Center for American Progress

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The Convergence of Energy Efficiency, Smart Grid, and Distributed Power Generation as the Next Frontier of the ICT Revolution

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ON THE COVER: John Limburg, a system dispatcher at FirstEnergy, works in the North East Ohio System Control Center. This high security center is where FirstEnergy tracks storms and power outages. Behind barbed wire in a secret location west of its headquarters, FirstEnergy Corp. hopes a new $22 million control center improves electric reliability for customers of the utility that was at the center of the 2003 blackout across much of the Midwest and East.

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Introduction and summary

Constructive national debate on energy policy in the United States has ground to a standstill despite broad political and economic consensus on the urgency of energy innovation. The American people are largely agreed on our goals, with deep bipartisan public consensus on the benefits of an energy strategy that promotes traditional energy resources alongside growing mainstream adoption of renewable energy, smarter grid networks, and energy efficiency. Yet the debate about the policy mechanisms required for reaching these consensus goals remains hotly contested.

In recent years progressives have focused on encouraging the development of new domestic markets for clean and efficient energy alternatives, pursuing the tools of environmental protection by pricing and regulating pollutants. Conservatives have tended to emphasize the policies of energy exploration—focusing on expanding access to traditional sources of fossil energy in an effort to boost supply and cut prices for conventional resources—and have increasingly minimized the role of climate change and environmental constraints in driving our energy choices. The upshot of this stalemate has been a protracted and highly politicized fight over federal energy policies, which delays innovation, slows economic growth, and fails to provide predictability to an industry desperately in need of certainty.

There is a better way forward through this impasse. Too little attention has been paid to how technology is actually deployed, how public and private collaboration can drive innovation, and how changing market needs can drive rapid and radical infrastructure transformation. When our nation's current energy challenges are understood as a massive technology-deployment challenge for the economy writ large and not as a pitched federal policy battle, an entirely different suite of strategies for progress emerges. In this approach—centered on technology deployment, market creation, and infrastructure transformation—a new group of tools becomes apparent, capable of attracting a broad national consensus that meets the goals of progressives and conservatives alike.

This paper offers a strategy for accelerating the coming transformation of the U.S. electricity grid system into a truly integrated network that brings an exciting new set of services to consumers. This grid will dramatically improve the reliability and efficiency of our overall energy system, deeply cut the damaging environmental consequences of our mostly fossil-fueled economy, and improve overall economic productivity through innovation and advanced technology. When approached through this lens of technology deployment and infrastructure innovation, we find that there is ample precedent in the recent past for dramatic improvements to our nation's strategic infrastructure over a small number of years. This research gives us profound optimism that the United States can finally align around a shared vision of energy opportunity fueled by investment and innovation.

Indeed, during previous bouts of intense partisan gridlock in Washington, efforts to imagine new policy tools and partnership strategies to break political standoff have resulted in radical technology revolutions. Over the past two decades our nation underwent a total transformation in information and telecommunications technologies. In telecommunications, old business models built on wired phones fell by the wayside as new models designed to serve a wireless and data-driven customer base transformed communications. At the same time the emergence of the Internet created an entirely new information technology industry that thoroughly transformed not only telecommunications but also the management of data and information across the entire economy.

Today we stand at the cusp of the next major transformation—one that connects the ongoing technology innovations in telecommunications and information technology with the emergence of intelligent, efficient, and cleaner energy networks. Three core technologies are rapidly converging, unlocking new productivity gains in our energy system that come from modern information technology-enabled networks. First, distributed energy generation is enabling efficient, decentralized energy production close to the point of use by consumers, integrating energy generation more fully into our homes, offices, and factories. Second, this trend coincides with new potential for improved energy efficiency in buildings, which substitutes better use of information for the wasteful use of energy and dramatically reduces the need for electricity production. Finally, both of these changes are being enabled through the integration of smart grid technology in the power transmission and distribution grid, which moves not only electrons but also information effectively through our energy networks. This convergence is creating a fundamentally new engineering model for managing energy.

Distributed generation brings alternative-energy production closer to the point of use on the energy grid, reducing the costs of energy, diversifying sources of energy, and improving grid operations. Energy efficiency uses intelligent building systems and information technology as well as advanced materials and better building management to reduce demand for energy overall and to shave demand during times of peak energy use, further cutting costs for consumers. And the smart grid serves as an operating system that links these diverse energy technologies together, balancing supply and demand more efficiently and productively. This optimizes the economic value of capital investments in energy generation and use, and facilitates grid optimization in order to manage a more dynamic, interconnected, and resilient energy network.

These changes are enabled through smart grid technology in the transmission and distribution grid, together creating a fundamentally new engineering model for managing energy.

Increasing decentralization and reliance on real-time management of energy services through more complex energy networks are fundamental trends that will continue to drive the structure of investment into our energy system and the productivity of the overall economy. This technical reality is essential to driving out carbon pollution from the functioning of our energy grid, but it would be a mistake to see it as the product of a green agenda. In fact, it is the logical evolution of the integration of information and communications technology into the effective management of energy. This technology-based transformation is entirely compatible both with the introduction of new advanced clean technologies and with the optimization of the grid to better realize the economic benefits of more traditional fossil fuels in an era of growing natural gas supplies.

Deploying this information-enabled clean energy web can deliver radical efficiencies and productivity gains to our economy similar to the telecommunications and information technology revolutions of the past few decades. Indeed, it is vitally important to remember that the U.S. economy has always grown through innovation. Our economic expansion has been driven by subsequent waves of capital investment in strategic infrastructures that made the overall economy more productive, efficient, and innovative. From the railroads to rural electrification, the space race to the launch of the Internet and telecom revolutions, U.S. entrepreneurs and industries have always remained at the cutting edge of global leadership and economic innovation through a smart blend of public policy coordination, strategic private-capital investment, and the incubation of domestic technology manufacturing.

Insights on both the magnitude of this opportunity and the ability to rapidly deploy transformative technology infrastructure can be found by looking at the last iteration of the information technology and telecommunications technology revolution in the not-too-distant past. In 1997 the Clinton administration with bipartisan and industry support elevated a national policy framework to advance the Internet. Vice President Al Gore posited at that time that:

> *We are on the verge of a revolution that is just as profound as the change in the economy that came with the industrial revolution. Soon electronic networks will allow people to transcend the barriers of time and distance and take advantage of global markets and business opportunities not even imaginable today, opening up a new world of economic possibility and progress.*

Just 12 years later, after watching these innovations fundamentally transform the global economy, it is hard to debate their impact—even though it was impossible then (and now) to predict precisely how this new strategic infrastructure would unfold through private investment.

Similarly, today federal leadership has been important in setting a vision for an energy infrastructure revolution. President Barack Obama spoke on the power of the second wave of this information revolution in a speech in De Soto, Iowa saying:

> *Now, it's time to make the same kind of investment in the way our energy travels—to build a clean energy superhighway that can take the renewable power generated in places like DeSoto and deliver it directly to the American people in the most affordable and efficient way possible. Such an investment won't just create new pathways for energy – it's expected to create tens of thousands of new jobs all across America in areas ranging from manufacturing and construction to IT and the installation of new equipment in homes and in businesses. It's expected to save consumers more than $20 billion over the next decade on their utility bills.*

We've quoted two Democratic leaders here, but the foundations of the telecommunications and Internet revolutions were forged in a Telecom Act crafted with bipartisan support in a Republican Congress led by then-Speaker of the House Newt Gingrich (R-GA) and signed into law by Democratic President Bill Clinton. Similarly, framework policies that have driven recent energy innovation—from smart grid pilot programs to energy R&D through the Advanced Research Projects Agency for Energy—were first signed into law by President George W. Bush with the backing of a Democratic House of Representatives led by then-Speaker of the House Nancy Pelosi (D-CA).. This opportunity for bipartisan collaboration in energy to deploy transformative technologies that launch new industries is captured well in the words of Sen. Lindsay Graham (R-SC):

> *We [are more] dependent on Mideast oil today, than we were before 9/11. That's a national security nightmare. So what I'd like to do, is … become energy independent, create jobs in low carbon technologies, like wind, solar, and nuclear, and … clean up the air. If my generation of political leaders could break our dependency on foreign oil, create a low-carbon economy that would allow America to develop technology and create new jobs for future generations, and pass on to the future generations cleaner air, that would be a pretty good use of my time.*

In all of these examples, an industry backed, nonideological approach to public policy that jumpstarts private-sector innovation and investment has been key. Moving forward, transformation of our electricity grid to a true network for transforming energy services will likewise open tremendous new economic opportunities. But unless existing policy to accelerate infrastructure investment and overcome market barriers for new technology deployment are addressed systematically, the United States may miss this chance to remain on the cutting edge of global leadership, competitiveness, and growth.

It's expected to save consumers more than $20 billion over the next decade on their utility bills.

Today the world is at the brink of a fundamental transformation of the global energy system. To understand the nature of this transition, it is important to recognize how a fully functioning smart grid that links robust energy-efficiency measures and distributes renewable energy generation differs from the traditional electricity grid first built by Westinghouse and Edison over a century ago. The traditional energy grid relies on highly centralized power generation, with one-directional flows of energy from centralized power plants through inefficient transmission and distribution lines to relatively ill-informed and disempowered end users. Continuous and fluctuating consumer demand for energy is a given that cannot be influenced but must instead be managed by grid operators who can only control power generation to keep supply and demand in balance.

Gradually, however, the introduction of disruptive new technologies is changing this old *linear* engineering model. Over time, it is giving way to a truly *multidirectional network*. In the old order power plants took care of generation, grid operators maintained balance on the network, and consumers received the benefits of available energy without engaging the system except to ask for more. Today, however, power generators, network operators, and consumers are all increasingly central to the task of managing the functions of balancing supply, demand, and grid optimization. Energy supply can now come from homes and businesses as well as large generators. Demand response in factories and office buildings can help manage the grid by curtailing the need for reserve margins and peak generation by power generators. And network management can happen through installation of storage technologies alongside the latest forecasting software to help integrate power from intermittent renewable energy sources such as wind, solar, and tidal flows.

In short, where electricity generation, transmission, and distribution, and consumer end use were once entirely distinct segments of the electricity grid, all nodes of the emerging networked energy web are increasingly more tightly interconnected, with producers, consumers, and grid operators all playing greater roles in optimizing supply, demand, and grid operations.

Throughout this process the modern energy grid is becoming a more integrated and self-healing network, operating in real time with multidirectional data flows and increasing automation. It is reasonable to expect that machine-to-machine communication in emerging advanced energy networks will achieve similar efficiency and productivity gains to those already achieved through the exchange of data and communications in advanced wireless and information networks. This transition from a more rigid and centralized network architecture to a more nimble, decentralized, and information-enabled network is in many ways similar to the transition from mainframe computers to cloud-based computing. Such a networked energy web will be far better suited to meeting the rapidly changing societal demands placed on our electricity grid to improve reliability, efficiency, and cost containment.

When anticipating coming challenges to engineering innovation on the electricity grid, it is important to recognize that our existing infrastructure has been highly successful at meeting the objectives that it was designed to accomplish. Historically, energy utilities and grid operators were charged with four key objectives—generating energy that is affordable, reliable, universally available, and safe. Our electricity grid performed this task admirably and drove decades of broadly shared economic expansion. But the emergence of new energy networks present exciting new opportunities—just when mounting energy security and environmental challenges are creating growing threats not only to energy managers but to our economy at large. As a result, the transition to advanced energy networks today requires the same thoughtful engagement from policymakers, market participants, and system operators to retool our electricity grid and meet a new more challenging set of design objectives.

While the same four objectives that drove the growth of our legacy energy system still apply, today's energy grid must also meet four new and equally pressing objectives: guaranteeing that the new network is also clean, transparent, private, and secure in order to respond to new pressures from advanced technology and a changing economy.

Each of these priorities is important to a wide range of stakeholders for a variety of reasons. And each must be included in the front end of this emerging energy system's design when crafting policies, regulations, and business models to speed this transformation. If done properly the implications of this revolution in our nation's energy system may ultimately be even more far-reaching and profound than that of telecommunications, creating enormous economic potential, unlocking dramatic new economic efficiencies, maximizing the productivity of existing industries and investments, and jump-starting job creation at a time of tepid economic recovery.

There is a targeted but essential role for the government to play in unleashing what will eventually be an industry-led transformation of our energy system. Meeting this challenge will require that we learn from the best practices of both government and industry, which helped to manage and accelerate technology changes in the recent past.

Meeting this challenge will require that we learn from the best practices of both government and industry, which helped to manage and accelerate technology changes in the recent past.

This paper first presents the overarching argument for why our nation needs to invest in this new, networked energy web. We then examine the precedents in recent public policy and private partnerships in information technology and telecommunications, which can provide a framework for understanding the underlying industry and infrastructure challenges in today's electricity grid networks. We then close the report with a proposed policy rubric for unleashing private-sector innovation in the service of building a truly modern networked energy web.

Over the next year it is our hope to build upon this rubric to develop a more detailed policy program with broad bipartisan and industry backing, capable of launching the development of a new networked energy web in earnest as a source of national pride and industrial competitiveness. In coming months the Center for American Progress will work closely with a broad range of stakeholders to further refine a shared vision, policy prescriptions, and a plan of action for advancing the transition to a networked energy web.

We organize our key recommendations in the main pages of this report around the guiding objectives for the functioning of this new energy web. As we seek to make our nation's energy system more transparent, private, clean, and secure, there will be distinct roles for lawmakers, regulators, industry investors, and individuals. These priority actions for assuring integrated advanced energy networks are detailed in the pages that follow, but briefly they will include the following:

- The networked energy web must become increasingly clean, efficient, and low carbon.
- The networked energy web must provide information transparency for consumers.
- The networked energy web must assure privacy for consumers.
- The networked energy web must be secure at all levels of operation.

How to implement these priority actions is the subject of the concluding section of our paper.

A better vision for America's energy economy

The U.S. economy is based on innovation, and our periods of greatest economic strength and industrial growth have always been fueled through investment in cutting-edge infrastructure. From railways to rural electrification to the interstate highway system, the United States has consistently sustained global economic leadership and built broadly shared prosperity for its citizens by establishing a foundation of innovative infrastructure as a platform for the growth of private industry. The next frontier in this American tradition is using information technology to address the demands of a new century on our energy infrastructure, transforming what the National Academy of Engineers has hailed as the greatest engineering achievement of the 20th century: the electric grid.

The challenge we face today is threefold. First, the capacity of our nation's aging energy distribution and transmission infrastructure is being rapidly outpaced by the burdens of daily energy demand. Second, increasing scientific evidence of global warming means that generators of electricity must transition away from high carbon energy and integrate new more variable renewable energy resources into the grid. Third, new information technologies are having a disruptive effect on energy markets, fundamentally altering the demands placed on the electric grid for improved management and information access. Overseas, China and the European Union are taking this challenge seriously, investing heavily in renewable energy and new transmission systems, and rolling out smart grid capabilities at a rapid rate in the hope of setting de facto standards and dominating intellectual property rights for years to come.

The tenuous position of the U.S. grid is often masked from the public eye, but in many parts of the country consumers are routinely experiencing the real costs of blackouts and supply disruptions. In fact in the 2009 American Society of Civil Engineers report card,[1] U.S. electricity infrastructure received a "D." The report went on to note that:

> *The "information economy" requires a reliable, secure, and affordable electric system to grow and prosper. Unless substantial amounts of capital are invested*

> *over the next several decades in new generation, transmission, and distribution facilities, service quality will degrade and costs will go up. These investments will involve new technologies that improve the existing electric system and possibly advanced technologies that could revolutionize the electric grid.*

A hard look at the numbers confirms this stark assessment. Electrical disruptions cost $79 billion a year[2] in damages and lost business. Coal-fired generation made up 44 percent of the electricity generation in 2011,[3] but is only 35 percent efficient.[4] This means 65 percent of the energy potential in coal never makes it out of the generator. In 2010, 14.9 percent of the total electricity consumption in the United States was lost or unaccounted for,[5] due to transmission and distribution-system failures. To put that number in perspective, the United States lost more energy that year than 185 countries use annually—enough to power the entire economy of Germany for a year, Spain for two years, or Sweden for three years.[6] Transmission congestion alone costs consumers in the eastern United States $16.5 billion in higher energy prices every year.[7]

The cost of inaction

The costs associated with operating a grid that is not fully optimized are real and calculable. Past experience with blackouts indicates that they can dramatically harm our economy, as evidenced when the regional northeast blackout in 2003 resulted in $7 billion to $10 billion in economic losses.[8] Utilities often have no way of ascertaining where and when outages occur locally, and are hamstrung by a fundamental lack of data transparency. The current design of the energy system increases the likelihood of a cascading effect when problems do occur, which decreases overall reliability and security.

What's more, the lack of access to energy-consumption data and energy-management tools leave consumers at the mercy of cost fluctuations and peak demand while simultaneously compounding problems for grid managers. Although there will be $45.5 billion spent on grid infrastructure over the next five years,[9] there is still a projected investment shortfall of $29.5 billion.[10] This shortfall is both a serious warning for our nation and a call to action for the government to help make private-capital investments in the energy grid more profitable and predictable for entrepreneurs and investors.

The costs of inaction include the opportunity costs of underdeveloped markets as well. Just as previous waves of information and telecommunications technologies unlocked new markets and better management systems, next-generation energy networks will similarly provide access to considerable new economic value to the larger economy. An excellent example of these costs can be seen in the market for energy efficiency in commercial real estate. A study[11] by McKinsey & Co. found that the United States wastes $130 billion each year on inefficient buildings and appliances. Expanding energy-information technology at the building level with improved building-management systems and controls to provide for the improved use of demand response and dispatchable energy efficiency to shape energy loads can substantially improve net operating income for building owners. This would also increase the efficiency and resilience of the grid within energy markets.

Transmission congestion alone costs consumers in the eastern United States $16.5 billion in higher energy prices every year.

Current economic inefficiency persists in spite of the availability of cost-effective energy-saving technologies, largely because opaque markets lack good information on both energy and economic performance for consumers, suppliers, and investors. Building more robust building-management systems linked to smart grid networks will go a long way toward improving this structural inefficiency in the larger economy, while also creating new demand for skilled workers in building retrofit jobs.

All of these costs speak to a larger shift currently underway. There is an entire emerging industry at the intersection of advanced information technology and energy management. Investments in this arena will improve the productivity of the overall economy and can be more than paid for through these efficiency gains. This sector will reconfigure existing industries and create new jobs focused on optimizing energy performance across the nation's built environment. The potential job creation from using new information tools to unlock energy efficiency and improve energy use is tremendous, akin to the disruptive efficiencies of Silicon Valley and Internet-inspired revolutions in the "information economy," except now spread over the entire "real economy" and touching every region in the country.

The past is prologue

We are moving toward a new energy web—a network that links energy consumers directly to markets and gives them the freedom and ability to choose when and how they consume energy.

This networked energy web creates the opportunity for renewable resources to replace conventional ones—a network that transmits not only electrons but also data and dollars in real-time conversation. This network can create real economic value and drive record investment in the built environment as well as research, innovation, and emerging industries nationwide.

This is a massive technical and investment challenge that will require developing strong public-private partnerships. In the very recent past, however, our economy has undergone similarly radical changes that mirror what is in store for our energy system. The political, regulatory, and technological context that guided the development of the Internet and telecommunications provide useful precedents for determining how to move forward.

Recent history demonstrates that the policies that will help create this new energy network can be enacted despite political gridlock in Washington. New technologies in telecommunications caused an upheaval in an entrenched industry, restructured the physical composition of core infrastructure, and enabled it to meet a whole new set of objectives while enhancing service delivery. Underlying this transformation, were a number of regulatory and policy decisions by diverse players from Congress to the Federal Communications Commission that enabled consolidation of larger markets, harmonization of regulations, and improved financial incentives for investors.

Similarly, the widespread success of the Internet can be traced in no small part to thoughtful policy strategies that combined public R&D investment with public-private partnerships on standard setting and other targeted government interventions that enabled more robust private-capital investment and spurred competition and industry growth. This experience with information technology, data, and communications can offer useful lessons on how carefully crafted policy can rapidly advance technological progress, fundamentally altering the economic landscape along the way. To better understand the current challenge, we examine how each of these revolutions came about.

Transforming technology: The rise of the Internet

Between 1994—when the "Internet in a box," the first commercially available Internet connection for consumers was introduced—and 1997, when the fledgling Internet had quadrupled in size,[12] a system originally built for a few thousand users was serving tens of millions. Stakeholders across a number of industries in defense, academia, and business were concurrently building out the platform without comprehensive standards, meaning that the emerging system was overburdened and uncoordinated, lacking universal standards and protocols necessary for speed, interoperability, and real interconnectivity.

Foreseeing the Internet's potential for the economy, jobs, and worldwide communication and commerce, the Clinton administration stepped in to do what none of the individual actors could do on their own. It enacted a series of executive actions approaching the various Internet developments through a comprehensive vision. The vision was laid out in the "Next Generation Internet Initiative"[13] and the "Framework for Global Electronic Commerce,"[14] which outlined principles for guiding government involvement in electronic commerce, supported private-sector investment on a global basis, and lent strong government support to the standards setting work of industry through the World Wide Web Consortium with the full backing of federal agencies from the Department of Defense to the Department of Commerce.

With narrowly targeted and focused government intervention, the Clinton administration helped organize principles and set standards in collaboration with the emerging industry, ultimately shaping the policy DNA for guiding this new information technology market. Together, government and industry could do what neither could do alone. By bringing competitors together around the same table in partnership with public agencies, shared standards and protocols were set for the entire industry that allowed new businesses to emerge and compete more effectively. The result of these early public-private collaborations was the Framework for Global Electronic Commerce, which outlined five major principles to guide the standardizing of the Internet for electronic commerce.

Through these efforts the Clinton administration made the development of the next generation Internet a top priority, even though much of its implementation lay well outside government control or responsibility, and helped organize and accelerate private investment in the field. The subsequent public-private partnerships can be credited with the success of the larger endeavor. By cooperating with the World Wide Web Consortium[15] and the industry as a whole, the administration was able to provide support for the various stakeholders in different industries without hindering or constraining cross-sector economic development. Ultimately this laid the groundwork upon which the Internet grew into what it is today.

These interventions led to a massive jump in technological progress to form modern day information technology. But the enabling policies are only half the story. The other half lies in the infusion of new information technology into incumbent telecommunications industries.

The telecommunications revolution

The political gridlock in Washington today is in many ways analogous to the hostility that characterized the bitter divisions between the Clinton White House and the Gingrich-led Congress in the mid-1990s. In the face of budget standoffs and government shutdowns there was nonetheless a need for both sides to produce some signature legislation that could give American workers and businesses hope, while allowing both sides to demonstrate that they were responsive to the changing needs of industry and the larger economy.

Pressures are building on issues of reliability and aging physical infrastructure.

The introduction of new information technology, which existed in part outside of the historic regulatory structure, challenged the existing business models of telecommunications companies. Suddenly, there was the possibility of new wireless companies co-opting customers and leaving the traditional telecommunications firms spreading sunk costs over a shrinking rate base. Smaller companies, who were previously unable to compete in a telecommunications market dominated by big players, seized the opportunity to harness these new technologies and bring innovative products to market. All parties—long distance carriers, local phone companies, wireless and data providers, cable companies, and emerging Internet technologies—needed clearer market rules in the form of federal policy. The emergence of a coherent industry voice in favor of policies to structure improved market rules set the stage for compromise and bipartisan action.

Pressure from consumers and industry was indispensible in building momentum for change, but key legislation and targeted executive action were ultimately needed to shaping this transition. One result was the passage the Telecommunications Act of 1996,[16] which had strong industry and bipartisan backing, in order to set new industry ground rules that could enhance competitiveness and facilitate technology deployment and infrastructure innovation.

Ultimately, the result of the law was a telecommunications system able to perform its original objectives—providing affordable and universal service—far better while branching out to meet new objectives of mobility, interoperability, and data integration.

The challenges facing the energy system today contain many parallels to the situation confronting the telecommunications industry in the mid-1990s. Incumbent utilities face shifting market structures and changing customer relationships.

Pressures are building on issues of reliability and aging physical infrastructure. New market entrants are beginning to deliver familiar services in new ways and a host of new technologies and capital solutions are waiting in the wings to supply growing demand for next generation products and services.

Seeds of change

Change in the policy framework governing energy management is already underway. Many actors have important roles to play in helping set market rules that will enable increased public and private investments into these transformative technologies. Federal, state, regional, and local governments as well as private-sector chief executives and regulators all have key responsibilities that can contribute to better market outcomes. In an effort to create an atmosphere where smart grids, energy-efficient buildings, and renewable energy sources can converge into a true network, for example, the Federal Energy Regulatory Commission has issued a series of rules designed to improve market structure allowing for grid technology innovation. These include:

- **Order No. 888,**[17] which promotes wholesale competition through open access to transmission services by public utilities and recovery of stranded costs

- **Order No. 2000,**[18] which encourages so-called regional transmission organizations to control transmission nationally

- **Order No. 125,**[19] which enables customers through their own demand response to participate in wholesale electric markets

- **Order No. 745,**[20] which determines when demand response should be considered a generation resource

- **Order No. 1000,**[21] which requires that transmission companies participate in a regional planning process and develop a regional cost allocation method for spreading the costs of investments in new technology across consumers who benefit

Similarly, U.S. legislators have passed important laws in this area, including the Energy Independence and Security Act of 2007 and the American Recovery and Reinvestment Act of 2009, which together spurred well over $100 billion in investment in the U.S. clean energy economy. Congress has also empowered both the National Institute of Standards and Technology and the Department of Energy to undertake highly productive projects nationwide. This includes the Smart Grid Investment Grant Program, supervised by Department of Energy, which generated $8 billion in public-private investment by 2009.

In response, utilities have charged ahead, rewarding this influx of investment with nationwide deployment of Advanced Metering Infrastructure.[22] For their part the National Institute of Standards and Technology has been steadily developing standards for interoperability to ensure that smart-grid development integrates the best available technology in a predictable way, including most recently the "NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 2.0."[23] These framework level standards are essential for building a well-integrated national and global market for integrating these technologies.

The Obama administration has supported this transition, issuing the "Blueprint for a Secure Energy Future,"[24] and the "Policy Framework for the 21st Century"[25] for high-level guidance in 2011. Specifically, in 2009 the administration passed Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance."[26] EO 13514 mandated federal agencies to set greenhouse gas emissions reductions targets within 90 days of issuance, increase energy efficiency, reduce fleet-petroleum consumption, conserve water, reduce waste, support sustainable communities, and leverage federal purchasing power to promote environmentally responsible products and technologies.

Each of these new policies promoting information disclosure has helped increase demand for advanced energy information technology in buildings of all sorts across the country. In both the public and private sectors, these and other efforts underscore that unleashing radical new efficiencies across the electric grid is a high priority for ensuring systemwide reliability, affordability, and security.

The convergence of these technologies is occurring when both regulatory bodies and the private sector are not equipped to handle the transformation alone. The proliferation of government initiatives referenced here proves interest exists among voters and policymakers, but the nation continues to lack an organizing framework to guide this transition. This offers a tremendous opportunity for leadership by the executive branch and Congress to shape a path forward for the entire nation. We now turn our attention to understanding the framework that must guide the development of a new networked energy web.

Framework for a networked energy web

Our nation's experience with information technology and telecommunications is more than just a metaphor; it is truly a technical corollary. During the restructuring of the nation's information and telecommunications infrastructure, government and businesses alike were forced to address a new set of challenges, such as automating management, decentralization of controls, real-time information management, and compressing project development timelines. One of the key lessons learned from the Internet and telecommunications revolution was that establishing an appropriate framework up front for understanding and managing change helped ensure that the resulting infrastructure reflected the public purposes that motivated the larger endeavor.

In guiding the first wave of this information revolution, the government played a limited but active role. By isolating the components of the changes that required government intervention, regulators, legislators, and the executive branch were able to unleash the private sector. The same can be said of the energy opportunity today: The energy grid is not a separate chapter in this story, it is the next frontier. Moving to a networked energy web is the next logical frontier in information technology transforming the broader economy.

This time, however, the stakes are potentially even higher because, with energy, the productivity of the entire economy will be enhanced. Moving to a true energy network will engage not only technology providers, but homeowners, commercial and industrial consumers, capital markets, and real estate investors, creating new efficiencies, consumer empowerment, and business opportunities across the whole economy.

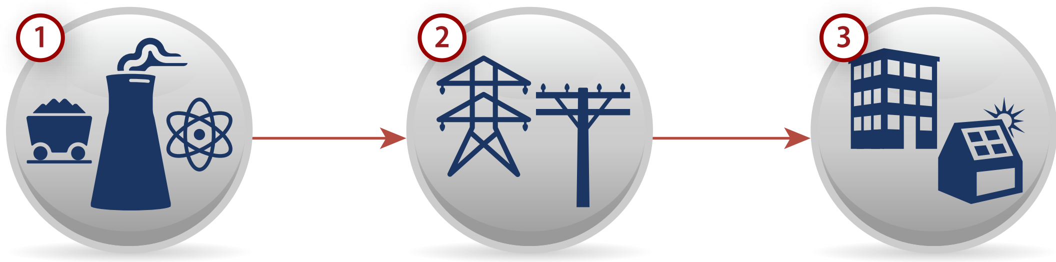
The Center for American Progress has developed a conceptual framework for understanding the challenges ahead and for optimizing the developing energy system to meet these new objectives. Below, the current energy system and its objectives are explained briefly before illustrating how revolutionary new technologies are driving the creation of a new networked energy web that can meet a changing set of societal objectives.

Understanding the historic energy grid and its linear design

The physical engineering model for our current energy system is based on a linear design that facilitates the one-way transport of electricity alongside enough information to deliver services but little else. Power is generated at one location, transmitted over a system of transmission wires, routed into a substation, and then rerouted through distribution networks into homes and businesses that consume the energy. In this model the values of reliability and affordability tend to have an inverse relationship, inefficiencies are tolerated throughout, and the flow of information to both consumers and the marketplace are severely constrained. (see Figure 1)

FIGURE 1

The historic energy grid



Physical infrastructure	1 Generation	2 Transmission and distribution	3 End use
Functions	**Supply:** Large-scale generation resources to provide power to the grid	**Network management:** Grid networks to move electricity to consumers	**Demand:** End-use energy consumers largely outside of grid management and control
	Technologies: • Large-base-load coal, nuclear, and natural gas power plants • Peaking units for responding to spikes in consumer demand • Small amounts of variable renewable energy at the margins	**Technologies:** • Long-distance, high-voltage transmission lines moving electrons from power plant to community • Local distribution grids moving energy from the substation to the meter • Grid operations and centralized controls	**Technologies:** • Residential retail energy customers and homeowners • Commercial and institutional buildings and campuses • Large-scale industrial customers and other major purchasers

This everyday suboptimal performance, the susceptibility of the system to cascading blackouts, and spreading the hidden costs of inefficient transmission among consumers through the rate base are increasingly untenable as new technologies emerge that can overcome these deficiencies and accomplish dramatically improved public and commercial outcomes.

The matrix above illustrates the classic engineering model for the energy system. This model includes a linear set of physical infrastructure that has very particular functions. Power-generation infrastructure has the basic purpose of supplying electrons through production. This is achieved through a set of technologies such as coal-fired and natural gas-fired power plants. Transmission and distribution infrastructure delivers the electrons from the power plants to the consumers of the energy and regulates the flow of those electrons to ensure their safe, reliable arrival. This is achieved through another set of technologies, which includes wires and the central control of the grid operators. End-use consumers encompassing commercial, residential, and industrial customers then consume the energy through another set of technologies. These include lighting, heating, ventilation and air conditioning systems, various appliances, and other machinery.

This system was designed using the technologies that were available at the turn of the last century. Figure 1 shows how these various technologies interact with each other to form an energy-delivery system. Power plants create electricity, which moves over a system of wires, and is delivered into the economy. Electrons flow principally in one direction and are monitored and controlled at a relatively few points in the system.

The current regulatory structure is designed to keep this system in balance and monitor the interactions of a narrow suite of constituent technologies. Yet disruptive new technologies are breaking onto the scene, changing private-sector opportunities and business models and creating a need for different kinds of public policy interventions.

The objectives of the linear energy model

The energy system described above evolved using available technologies to meet the societal needs and public mandates of its time. A century of grid operators and power providers did a fantastic job: the American electricity grid stands as the "largest and most complex machine in the world."[27] It is important to clearly understand the objectives that guided the design and operations of this system. These public purposes of the current energy grid include four basic objectives:

- Universal service
- Affordable rates
- Reliable delivery
- Safe generation, transmission, and distribution to the home

Let's examine each of these basic objectives in turn.

The energy system must be universal

Today's U.S. electrical system provides energy to every corner of the country, requiring only a subscription to service. But this has not always been the case. There was a time when electricity was reserved for homes that were lucky enough to be near a population center and power-generation resource.

To make matters worse, multiple companies could sell energy in the same locality, creating a tangled and redundant system of wires in some areas and a total absence of supply in others. Crafting regulations and physically designing the traditional energy grid to move toward universal access overcame multiple challenges and empowered consumers. Major public policy initiatives were required to enable rural electrification, for example, and other efforts to ensure universal access to electricity and the economic development benefits it brings. These early public policies eventually resulted in economies of scale and market penetrations that now allow the industry to commercially supply electricity in areas that once were not economically viable.

The energy system must be affordable

Making energy inexpensive is integral to increasing access. Energy markets are crafted and regulated to deliver electricity to consumers at the cheapest price possible. Electricity rates are determined by a neutral source, a Public Utility Commission, which weighs competing factors and divides the amount of money required to provide service by the amount of energy that will be sold to ascertain a just and reasonable rate.

Additionally, the process by which sources of energy generation are purchased by power-generation companies for distribution into the market prevents expensive energy from being pushed onto consumers unnecessarily. Case in point: The market operator determines a clearing price that is the maximum compensation generators will receive at any given point in time. This prevents expensive generation sources from firing up when electricity demand would make it uneconomical. This system of regulation is essential for protecting the public interest in access to affordable energy supplies. Without public management, this outcome would never be met.

The energy system must be reliable

A century of grid operators and power providers did a fantastic job: the American electricity grid stands as the "largest and most complex machine in the world."

The current electrical grid operates at 99.97 percent reliability. As such, Americans have come to expect that energy will be delivered on time whenever it is expected. We view blackouts as a major inconvenience and a relatively rare event. With growing reliance on information technology, dependable and uninterrupted access to electricity has moved from a modern convenience to a truly essential economic fundamental.

Meeting these high standards requires a tremendous amount of investment and brainpower. Because electricity generation and delivery happens in real time, monitoring and routing of energy takes place 24 hours a day, balancing supply and demand on an instantaneous basis to keep the entire grid network functioning. The North American Reliability Corporation is a nonprofit organization established in 1968 to assess and research the state of the U.S. grid and push for standards that reflect best practices.

The energy system must be safe

Access to reliable energy isn't much good unless it is safe to use. Streamlining the standardization process through the National Institute of Standards and Technology ensures that energy companies have to meet regulatory criteria in order to compete. This allows consumers to use electricity to power their homes and lives without fear of harm.

These objectives will not, and cannot, be cast aside with a changed energy system. Any transformation must still be universal, affordable, reliable, and safe.

In fact, in looking forward, these traditional objectives should be enhanced through the use of new technologies to meet these historic objectives more effectively while also taking on new array of changing societal purposes.

The coming networked energy web

What lies ahead is a reconfiguration of this linear energy model into a network that optimizes existing assets and engages new technological capabilities. It will allow for multidirectional flows of electrons, information, and dollars, as well as optimization and efficiency across the whole structure. Renewable energy will be fully integrated, both in large-scale generation projects and distributed generation systems. Energy-efficiency measures, intelligent buildings, smart meters, real-time pricing, and electric vehicles will all empower consumer choice and allow customers to manage their energy usage as well as participate in energy markets through demand response—a boon to grid operators who struggle to balance supply and demand during peak hours.

The transition from a linear energy grid to a functioning network creates tremendous potential for economic value creation. In a networked energy web, value is created at every node and point of connection in a multidimensional network. Consumers can participate in energy commerce by creating and selling energy onto the grid with distributed generation. Grid operators can ease the burden during peak hours by utilizing demand response and harnessing electrical vehicle storage. Renewable integration ensures that clean energy is the lifeblood of the network, while increased decentralization decreases the susceptibility of the grid to blackouts or attack.

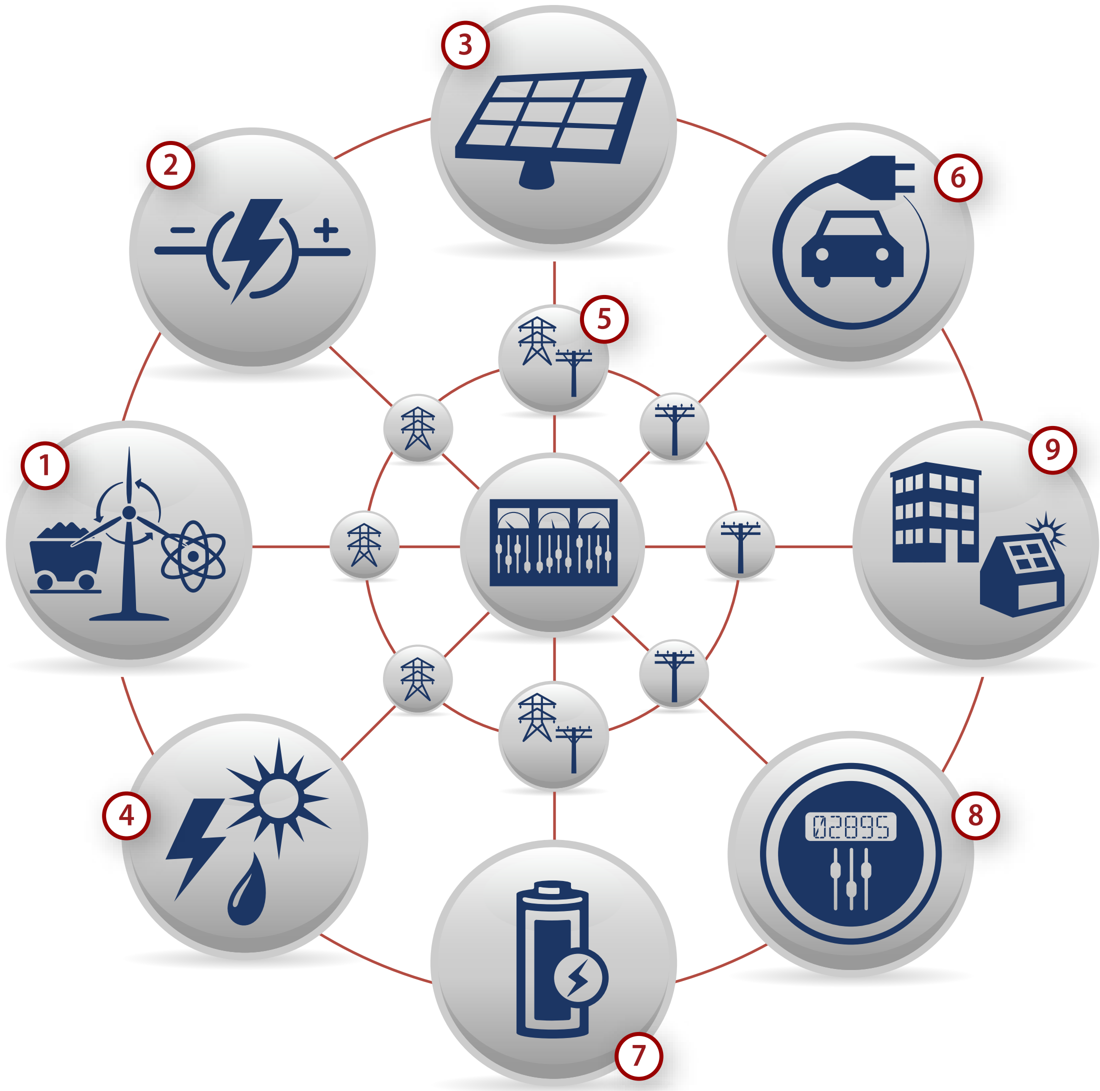
In moving to a networked energy web from the traditional grid design, historic functions of supply, demand, and grid operations are decoupled from the old division of labor between generators, network operators, and end users. Instead, each of these functions can happen throughout the network improving efficiency, reliability, and overall performance. (see Figure 2)

Figure 2 charts the new set of functions that occur at each node of the physical infrastructure. The classic functions of supply, network management, and demand will now take place at each point in the energy system, creating a networked web of new relationships between technologies and electrons. The classic and new functions in the physical infrastructure are reflected in the wide range of disruptive new technologies listed above.

FIGURE 2

The networked grid

The grid is now interconnected at several points as the old physical infrastructure takes on new functions



Physical infrastructure → / Functions ↓	Generation	Transmission and distribution	End use
Supply	**(1) Integrating new-generation resources into the mainstream energy supply** **Technologies:** • Greater use of intermittent renewable energy • Increased use of natural gas resources • More dynamic management of base-load power plants	**(2) Optimizing transmission and distribution grids to provide more useable energy** **Technologies:** • Voltage regulation to increase energy throughput on lines • Synchrophasors to better manage long-distance transmission • New DC transmission lines for renewables	**(3) Distributing generation to produce power close to the point of consumption** **Technologies:** • Onsite rooftop solar PV power generation • Industrial cogeneration and combined heat and power systems • Microturbines and fuel cells for backup or base-load power
Network management	**(4) Maximizing use of the generation fleet with IT and management interventions** **Technologies:** • Greater automation of the generation fleet • Improved forecasting software for renewable electricity resources • Hybrid base-load plants that blend fossil and renewable power to reduce variability	**(5) Automating transmission and distribution to optimize network management** **Technologies:** • Grid automation and machine-to-machine communication • Removing bottlenecks in long-distance, high-voltage transmission • Upgrading distribution networks to improve local-system reliability	**(6) Aggregating end-use electricity demand dynamically in real time** **Technologies:** • Automated efficiency through building management systems • Distributed energy storage with electric vehicles and batteries • Time-of-use pricing to engage consumers in grid management
Demand	**(7) Dispatching active-load management to offset central power generation** **Technologies:** • Large-scale energy storage of intermittent resources • Dispatchable demand response and virtual efficiency power plants • Planning for efficiency as a resource in long-term capacity markets	**(8) Reducing energy demand through transmission and distribution networks** **Technologies:** • Smart meters and advanced metering infrastructure • Neighborhood and campus-scale microgrids • Improved ICT and data transparency in distribution networks	**(9) Increasing end-use energy efficiency to reduce total electricity demand** **Technologies:** • Improved building envelopes through duct sealing and insulation • LED lighting, efficient appliances, and energy-saving technologies • Improved operations and maintenance of mechanical systems

Additionally, a host of new technologies will interact in different ways. Instead of forming linear relationships they will form networked connections much like the transformation from centralized hardware computing into cloud computing.

The networked energy web model shows a complex series of interrelationships between these disruptive new technologies. Electrons move in a variety of different directions, balanced by the various network-management technologies spread throughout the physical infrastructure. Electron supply can occur through large-scale generation or through distributed generation. Demand response and energy efficiency can alter the composition of peak load. Energy storage alters classic conceptions of the need for reserve margins. Some management technologies, such as forecasting, make new generation resources such as wind and solar cheaper and easier to integrate into the base load of the energy network. (see Figure 3)

These technologies will not only encourage new entrants into energy commerce, but also enable the energy system to meet a changing set of societal objectives. These new objectives are every bit as urgent and publically necessitated as the original operating objectives which governed the design and management of the earlier electricity grid.

FIGURE 3

Melding the historic grid with the networked grid

The traditional four objectives of power generation are now enhanced by four new objectives

Universal
Affordable
Reliable
Safe

And now, also…

Clean
Transparent
Private
Secure

The objectives of a networked energy web

Targeted investments and forward-thinking strategy have enabled collaboration between the public and private sectors to build an electricity system that met public objectives using the best technology available. The challenges these objectives were intended to overcome still exist today and the new networked energy web must still address them.

The advancement of technology, particularly information technology, however, has transformed opportunities for accomplishing some of these objectives even as regulatory and market structures have slowed adoption of innovative technologies. This has created a new urgency for ensuring market transparency to access the economic benefits of improved information management. At the same time, along with substantial inputs of consumer data and more interconnectedness of grid networks come new threats to security and privacy requiring urgent attention and management.

Further, the rising pressure to de-carbonize our energy production and consumption to avert a growing global climate crisis has made it even more essential to unlock the efficiencies that are now possible across the broader electricity system through increased interconnectedness, communications tools, and greater reliance on distributed renewable energy.

The unique challenge today is to transition to a new energy system without failing to meet the responsibilities that made the historical linear electricity grid so successful. It is not enough to talk about these objectives in the abstract, however. There is a need to outline a framework that helps the government remove policy barriers so that the market can drive these changes forward—a framework that offers certainty, predictability, and appropriate direction on public purposes as private-sector actors pursue their commercial goals.

As we look ahead, one thing is certain—all parties stand to gain more from a revolutionized energy system than they do from maintaining their stake in the status quo. But to enable improved collaboration and a shared commitment to action, a clearer policy roadmap is essential. Below we evaluate possible actions for the public and private sectors in accomplishing these four new objectives.

The energy web must become increasingly clean, efficient, and low carbon

The old system sought to have universal accessibility—a core reflection of the values of society. Today we take energy access for granted as it has become such a fact of life. Similarly, the new objectives start with the moral proposition that the new system must be clean. The combination of exciting new technological capabilities and the looming climate threat have created a sense of urgency around integrating low-carbon alternatives into every part of the value chain of our electricity networks.

The new networked energy web is much better suited to integrate the variety of renewable energy resources in ways that enhance the performance of the grid while lowering the cost of energy overall by diversifying the sources of energy.

The energy web must provide information transparency

Just as the objective of affordable energy offers a guideline for the way the market should operate, we face new market challenges with the networked energy web that must also be addressed. A new requirement on the market brought on by the massive use of data is information transparency. Information technology will revolutionize the energy system and can spark innovative new products, increased consumer access to their energy consumption data, and new business designed to manage energy information and deliver enhanced energy services.

Ensuring a smooth transition to these dramatically changed business models will require that consumers and third-party companies are able to have predictable and fair access to information on the new networked grid. Without these new business models, innovation will remain severely constrained.

Information technology will revolutionize the energy system and can spark innovative new products and services through increased consumer access to their own energy-consumption data.

The energy web must assure privacy for consumers

Increasing the amount of energy data available in the market will contain digital clues about consumers' lifestyles, behaviors, and personal choices that could be used without their consent. Ownership questions will have to considered and resolved to address the legitimate privacy concerns for consumers, while still allowing new business products and service innovations to flourish by using consumer data where privacy concerns are honored. Just as reliability was a watchword for effective industry performance, so too, privacy must now be safeguarded in all aspects of the operation of advanced energy networks.

The energy web must be secure at all levels of operation

We have always demanded that the energy delivery system be safe for use—it would be of little practical value if it wasn't. Now, security must also play a leading role at the national and regional level, as well as in protecting personal health and property. The physical integrity and virtual security of the grid must be maintained and strengthened as we anticipate changes to its infrastructure design and operation.

Currently, the electricity grid has a hard shell and a soft center. Some protections exist to harden the grid but they are substantially inadequate to protect this critical infrastructure from modern cyberattack. Once penetrated, the grid is exceptionally vulnerable to destabilization. The result is that we currently have a brittle grid susceptible to attack, while the lack of standards and cooperation across the board are further increasing the vulnerability and system risk. A networked energy web, while in some ways difficult to harden and defend, is substantially more resilient and harder to bring down As a true network with built-in redundancies, integration of microgrids, and multiple nodes of generation, it possesses inherent stability and the potential for a high degree of security if properly designed. As we move to a more decentralized and interconnected system, a more complete understanding of the full range of threats to grid security and stability is essential, and clear pathways for engaging key stakeholders in enhancing operational security on the energy web.

What role for policymakers?

Transforming the U.S. energy system to maximize a new set of objectives will not only require a new, innovative generation of engineers, grid operators, and energy-service entrepreneurs, but also a new class of policymakers that are willing to connect the pieces and drive real change. Within each of the new objectives—clean, transparent, private, and secure—every actor in our energy system will have important new roles and responsibilities to undertake and will face a wide variety of pressing policy choices.

Here we detail what the executive branch, Congress and state legislators, state and federal regulatory agencies, and the private sector can each do to advance the modernization of our national energy system. Our recommendations are suggestive rather than proscriptive, giving an indication of what choices must be made in coming years by each of these key stakeholders and highlighting what they must do separately and together to build this exciting future energy system.

Over the next few months the Center for American Progress will use these objectives as a platform for engagement with relevant stakeholders and will publish another report that offers specific policy prescriptions for each set of public- and private-sector actors on how they can best work to cooperate on seizing this opportunity to transition to a networked energy web.

The networked energy web must become increasingly clean, efficient, and low carbon

The combination of exciting new technologies and the looming climate threat creates a sense of urgency around integrating low-carbon alternative sources of energy into each part of the energy web's value chain. Here are some of the steps that the most important stakeholders in this process could undertake.

Executive branch

Federal agencies should scale up their use of procurement tools such as Energy Savings Performance Contracts, which allow federal agencies to pay back the capital costs of energy-efficiency projects with a portion of their energy savings over a long-term contract; clean energy purchasing; Government Services Administration standards for leasing energy-efficient green buildings; and requirements for real-time data measurement and access. A benchmark for success in this area can be found by using the Office of Management and Budget's Sustainability and Energy Scorecards.[28]

Congress and state legislators

Federal and state legislation should establish predictable markets for clean, efficient, and intelligent energy systems through tools like aggressive Clean Energy Standards, Energy Efficiency Resource Standards, and smart grid demonstration projects. State legislators in particular should adopt Renewable Energy Standards and CLEAN contracts—with currently all or part of 14 states having adopted CLEAN contracts,[29] and 28 states have a Renewable Energy Standards[30]—and set ambitious targets to drive investment.

State legislators should also consider adoption of agreements that enable repayment of the upfront costs of renewable energy and efficiency-retrofit projects through energy savings with innovative financing models such as on-bill financing, which allows individuals to pay the capital costs of energy projects through the energy savings over long-term contracts.

State and federal regulatory agencies

State and federal regulatory agencies should adopt regulations that encourage and reward new utility rate structures to incentivize efficiency and streamline the rules to match renewable energy standards. Regulators should also work to increase communication between the National Association of Regulatory Utility Commissioners, State Public Utility Commissions, and the Federal Energy Regulatory Commission, or FERC, to minimize regulatory barriers to deployment of clean energy policies.

FERC, supported by the Departments of Energy and Interior, should accelerate planning and siting of high voltage transmission lines to reach remote renewable energy resources. Additionally, state regulators should develop cost tests and market rules that place clean energy on an equal footing with polluting alternatives and recognize consumer protection benefits from advanced energy networks.

The private sector

Private-sector energy companies and investors should expand investment in renewable energy projects at the point of generation, increase automation across the existing grid, and streamline energy-management technology with real-time pricing to help offset peak demand and increase consumer empowerment. Electric utility companies, along with telecom and other utilities and businesses, should all explore altering their business models to more fully value the economic benefits of clean energy generation and transmission to invest in delivery of energy efficiency measures and services, to adopt internal carbon reduction measures, craft long-term energy sustainability plans, and fully integrate low-carbon energy into their growth plans. Additionally, utilities, clean-technology providers, and financial institutions should develop improved market mechanisms to accelerate clean energy deployment including better information measurement of environmental and economic performance from clean energy investments, and innovative tools for financing private-capital investment.

The networked energy web must provide information transparency

Information technology will revolutionize the energy system and can spark innovative new products and services through increased consumer access to their own energy-consumption data. Ensuring a smooth transition will require that consumers and third-party companies are able to have predictable and fair access to information. Here are some of the steps the most important stakeholders in this process could take.

Executive branch

Voluntary efforts such as the "green button" initiative, which requires utilities to present individuals energy-consumption data in an easy-to-understand and easy-todownload format, should continue to receive federal support and engagement from the Office of Science and Technology Policy and the Department of Energy, and private-sector participation should be expanded.

Additionally, data disclosure at the federal level should be required and federal benchmarks for energy use should be set, maintained, and enforced. Federal agencies and trade negotiators should support international standards for interoperability and data transparency with competitors in international negotiations.

Congress and state legislators

Enhancing the above federal policies and spurring similar change at the state and local level should be pursued.

State and federal regulatory agencies

State Public Utility Commissions should follow California's precedent in guaranteeing consumer access to their energy data upon requesting the utility, and should expand rulings to encourage utilities to provide this information in easy-to-understand formats.

The private sector

Companies should continue to engage in collaborative standard setting to allow strong global-technology markets to develop better energy management. Utility companies should aggressively pursue establishing voluntary interoperability standards and other industry standards to increase coordination and the use of standards across the industry.

The networked energy web must assure privacy for consumers

Increasing amounts of energy data will contain digital clues about consumers that could be used without their consent. Ownership questions will have to be considered and resolved without being too restrictive to industry. Here are some of the steps that important stakeholders in this process could undertake.

Executive branch

Build upon the resources available at the Energy Information Agency to track and monitor data transparency in public and private buildings. This should include ensuring security, maintaining privacy, and providing access for energy consumption data in public spaces. Also, the executive branch should encourage the adoption of the Fair Information Practice Principles[31] for data disclosure, put forward by the Federal Trade Commission.

Congress and state legislatures

Congress and state legislators should pass provisions acknowledging the ownership and responsibility for energy data, specifically safeguarding consumer rights and holding parties accountable when breaches occur. Specifically, data ownership should remain with the consumer, but power utility companies should be responsible for secure storage and transmission of the data under their purview.

State and federal regulatory agencies

State and federal energy regulatory agencies should ensure that energy data disclosure to third parties is decided by the consumer, but that energy data can be viewed blind and in aggregate by utilities to perform essential functions. The California Public Utility Commission ruling[32] on this issue should be strongly considered as precedent for future regulation by other entities.

The private sector

The private sector should adopt the Fair Information Practice Principles for data disclosure put forward by the Federal Trade Commission, specifically by advocating internally for the development of privacy settings and principles that can be incorporated in a predictable way in the new waves of technology using energy data. Effectively sharing information while encouraging best practices in the protection of privacy will be indispensable to the growth of this emerging infrastructure.

The networked energy web must be secure at all levels of operation

The physical and virtual security of a new energy web must be maintained throughout the evolving changes to its infrastructure design and operation. Currently, the electricity system is brittle and susceptible to malicious attack, while the lack of standards and cooperation also increase vulnerability. As we move to a more decentralized and interconnected system, a more complete understanding of the full range of threats to grid security and stability is essential, and clear pathways must be found for engaging key stakeholders in enhancing operational security on the new networked energy web. Here's how each of them could act.

Executive branch

Federal agencies and military bases should develop secure microgrids and distributed-energy generation to minimize the potential for damage through supply disruptions on the larger grid or malicious or terrorist action. Increased decentralization should be viewed as a long-term goal to decrease susceptibility to cyberattacks.

Congress and state legislatures

State and federal laws should be established setting mandatory minimum requirements on cybersecurity practices for energy-data managers, in both public and private entities. Congress also should enact federal cybersecurity legislation that includes a requirement to safeguard critical energy infrastructure.

State and federal regulatory agencies

State, local, and regional authorities should adopt regulations that mandate information security by individual energy utilities and carefully monitor energy information transactions.

The private sector

Companies should seek to develop technology that preserves the security of data and physical assets to the maximum possible degree, as well as adopt best practices that ensure safe transactions between utilities, consumers, and third parties.

Ensuring a clean, transparent, private, and secure networked energy web with different stakeholders undertaking differentiated responsibilities such as these will help ensure that the United States rises to the challenge of revolutionizing our energy system. For this to happen, however, requires coherent organizing mechanisms and some agreement over shared goals. Taking the appropriate, incremental steps to build a transformative new infrastructure may make the networked energy web the most important infrastructure innovation of the 21st century.

Conclusion

In the coming months the Center for American Progress will work closely with relevant stakeholders to publish further reports building on the frameworks outlined here to offer additional specific policy prescriptions for each set of public- and private-sector actors on how they can best work to collaborate in seizing this opportunity to transition the U.S. economy to operate on a robust networked electricity web. Public leadership is the indispensible element for advancing a shared vision and translating this into a strategic framework with industry and a plan of action for moving forward together.

Public opinion clearly supports clean energy innovation in smart grid, energy efficiency, and distributed renewable energy. Yet there remains a clear opportunity to articulate a more compelling public narrative that integrates these discrete efforts into a single overarching vision. This challenge can animate the innovative spirit of our nation, if backed by a signature leadership initiative for policy and technology transformation. Such a strategic framework must reflect an understanding of the true magnitude of the transformation that is underway. This is a significant leadership opportunity for both the White House and Congress. Progress will be made most effectively when the full stakes of this vision are understood, communicated, and organized in bipartisan partnership with industry, advocates, and state and local leaders.

In transitioning to smart, clean, and efficient-energy systems, we are doing much more than improving the environmental footprint of our energy use—we are changing the fundamental architecture of how the grid system operates. We are in the midst of a shift in the design and management of global electricity systems, which are moving from a highly centralized and vulnerable grid architecture to one that operates as a truly robust network that is distributed, information enabled, and resilient. The opportunity is large and the economy cannot wait. We must put Americans back to work now through the transformation of our energy infrastructure. This is the next wave of information technology and communications innovation and could unleash investment, global competitiveness, job creation, and growth. It is time for the United States to commit to the next great wave of technology innovation through clean energy.

About the authors

Bracken Hendricks is a Senior Fellow at the Center for American Progress and a longtime leader in promoting policies that create clean energy jobs, sustainable economic development, and technology investment. Hendricks is a strategic advisor to former President Bill Clinton, the William Jefferson Clinton Foundation, and the Clinton Global Initiative on matters of infrastructure finance, energy efficiency, technology innovation, and job creation.

Hendricks has served as an advisor to the campaign and transition team of President Barack Obama, and was a key architect of numerous pieces of clean energy and jobs legislation including: clean-energy portions of the American Recovery and Reinvestment Act, the Green Jobs Act, the Energy Efficiency and Conservation Block Grant Program, and Cash for Clunkers among others. He served in the Clinton administration as special assistant to the Office of Vice President Al Gore, with the Department of Commerce's National Oceanic and Atmospheric Administration, and with the President's Council on Sustainable Development.

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Endnotes

1 American Society of Civil Engineers, "Infrastructure Fact Sheet" (2009).

2 Kristina Hamachi LaCommare and Joseph H. Eto, "Understanding the Cost of Power Interruptions to U.S. Electricity Consumers" (Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory, 2004).

3 U.S. Energy Information Administration, "Electric Power Monthly" (2012).

4 ABB Inc., "Energy Efficiency in the Power Grid" (2007).

5 U.S. Energy Information Administration, "Annual Energy Review" (2012).

6 Central Intelligence Agency, "Country Comparison: Electricity Consumption" (2011).

7 American Wind Energy Association, "Green Power Superhighways: Building a Path to America's Clean Energy Future" (2009).

8 Energy Future Coalition, "Smart Grid Facts" (2009).

9 American Society of Civil Engineers, "Infrastructure Fact Sheet" (2009).

10 Ibid.

11 Hannah Choi Granade and others, "Unlocking Energy Efficiency in the U.S. Economy" (New York: McKinsey and Company, 2009).

12 "Internet Growth Statistics," available at http://www.internetworldstats.com/emarketing.htm.

13 The Large Scale Networking Working Group of the Computing, Information, and Communications R&D Subcommittee, "Next Generation Internet Initiative" (July 1997).

14 President William J. Clinton and Vice President Albert Gore, Jr., "A Framework For Global Electronic Commerce" (July 1997).

15 "World Wide Web Consortium," available at http://www.w3.org/.

16 *Telecommunications Act of 1996*, Pub. LA. No. 104-104, 110 Stat. 56 (1996).

17 *Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities*, Order No. 888, 104th Cong. (April 24, 1996).

18 *Regional Transmission Organizations*, Order No. 2000, 106th Cong. (December, 20, 1999).

19 *Wholesale Competition in Regions with Organized Electric Markets*, Order No. 125, 110th Cong. (October 17, 2008).

20 Energy Future Coalition, "Smart Grid Facts" (2009).

21 *Transmission Planning and Cost Allocation by Transmission-Owning and Operating Public Utilities*, Order No. 1000, 112th Cong. (July, 21, 2011).

22 Electric Power Research Institute "Advanced Metering Infrastructure" (2007).

23 National Institute of Standards and Technology, "NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 2.0" (2012).

24 The White House, "Blueprint for a Secure Energy Future" (2011).

25 Executive Office of the President, "The 21st Century Grid: Enabling Our Secure Energy Future" (2011).

26 The White House, "Executive Order 13514 Federal Leadership in Environmental, Energy, and Economic Performance" (2009).

27 David Roberts, "The Plan to Build the Next Electric Grid," *PopSci*, June 23, 2009, available at http://www.popsci.com/environment/article/2009-06/next-grid.

28 "OMB Sustainability and Energy Scorecards," available at http://www.whitehouse.gov/administration/eop/ceq/sustainability/omb-scorecards.

29 John Farrell, "U.S. CLEAN Programs: Where Are We Now? What Have We Learned?" (Washington: Institute for Local Self Reliance, 2012).

30 Union of Concerned Scientists, "Renewable Electricity Standards at Work in the States" (2009).

31 "Fair Information Practice Principles," available at http://www.ftc.gov/reports/privacy3/fairinfo.shtm.

32 California Public Utilities Commission, "CPUC Adopts Rules To Protect The Privacy And Security of Customer Electricity Usage Data," *California Public Utilities Commission*, July 28, 2011, available at http://docs.cpuc.ca.gov/published/News_release/140316.htm.

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