fundamental requirement for utility control networks. The record indicates that commercial wireless data networks can become congested or may fail completely because of a lack of power backup or path redundancy.[28]

In summary, the lack of a mission-critical wide-area broadband network capable of meeting the requirements of the Smart Grid threatens to delay its implementation.[29]

The country should pursue three parallel paths. First, existing commercial mobile networks should be hardened to support mission-critical Smart Grid applications. Second, utilities should be able to share the public safety mobile broadband network for mission-critical communications. Third, utilities should be empowered to construct and operate their own mission-critical broadband networks. Each approach has significant benefits and tradeoffs, and what works in one geographic area or regulatory regime may not work as well in another. Rather than force a single solution, these recommendations will accelerate all three approaches.

RECOMMENDATION 12.1: As outlined in Chapter 16, the Federal Communications Commission (FCC) should start a proceeding to explore the reliability and resiliency of commercial broadband communications networks.

Commercial broadband networks, and wireless broadband networks in particular, can serve more mission-critical and wide-area utility communications needs as service providers adopt measures to improve the reliability and resiliency of these networks during emergency scenarios. Because 97.8% of Americans are already covered by at least one 3G network,[30] a hardened commercial wireless data network could serve as a core part of the Smart Grid.

The benefits of a more reliable commercial broadband network are much broader than enabling the Smart Grid alone. A more reliable network would also benefit homeland security, public safety, businesses and consumers, who are increasingly dependent on their broadband communications, including their mobile phones. Today, more than 22% of households in America do not subscribe to fixed-line telephone service.[31]

RECOMMENDATION 12.2: States should reduce impediments and financial disincentives to using commercial service providers for Smart Grid communications.

Commercial wireless networks are often suitable and widely used for many Smart Grid applications, particularly metering and routine sensing systems. In certain situations, compared with private networks, commercial networks may provide substantially similar network performance at an equal or lower total cost of ownership.[32] A commercial network that can ensure service continuity would be capable of supporting additional mission-critical applications. However, many large utilities have economic disincentives to use commercial networks and may be making suboptimal choices. As rate-of-return regulated utilities, they typically earn guaranteed profits on the assets they deploy—including private communications networks—but only receive cost recovery if they use commercial networks.

Public utility commissions (PUCs) must ensure that utilities' incentives do not lead them to make suboptimal communications and technology decisions. State regulators should carefully evaluate a utility's network requirements and commercial network alternatives before authorizing a rate of return on private communications systems. Consistent with EISA,[33] PUCs should also consider letting recurring network operating costs qualify for a rate of return similar to capitalized utility-built networks. California is currently considering this question.[34]

In many states, electric utility incentives are still oriented toward deploying assets and selling more power, not selling less or cleaner power.[35] This thorny structural problem is outside the scope of the National Broadband Plan, despite its explicit Congressional mandate to address energy efficiency. However, a national strategy to support the growth of the Smart Grid must recognize that many large electric utilities have inherent financial incentives to deploy regulator-approved communications systems but have mixed-to-poor incentives to use these systems to deliver energy more efficiently. There are meaningful exceptions: Box 12-3 illustrates an example of a U.S. utility working collaboratively with customers to reduce peak load and to encourage energy efficiency.

RECOMMENDATION 12.3: The North American Electric Reliability Corporation (NERC) should clarify its Critical Infrastructure Protection (CIP) security requirements.

NERC, the organization under FERC's authority responsible for the reliability of the bulk power system, should revise its security requirements to provide utilities more explicit guidance about the use of commercial and other shared networks for critical communications. In future versions of the CIP standard, NERC should clarify whether such networks are suitable for grid control communications. NERC should also clarify how its CIP requirements will coexist with NIST's cybersecurity standards. The perceived ambiguity on CIP requirements appears to be slowing utility decision-making and stifling the deployment of some Smart Grid applications on commercial networks.[37]

RECOMMENDATION 12.4: Congress should consider amending the Communications Act to enable utilities to use the proposed public safety 700MHz wireless broadband network.

The wide-area network requirements of utilities are very similar to those of public safety agencies. Both require near-universal coverage and a resilient and redundant network, especially during emergencies. In a natural disaster or terrorist attack, clearing downed power lines, fixing natural gas leaks and getting power back to hospitals, transportation hubs,

BOX 12-3:

The Idaho Power Company: A Case Study[36]

The Idaho Power Company, which serves more than 485,000 customers in the state, has had some of the lowest electricity prices in the nation due to its heavy reliance upon cheap hydroelectric power. The impact of a statewide drought and the 2000-01 Western energy crisis led prices to spike tenfold, and the Idaho Public Utilities Commission put in place an aggressive set of energy efficiency programs to reduce price volatility and help lower customer bills.

The utility instituted a demand response and direct load control program, supported by broadband and other communications technologies, that compensates homeowners, farmers and businesses for reducing their electricity use during periods of peak demand. Homeowners receive a $7 credit if the utility can automatically cycle their air conditioners. Farmers, who require a significant amount of electricity to pump water to irrigate their fields, can earn rewards if they cut their irrigation time by up to 15 hours a week.

In addition, Idaho Power offers rebates for attic insulation, advertises to promote consumer-oriented energy efficiency products and runs energy-saving classes for customers. Since state regulators have decoupled the company's profits from how much energy it sells, the utility has new incentives to get its customers to reduce their energy use.

These measures have led to a 5.6% drop in the state's peak power demand and have saved more than 500,000 MWh of energy since 2002, equivalent to eliminating the energy used by 5,000 homes over the intervening eight years. In addition, some customers have seen reductions of as much as 30% in their electricity bills.

water treatment plants and homes are fundamental to protecting lives and property. Once deployed, a smarter grid and broadband-connected utility crews will greatly enhance the effectiveness of these activities.

Congress should consider amending the Communications Act to enable utilities to use the public safety wireless broadband network in the 700MHz band, subordinated to the communications of Section 337-defined public safety services. Jurisdictions that are licensees or lessees of the public safety 700MHz broadband spectrum should be allowed to enter into agreements with utilities on uses and priorities. At the sole discretion of the public safety licensee, utilities should also be able to purchase services on a public safety network, contribute capital funds and infrastructure or even be the operator of a joint network. These statutory changes should create more options for the construction and operation of a public safety wireless broadband network. Although the network will take years to build, carrying critical traffic from multiple users can help lower costs for all.

Several examples already exist of networks that are being shared successfully by public safety entities and utilities. SouthernLINC, a subsidiary of the Southern Company, provides commercial wireless service in the Southeast and voice communications for Southern Company itself. Because the network was built to very high reliability standards, almost a quarter of SouthernLINC's customers are public safety and other public agencies. Another example is the Nevada Shared Radio System, which is jointly operated by two Nevada utilities and the Nevada Department of Transportation (the Nevada State Patrol is also a customer).[38]

RECOMMENDATION 12.5: The National Telecommunications and Information Administration (NTIA) and the FCC should continue their joint efforts to identify new uses for federal spectrum and should consider the requirements of the Smart Grid.

Many large utilities plan to build their own private wireless broadband networks to support their mission-critical Smart Grid applications.[39] Traditionally, utilities have not participated in broadband spectrum auctions because the geographic boundaries and regulatory requirements of these licenses have been incompatible with utility business models and service territories.[40] Utilities report they are limited by their lack of access to suitable wireless broadband spectrum[41] and that lack of a nationwide band to build an interoperable Smart Grid will slow the nation's progress toward greater energy independence and energy efficiency.[42] Several vendors do provide private wireless solutions in licensed spectrum, but in various bands, protocols and speeds.[43]

Identifying a nationwide band in which Smart Grid networks could operate would speed deployment of a standardized and interoperable broadband Smart Grid.[44] Establishing a nationwide band would also promote vendor competition and lower equipment costs.[45]

NTIA and the FCC should specifically explore possibilities for coordination of Smart Grid use in appropriate federal bands. Any new broadband network built in the identified spectrum should be required to meet standards of interoperability, customer data accessibility, privacy and security. Use of this spectrum should not be mandated, so that legacy systems are not stranded and that commercial, other shared networks and unlicensed wireless networks can be used where appropriate.

RECOMMENDATION 12.6: The U.S. Department of Energy (DOE), in collaboration with the FCC, should study the communications requirements of electric utilities to inform Federal Smart Grid policy.

Understanding the evolving communications requirements of electric utilities will help DOE develop informed Smart Grid policies for the nation. As an input to this plan, the FCC solicited public comment on Smart Grid technologies, and a number of utilities filed detailed responses. However, many utilities declined to comment, and others understandably declined to reveal confidential or sensitive information in public filings.

DOE, in collaboration with the FCC, should conduct a thorough study of the communications requirements of electric utilities, including, but not limited to, the requirements of the Smart Grid. Building upon the FCC's recent efforts, DOE should collect data about utilities' current and projected communications requirements, as well as the types of networks and communications services they use.

12.2 UNLEASHING INNOVATION IN SMART HOMES AND BUILDINGS

One of the most important and cost-effective ways to meet national energy goals is to encourage energy efficiency in homes and businesses—but end-users need better information in order to maximize energy and cost savings.

Today, most Americans receive an electricity bill—via paper or an electronically delivered PDF—12 times a year after the energy use occurs. They do not know the price of electricity, the source of the power or the amount of power needed to run each of their appliances. Most Americans know how much gasoline they need for a week's worth of commuting, yet almost no one knows how much electricity it takes to run a load of laundry, turn on an additional flat-screen television or cool a home an extra two degrees.

Smart meters help change this equation because they generate real-time data. In addition to their other operational capabilities such as automated meter reading and remote power monitoring, smart meters can record or transmit three types of information:

- Historical energy consumption data (e.g., "How much power did I use yesterday, last month and last winter?")
- Real-time data (e.g., "How much power am I using right now?")
- Price and demand response data (e.g., "What is the price of electricity right now?")

In dozens of consumer trials, Advanced Metering Infrastructure (AMI) technologies combined with time-based pricing tariffs have led to reductions of both peak demand and total energy consumption. A recent study of 15 utility pilots by the Brattle Group found that time-based or dynamic pricing of electricity resulted in a drop of peak demand between 3% and 20%, depending on how the pricing was set up. Adding technologies such as two-way programmable communicating thermostats, in-home energy displays and two-way load control systems drove the drop in peak demand to between 27% and 44%.[46] When people see just how expensive electricity is when demand peaks on a hot summer day, they find ways to conserve energy or defer their usage. This not only saves consumers money, but also greatly cuts costs for the utilities, given that the plants brought on line to meet peak demand are easily the highest-cost producers. A drop in peak demand also helps the environment because it helps prevent the need for new fossil-fueled power plants.

Even without price incentives, simply providing consumers better information about their energy use has been shown to reduce total consumption by 5–15%,[47] equating to savings of $60–180 per year for the average American household.[48] Making better information widely available would result in billions of dollars in savings per year by consumers and businesses.

Real-time energy consumption and price data also create an opportunity for consumers to select from a growing number of products and services that can help save energy. General Electric, for example, is developing refrigerators that automatically wait until power is less expensive before they run a defrost cycle or make ice.[49] Whirlpool plans to have one million Smart Grid-compatible clothes dryers available by 2011 and has announced that by 2015 all of its appliances will be able to connect to a Smart Grid.[50] Programmable communicating thermostats and energy displays like those made by Tendril, EnergyHub and others can show consumers how much they have spent to date and can automatically adjust the temperature based on a customer's desired energy spending amount and level of comfort.[51] Google and Microsoft, among others, have released Internet-based visualization tools that help consumers get a better handle on their energy use.[52]

For commercial and industrial customers, innovative software companies are already finding ways to deliver real value from energy data. Minnesota-based Verisae, for example, remotely monitors and manages its customers' assets, such as a grocery chain's freezers, over the Internet. Analyzing detailed data, Verisae can identify opportunities for its customers to invest in energy-efficiency improvements that maximize return on investment. Verisae can even identify when assets require maintenance, preventing costly failures and extending equipment life.[53] And as explained in Box 12-4, Massachusetts-based

BOX 12-4:

A Virtual Power Plant

Downtown Boston is home to one of the country's largest power plants. But instead of nuclear fuel rods or massive piles of coal, this plant is powered only by sophisticated software, broadband Internet and companies that are willing to reduce their energy use on demand.

The idea behind this "virtual power plant," run by Massachusetts-based EnerNOC, is simple. Typically, when electricity demand rises above supply, utilities must either generate more electricity or buy additional power from other suppliers on the grid. Financially, EnerNOC functions like an extra power plant during these peaks. But instead of generating additional electricity, EnerNOC provides the grid a temporary reduction in demand (the service is called demand response in industry parlance). EnerNOC partners with more than 3,000 commercial and industrial customers who are willing to temporarily reduce their power consumption. These businesses, from grocery stores to factories, reduce energy demand by dimming non-critical lights in a warehouse or by temporarily suspending an energy-intensive industrial process.

EnerNOC needs two things to make this virtual power plant work: broadband Internet and access to its customers' real-time energy consumption data to verify they are really curtailing load when called upon. Many customers already have Internet connections and where they lack connectivity, EnerNOC can install commercial wireless data modems. But getting a customer's real-time energy information can be an onerous process, often involving a meter upgrade. As more residential, commercial and industrial customers upgrade to smart meters, the number of customers that can participate in such virtual power plants will expand, but only if these customers and their vendors have access to real-time digital energy information.

EnerNOC uses real-time energy data and secure communications over the Internet to create a virtual power plant made up of commercial and industrial customers who earn money by temporarily reducing their loads during critical peaks.[54]

Broadband is essential to realizing the full potential of smart homes and buildings.[55] Pervasive Internet connectivity brings innovative competitors, technologies and business models to energy management systems, from sophisticated building management systems to simple home thermostats. Internet connectivity to stand-alone energy displays, multipurpose security and home automation systems, televisions, computers and smartphones enables consumers to see more information (e.g. weather conditions, energy prices, bills-to-date) and make smarter decisions about energy use. Broadband allows consumers to monitor and control their home energy use from the convenience of a mobile phone.

However, broadband by itself is not sufficient to unleash the full innovation potential of smart homes and buildings. The country also needs open standards and customer data accessibility policies.

Standards are critical to the Smart Grid. For example, the faster NIST can accelerate market convergence toward a small number of appliance communications standards, the sooner manufacturers can offer smart appliances that communicate with the rest of the smart home. Standards will help ensure that the Smart Grid is "plug-and-play," encouraging innovation by giving companies a large potential market for devices and applications and providing customers with the ability to use any of them to take advantage of the grid. The NIST standards development process should continue to draw on lessons from the Internet. Open standards are critically important—Internet Protocol being a prime example. In addition, security and privacy should be fundamental to both network architectures and everyday business processes.

Despite the wide variety of potential uses for the energy information created by smart meters, these data are not yet available to customers. One study of a number of large utilities found that of the almost 17 million meters being planned or deployed by the respondents, there were clear plans to provide customer access to the data only 35% of the time. Furthermore, less than 1% of the respondents' customers have real-time access to their energy data today.[56]

A national Smart Grid policy should encourage tens of thousands of entrepreneurs to innovate—using new technologies and business models—to create a wide variety of in-building energy management and information services. Making energy data available to customers and their authorized third parties, while employing open and non-proprietary standards, is the best way to unleash this vast potential for innovation.[57] The history of the Internet illustrates how entrepreneurs can develop disruptive applications, attract investment capital and compete to deliver value to customers—thereby driving innovation, economic growth and job creation (see Box 12-5).

BOX 12-5:

Energy Management Applications[58]

It is a blistering hot summer day. You have just arrived at work and realize that you forgot to turn off your home air conditioning, which is blowing full blast. In the past there was nothing you could do until you returned home. But today there are new mobile applications ("apps") that allow you to take action anytime, anywhere.

There are already dozens of apps on smartphones, computers and other devices dedicated to home energy measurement and management. Companies such as Visible Energy, Control4 and many others offer apps that let you monitor your energy consumption and control your lights, security system, entertainment system and thermostat from the comfort of your living room couch or a remote location.

These applications are not just for early adopters with high-end home automation systems. Socially minded or cost-conscious consumers who want to better track their energy use can use online sites like Microsoft's Hohm and Google's PowerMeter.

A national broadband plan in 2010 cannot fully anticipate how Americans will use energy in 2050. Perhaps energy generation (and storage) will be much more distributed by then, with the grid functioning mostly as an intelligent broker between net-zero buildings exchanging power. Maybe energy transactions, not just energy management and efficiency, will be the next killer application of the Internet. The federal government need not know the answer in 2010; rather, it should use a combination of incentives, rules and standards to foster an open marketplace where the best ideas, technologies and entrepreneurs can compete for investment capital and customers.

RECOMMENDATION 12.7: States should require electric utilities to provide consumers access to, and control of, their own digital energy information, including real-time information from smart meters and historical consumption, price and bill data over the Internet. If states fail to develop reasonable policies over the next 18 months, Congress should consider national legislation to cover consumer privacy and the accessibility of energy data.

Consumers, and their authorized third parties, must be able to get secure, non-discriminatory access to energy data in standardized, machine-readable formats. Customers should have access to their data in the same granular form in which it is collected, and in as close to real-time as possible. Innovative companies—from large service providers to small startups—and utilities should be able to compete on a level playing field to provide a wide variety of home and building energy information and management services.

PUCs should mandate data accessibility as a part of Smart Grid rate cases, especially smart meter deployments. Consistent with EISA, these policies should mandate secure consumer accessibility to real-time energy consumption data, time-series consumption and billing data and dynamic price data.[59] Regulators should also require regulated utilities to adopt business processes that clearly articulate the methods by which consumers can authorize and de-authorize third-party access. Regulators should also strongly consider requiring distribution utilities to provide consumers' generation mix and emissions data in as close to real time as possible.[60]

Several state PUCs and legislatures have already started to require customer access to energy data. The California PUC has recently ruled that its major investor-owned utilities must provide customers access to their usage and price data by the end of 2010 and must provide real-time access by the end of 2011.[61] The Pennsylvania legislature has required all large utilities to create a plan for deploying AMI systems with customer data access capabilities. In Texas, the PUC has established a common data portal in which customers, utilities, electricity retailers and third parties will be able to securely access and exchange digital energy information over the Internet.

States and utilities should not wait for full smart meter deployments to take these steps. Though smart meters will provide increased data resolution, digital access to simple monthly consumption data has many benefits. Historical usage and bill information lets consumers analyze their energy usage over time, evaluate prospective energy-efficiency measures and even compare their consumption against similarly sized houses. Better access to utility bill data also lets new buyers of homes or buildings factor energy efficiency information into their purchase decisions.

With reasonable privacy protections, the federal government should be granted limited access to utility bills from homes receiving federal energy efficiency funds to better evaluate the government's energy efficiency programs, such as weatherization. Energy consumption data, when aggregated, can be very useful to a wide variety of public policy and economics researchers. States should consider how third parties might get access to anonymized datasets for research purposes, with strict privacy protections.

By the end of 2010, every state PUC should require its regulated investor-owned utilities to provide historical consumption, price and bill data over the Internet, in machine-readable, standardized formats. By the end of 2011, every investor-owned utility should develop and implement this capability.

While a handful of states are moving quickly to develop pro-innovation energy data policies, a number of states are moving too slowly, or not at all. Congress should monitor the issue and should consider national legislation if states fail to act. America's energy and environmental challenges are too important to wait.

RECOMMENDATION 12.8: The Federal Energy Regulatory Commission (FERC) should adopt consumer digital data accessibility and control standards as a model for the states.

RECOMMENDATION 12.9: DOE should consider consumer data accessibility policies when evaluating Smart Grid grant applications, report on states' progress toward enacting consumer data accessibility, and develop best practices guidance for states.

The federal government should promote consumer accessibility to digital energy information. Although retail energy services are regulated at a state level, FERC and DOE should encourage consumer data accessibility and control. As FERC begins its rulemaking to adopt NIST standards, it should also include NIST standards focused on consumer data access to provide states a model on which to base their own Smart Grid rulemakings. FERC should also encourage wholesale market entities—independent system operators/regional transmission network organizations—to provide information on generation mix and emissions data as close to real time as possible at a system level. In future versions of its Smart Grid Systems Report,[62] DOE should specifically provide updates on the progress of each state in enacting strong consumer data accessibility policies. DOE should also develop a set of best practices for states by publishing a set of model energy data policies.

RECOMMENDATION 12.10: The Rural Utilities Service (RUS) should make Smart Grid loans to rural electric cooperatives a priority, including integrated Smart Grid-broadband projects. RUS should favor Smart Grid projects from states and utilities with strong consumer data accessibility policies.

The U.S. Department of Agriculture's Rural Utilities Service can play an important role in modernizing the operations of the rural electric cooperatives that own and operate 42% of the nation's distribution infrastructure.[63] In FY2009, RUS disbursed 209 electric loans and loan guarantees totaling $6.6 billion, giving it a total loan portfolio of $40 billion.[64] Similar to the directive in EISA, RUS should ensure that electric cooperatives have considered investment in qualified Smart Grid systems before undertaking investment in less sophisticated grid technologies.

12.3 SUSTAINABLE INFORMATION AND COMMUNICATIONS TECHNOLOGY

ICT industries account for 120 billion kilowatt-hours (kWh) of electricity use annually—approximately 3% of all U.S. electricity.[65] They are responsible for 2.5% of the national greenhouse gas emissions, and their emissions share is forecast to grow three times faster than those from other sectors of the economy.[66] The growth in energy usage and resulting emissions can be divided into three components: increased penetration and usage of personal computers (PCs) and peripherals, growing demand for communications services and rapid growth of data centers.

PCs and peripherals made up approximately 3.3% of residential and commercial electricity use in the U.S. in 2005,[67] a share that is expected to grow to approximately 4.7% by 2011.[68] This growth will be driven by the increased penetration and usage of devices such as mobile phones, netbooks and video-game consoles. Simple behavioral changes can lessen the impact of these devices. For example, one study found that 60% of all desktop PCs remain fully powered during nights and weekends.[69]

A new standard for a universal charging solution for mobile phones, recently approved by the International Telecommunication Union, will cut standby power consumption in half. The drop will occur because the same highly energy-efficient charger will be used for all future handsets, regardless of their make or model. The change will eliminate up to 21.8 million tons of greenhouse gas emissions a year and reduce by up to 82,000 tons annually the chargers that need to be produced, shipped and subsequently discarded.[70]

Communications networks also can be made more efficient. Approximately 0.8% of U.S. electricity is consumed by the telecommunications industry.[71] Emissions related to mobile networks, in particular, are expected to increase from 10.5 million metric tons of greenhouse gases in 2008 to 11.2 million metric tons in 2013 under a business-as-usual scenario.[72] But the large service providers are not sitting still. They recognize that reducing the energy intensity of their operations will not only help the planet but also reduce costs and maximize their profits. To take one example, Sprint has audited all of its facilities and installed building automation systems and Web-based meter-information systems, leading to a 9% annual energy savings (~23 million kWh) and preventing 21,400 tons of CO_2 emissions per year.[73] The company has also installed hydrogen fuel cells and solar power at a number of its cell tower sites.[74]

