

# Rethinking Regulation

## Five Challenges to Aligning the Smart Grid and Utility Regulation

A Smart Grid Oregon Thought Paper

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### Summary

The Smart Grid introduces transformative technologies to the energy industry. Utility regulation, in turn, faces new challenges in adapting to the innovations in technologies, operations, and business models made possible by the Smart Grid. This paper encourages energy policy stakeholders to recognize a number of fundamental, first-principle opportunities to better align emerging Smart Grid technologies and utility regulation. Understanding and making the most of these opportunities can help stakeholders – including Governors' offices, state legislatures, utilities, environmental organizations, utility commissioners and staff, consumer advocates, and consumers of all types – to rethink regulation to make the most of the Smart Grid.

This document intends to offer problem definition as a first step towards building eventual stakeholder consensus for policy evolution, and deliberately stops short of making recommendations or posing solutions. The challenges to alignment we identify between Smart Grid and utility regulation include:

- **Time horizon:** Smart Grid technologies evolve (but do not necessarily become functionally obsolete) at a faster rate than traditional power sector equipment.
- **Externalities:** Smart Grid benefits flow well beyond the boundaries of evaluation that have been utilized historically, both within and beyond the realm of utility regulation.
- **Jurisdiction:** Smart Grid investments, which take place largely at the state-regulated distribution level, can impact both investment decisions and operations of generation, transmission, and of consumers in ways that extend beyond the jurisdiction of state regulators.
- **[De]centralization:** Smart Grid technologies enable distributed intelligence and resources, localized energy resources, and decentralized information that challenge the traditional top-down, supply-biased, deterministically-planned, one-way electricity paradigm and requires clarification of roles, responsibilities, cooperation, and competition among government, utility, third-parties, and

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consumers.

- **Uncertainty:** Smart Grid systems introduce technological, economic, and operational uncertainties – both positive and negative – which utility regulation tends to discourage and for which it is often unprepared.

It is our hope that utility regulation can be an asset, rather than an impediment, to leveraging the Smart Grid to meet state, regional, and national goals of environmental stewardship; to encourage more efficient utilization of our energy resources for economic gain; and to accelerate job creation through innovation in and deployment of clean energy technology and infrastructure.

### **Utility Regulation History**

A basic familiarity of the origins of utility regulation provides useful context for understanding how and why the current system has come into place. Utility regulation began not long after Thomas Edison built the Pearl Street Station, the first commercial electric power generating station, in lower Manhattan in 1882, and has remained largely unchanged since its beginnings. Once the health, environmental, safety, and economic benefits of electrification became widely recognized, state-by-state "regulatory compacts" were established between utilities and governments in the early 20<sup>th</sup> century. Coupled with rising economies of scale up until the 1970s, this arrangement is responsible for building the electricity grid we know and depend on it today. Since the 1970s, mounting environmental concerns and the mixed experience with deregulation in the 1990s have altered, but not fundamentally changed, this regulatory compact of balancing supply, reliability, cost, and environmental protection.

At the outset of the electric power industry, regulators stayed out of technology battles and facilitated rights of way or protected franchises. The first technological battle was between Thomas Edison's Direct Current (DC) and George Westinghouse's Alternating Current (AC). In 1889 a small company in Oregon, Willamette Falls Electric, strung high voltage lines from the falls to Portland, 14 miles away, and lit up the streets using a DC system. It was the first commercial long-distance transmission of electricity in the world.<sup>4</sup> Months later the project switched to an AC system that also worked, but reduced power losses significantly. The battle essentially ended in 1893 with the invention of a system that allowed both DC/AC systems to coexist on the same network.

As electric systems proliferated and the usefulness of electricity became increasingly compelling as a driver for economic growth, human health, and quality of life, state governments resolved to extend the benefits of electric power to all citizens by creating monopoly service territories in exchange for utilities

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<sup>4</sup> A longer transmission link between Niagara Falls and Buffalo, New York (25 miles) was established in 1896, seven years after Willamette Falls Electric's line in Oregon.

agreeing to an “obligation to serve” under regulated rates of return. This “regulatory compact” reflected the facts that electric power was a capital-intensive industry with high barriers to entry and falling per unit prices as the scale of the enterprise grew – key characteristics of natural monopolies. Wisconsin was the first state to establish electric power regulation in 1907, and by 1930, every state but Delaware had followed suit.<sup>5</sup>

The power sector’s first “killer app” – electric lighting – quickly outcompeted the incumbent – gas lighting – and the introduction of the first practical AC electric motor in 1888 swiftly extended electrification into other sectors, including manufacturing, commerce, and end-use consumer appliances. As expanding use of electricity drove improvements in system load factor –improved utilization of the power infrastructure – prices per unit electricity continued to fall, further encouraging users large and small to connect to the regulated monopoly grid, and continually stimulating increased electricity consumption.

