Introduction

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The smart grid—an electricity grid that uses two-way digital technology to optimize supply and demand—has intrigued energy experts for years. Its advent promises improved reliability by enabling quicker and more effective response to outages, greater customer awareness of energy usage and costs, and facilitation of the adoption of technologies such as renewable generation sources and electric vehicles. In this inaugural issue of *McKinsey on Smart Grid*, we have marshaled insights developed through our work with leading utilities and other players on the future of this landscape-changing approach to power distribution. Here we consider how the smart grid will affect utilities, equipment and systems providers, and policy-makers, and how these actors should respond to the daunting challenges that can also harbor enormous opportunities.

The stakes are substantial. In the United States alone successful deployment of smart grid technologies could yield savings to society of $130 billion *annually* by the end of this decade. Customer applications, such as dynamic pricing programs, in-home displays and direct-load controls could save society $59 billion. Advanced metering infrastructure (AMI) can save $9 billion and grid applications a staggering $63 billion by improving transmission efficiency and reliability.

The accelerating adoption of advanced metering infrastructure, which could soon be deployed in nearly 40 million locations, has created a platform for utilities to add intelligence to the grid. The prospect of a global framework to address greenhouse gas emissions, the presence of ample global stimulus funds for energy infrastructure and smart grids in particular, the heightening interest in renewable energy, and the promise of electric vehicles are all building additional momentum for the smart grid project.

The course of smart grid adoption, however, is yet far from clear. The underlying technologies remain expensive; their business cases rely on assumptions of significant changes in customer behavior; and cost-effective integration of existing systems and emerging technologies is not yet proven. The business model is still emerging, especially for customer applications, as regulators, utilities, and third-party service providers define their roles and set technology standards. Many core systems remain unproven and as we go to press, not a single full-feature AMI system has been stably and fully deployed in the United States at scale.

The forces of change

Despite the challenges, smart grid technologies promise to have a profound impact on the electric power industry. The articles in this collection discuss the key themes that we believe will define the future of the industry, particularly as they affect utilities, technology vendors and policy-makers—the forces that will determine the pace of development and deployment.

Utilities

Utilities stand to gain the most from the smart grid, but it also presents them with significant risks. Some will see bottom-line benefits from enormous capital deployment, and all could achieve increased operational efficiency. New technology will also help utilities make the transition from an aging workforce—nearly 25 to 35 percent of the utility technical workforce is likely to retire over the next 5 years.

Smart grid technologies will reduce outages and improve power quality, while also offering a wide range of new products and services. The challenge will come in the form of increased complexity in operations and business models. Without careful analysis and planning, billions of dollars could be wasted on automated systems. Similarly, unless the impact on front-line employees is handled intelligently, the expected operational benefits may not materialize.

Technology vendors

Smart grid deployment by utilities will create $15 billion to $31 billion annually by 2014 in potential sales for telecommunications companies, semiconductor producers, IT and grid hardware providers, software firms, and systems integrators. These companies will, however, have to exploit partnerships and add expertise in order to adapt to the long and consultative sales cycles, regulatory requirements and organizational consensus that marks utility procurement processes. The wave of infrastructure investment will benefit traditional grid equipment players by spurring demand for legacy products as well as smart grid-enabled equipment.

Policy-makers

The smart grid can advance major societal goals such as greenhouse gas abatement, a more reliable electricity supply and lower energy costs. Achieving those goals will require shifting the existing regulatory regime from being supply-focused to one that gives added weight to demand-side opportunities. Policy-makers will have to focus on facilitating development of standards as well as gauging the technical feasibility of large capital projects in the near term. They will increasingly need to evaluate social benefits as part of regulatory rate cases, and be open to supporting more innovative pricing and programs to influence customer behavior. Policy-makers will have to ensure appropriate supply and demand resources across a much wider range of assets—traditional generation, distributed generation, electric vehicles, demand response programs—while guaranteeing customer service.

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As is true for any truly transformative technology, the long-term benefits will often be obscured by the near-term disruptions. While plotting a course in such an uncertain realm is daunting and the likelihood of early missteps is high, smart grid momentum is growing and its ultimate arrival is certain. For the actors in the electric power industry, then, the biggest risk would be in waiting to see how others prepare to surmount the attending challenges.

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