Data centers accounted for 1.5% of U.S. electricity consumption in 2006, and demand is expected to double by 2011.[75] Demand will rise in large part because of the rapid increase in the need for data processing and storage of electronic information, compounded by data center servers' very low utilization rates and inefficient cooling systems.[76]

The largest efficiency opportunities for data centers can be achieved through virtualization, a technique that lets a single server be treated as though it is multiple machines. This means that servers do not need to be dedicated to specific purposes and can be used wherever processing power is needed. At the moment, only 5-15% of server capacity in a typical data center is being used at any one time, but virtualization can significantly increase that figure.[77] Such increased efficiency can reduce a data center's greenhouse gas emissions by an average of 27%.[78] Better temperature monitoring and control devices, as well as reducing a data center's reliance on air conditioning, can cut emissions by 18%.[79] Lastly, locating data centers in areas where a high proportion of baseload power is generated from low-carbon sources can lead to significant emissions reductions.[80]

RECOMMENDATION 12.11: The FCC should start a proceeding to improve the energy efficiency and environmental impact of the communications industry.

The FCC should start a Notice of Inquiry to study how the communications industry could improve its energy efficiency and environmental impact. This proceeding should examine such topics as data center energy efficiency, the use of renewable power for communications networks and the steps that communications companies can take to reduce their carbon emissions. The proceeding should also study how service providers can impact the energy usage of peripherals in the home, including mobile phone chargers.

RECOMMENDATION 12.12: The federal government should take a leadership role in improving the energy efficiency of its data centers.

The federal government owns and operates approximately 10% of the nation's data centers and servers.[81] Research suggests that data centers can cut their electricity use by up to 45% by adopting best practices in energy efficiency.[82] Federal agencies should take measures to improve the energy efficiency of their data centers in accordance with President Obama's Oct. 5, 2009, Executive Order 13514 that promotes environmental stewardship (including "implementing best management practices for energy-efficient management of servers and Federal data centers") and the announced 28% greenhouse gas emissions reduction target set for the federal government by 2020.

Specifically, the federal government should set a goal of earning the government's ENERGY STAR for all eligible data centers it operates. A first step toward this goal should be metering the energy use in all federal data centers as soon as practicable. This will enable data centers to receive an ENERGY STAR rating upon the U.S. Environmental Protection Agency's release of the data center Portfolio Manager in June 2010. By metering their data centers and using the rating tool, departments and agencies will be able to measure their progress toward earning the ENERGY STAR, which will be given to the top 25% of energy-efficient facilities. With limited national security exceptions, agencies should post their data center efficiency ratings online so the public can track the government's progress. In addition, all new federal data centers should be designed to earn the ENERGY STAR. Finally, DOE should consider and report on whether the government can go beyond ENERGY STAR savings, and if so, how.

12.4 SMART TRANSPORTATION

The transportation industry is the second-largest consumer of energy, a primary reason for the country's reliance on oil and the sector that is the second-highest emitter of greenhouse gases.[83] Broadband and advanced communications infrastructure will play an important role in modernizing various transportation systems by making them safer, cleaner and more efficient.

Broadband and other information and communications technologies can reduce emissions by enabling more efficient driving. Adding communications technologies to vehicles and to key infrastructure, such as traffic signals, can help reduce the amount of time spent on the road. Drivers can optimize routes based on real-time traffic conditions, and commercial operators can plan more efficient routes and supply chain logistics. Communications can also enable potential future transportation policies such as congestion pricing and performance-based mileage standards, which would cut traffic and encourage drivers to be as efficient as possible. Collectively, information and communications technologies can eliminate as much as 440 million metric tons of greenhouse gas emissions from transportation by 2020.[84]

Automakers are increasingly building wireless communications into vehicles, for safety, navigation, entertainment and productivity. OnStar, a service offered by General Motors, uses an embedded cellular connection to provide emergency alert services and diagnostics that can improve a vehicle's performance and gas mileage. Vehicle communications can also come from a driver's personal mobile phone; Ford's SYNC service, for example, allows drivers to use their wireless phones to provide in-vehicle connectivity for a variety of entertainment, communications and safety applications.