Through the first half of the 20<sup>th</sup> century, synchronous AC systems grew, added generation and extended their reach. Eventually systems began running into each other and owners realized the value of combining systems to take advantage of different generating sources, building infrastructure and leveling the load. Many of these mergers were politically charged as owners such as Samuel Insull and J.P. Morgan fought to build electric empires. In response to the excessive control certain companies were achieving in utility service such as electric power, Congress passed the 1935 Public Utility Holding Companies Act, which laid down stringent restrictions on corporate structures of “public utilities.” In certain regions, especially the Northeast, cooperation among different systems arose to create power pools to self-regulate interconnected parties. The merger battles lasted through the first half of 20<sup>th</sup> century and consolidation continues today, albeit most often in congenial unions such as the one recently proposed by Duke Energy’s acquisition of Progress Energy.

After World War II, economies of scale began to be realized across the industry. The prevailing attitude was “bigger is better”: high voltage transmission was more efficient, and ever-larger nuclear and large coal-fired steam generators converted input fuels to electricity more efficiently and cost-effectively. The per unit price of electricity in the US steadily declined from 1945 through the 1950s, and generation growth averaged 9% through the 1950s, and 7% through the 1960s. Vertically integrated utilities providing generation, transmission, and distribution of electric power were the prevailing model through the 1970s, when economies of scale in power generation began to plateau and sweeping environmental policies came into being. With pressure to reduce pollution and keep generation affordable, Congress passed the Public Utility Regulatory Policies Act (PURPA) in 1978, which effectively introduced competition into the

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<sup>5</sup> Delaware eventually established its Public Service Commission in 1949.

generation sector by encouraging non-utility generators to sell power at utilities' marginal cost of producing electricity, which was generally an attractively high value. A new responsibility for regulators became to determine this "avoided cost" of marginal generation figure and to facilitate a new competitive market for generation.

As the electric system evolved, the power distribution system stretched out to connect consumers coast to coast, across farmlands, over mountains, and throughout metropolitan areas. Since power generation stations were increasingly located far from population centers, transmission systems were built to link central generation and local distribution. Transmission was stepped up to high voltages for efficient transport, and then be stepped down to lower voltages for distribution to people's homes. Distribution circuits naturally tended to follow residential roads, which often were built radially, resulting in one-way power flows from power plants to customers' homes. For over 100 years the system developed in this manner.

PURPA was the first of a set of policies increasingly favorable to competition in electric power generation, inspired by the string of successes in bringing down prices and improving service by deregulating America's railroad, natural gas, telecommunications, trucking, and airline industries. By 1999, 22 states had "restructured" their regulatory systems to allow retail competition in electric power supply, but the spectacular failure of California's flawed competitive power market structure in 2000-01 brought a swift halt to retail competition in many states. Today, only 14 states retain any vestiges of retail electric competition. The Energy Policy Act of 2005 embraced wholesale, but not retail, competition as national policy, and the wholesale markets continue to develop under Federal Energy Regulatory Commission (FERC) oversight and within the bounds of independent system operators or regional transmission organizations.

In the face of rising energy prices, limits to the economies of scale, mounting environmental requirements, and growing challenges in siting new generation and transmission infrastructure, electricity policy discussions today often raise the topic of decoupling – the separation of utility profits from electricity sales – as a means of reforming regulation to remove the inherent disincentive faced by a utility against energy efficiency. We find that Smart Grid investments are underway or being seriously considered in nearly every state in the country. This trend is independent of whether utilities are vertically integrated or unbundled; whether market competition is allowed; and whether decoupling is moving forward. Clearly, the Smart Grid is taking shape across the nation.

## Why Smart Grid?

### MANAGING COMPLEXITY

We are increasingly asking our power system to do more than just send electric current down the wires from central power plants to customers' homes and businesses. These days, we are adding intermittent generation (e.g., wind, solar); distributed generation that can help reduce peaking generation needs; Plug-in Hybrid Electric Vehicles (PHEVs) and Electric Vehicles (EVs) that might exacerbate or ameliorate peak demand; siting and permitting constraints on new transmission and generation; environmental constraints imposed on generation sources and transmission, and increases in end-use demand on the system created by a growing population and continuing digitization of our economy. Without Smart Grid technologies, the analog, electromechanical, and manually-operated energy delivery system that we have relied upon from the turn of the 20th century through today simply cannot be expected to cope cost-effectively or reliably with these new opportunities, limits, and needs.

### ADDRESSING ENERGY COSTS

All signs point to eventual upward pressure on the cost of energy. Constraints on adding generation and transmission, as well as rising environmental concerns regarding climate change, water impacts, and conventional pollutants all underscore the need to more efficiently and effectively operate the energy delivery system to mitigate these cost pressures. Smart Grid technologies can readily address these pressures through demand-response programs, optimizing system operations, integration of renewables and EVs, next-generation energy efficiency tools, and meaningful customer engagement. Better system monitoring and asset management, both of which reduce costs and improve system performance, can also be facilitated through these technologies.

### MODERNIZATION FOR RELIABILITY

Our growing reliance on electricity drives the need for greater reliability. