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The Networked Energy Web

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

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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 15 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-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):

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.

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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.

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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.

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