While the number of vehicles with broadband is small today, all U.S. automakers have begun offering integrated or aftermarket-compatible solutions that presage eventual mass-market, in-vehicle broadband adoption. Whatever its form factor or application, in-vehicle broadband is likely to contribute to the growing need for commercial broadband spectrum.

The benefits of broadband-connected vehicles will be great, but the risks of increased driver distraction must be proactively addressed. The addition of new technologies in the vehicle must be coupled with a commitment by individuals, families and automakers to use and deploy these technologies responsibly, in a manner that minimizes driver distraction. Solving these challenges will require coordinated leadership from industry, government and consumer groups. Solutions must be pursued before these applications are widely deployed, rather than as an afterthought.

The federal government has already swung into action. The U.S. Department of Transportation (DOT) held a distracted driving summit and launched Distraction.gov, the federal government's official website for distracted driving—currently featuring Oprah Winfrey's campaign against distracted driving. The FCC held a workshop exploring technologies that could play a role in reducing the risk of distracted driving. DOT and the FCC have also launched an interagency collaboration on distracted driving, focused on consumer outreach and on technological approaches to the problem. The federal government should continue to work with industry to safely incorporate the next generation of in-vehicle communications technology.

Broadband can also encourage the use of alternatives to automobile transportation. Route-planning applications make public transportation easier to use, and in-vehicle broadband can make mass transit more attractive. For example, intercity bus companies cite broadband as one factor increasing ridership since 2006.[85] Several companies offer free Wi-Fi to passengers, a feature Megabus credits with attracting new riders to its Boston-New York City service, which saw ticket sales rise 67% in 2009.[86]

As discussed in Chapter 13, broadband itself provides an alternative to transportation and travel, through Web conferencing, telecommuting and videoconferencing. Already, many companies are minimizing emissions and saving costs by avoiding air travel, and telecommuters are saving time and gas by working from home.

Advanced communications systems also have the potential to help reduce the nation's tens of thousands of automobile fatalities each year.[87] For example, imagine a driver needs to suddenly brake while traveling on a busy highway. An ad hoc vehicle-to-vehicle communications system could allow cars following several vehicles to be alerted of the danger almost as soon as the first car's driver pushed the brake pedal. This would give more drivers a critical opportunity to prevent a high-speed, rear-end collision—a common cause of highway fatalities. In 1999, the FCC allocated 75 MHz of spectrum in the 5.850–5.925 GHz band for these types of specialized Intelligent Transportation Systems (ITS) applications. The transportation industry envisioned using dedicated short-range communication (DSRC) protocols to communicate between vehicles (vehicle-to-vehicle) and roadway infrastructure (vehicle-to-infrastructure). Despite promising tests, these networks have not been deployed.

For some ITS applications, such as vehicle-to-vehicle collision avoidance, DSRC technology may be required because it provides extremely low latency communication between vehicles. However, these applications require a critical mass of vehicles with the technology to deliver real benefits. Practically speaking, this means DOT would need to mandate the technology in new vehicles or otherwise encourage adoption, possibly by implementing a consumer information program through the New Car Assessment Program. DOT has committed to making a decision on its approach by 2013.

Whatever the ultimate decision, the country need not wait for deployment of DSRC technology to begin aggressively developing and deploying smart transportation applications. In the 10 years since the FCC allocated spectrum for ITS applications, commercial wireless data networks have been built to cover much of the country's roadways. These networks and Internet-hosted applications are capable of delivering many of the efficiency, mobility and sustainability applications envisioned in ITS. DOT should explore ways to leverage commercial wireless data networks and the Internet to achieve its goals.

CHAPTER 12 ENDNOTES

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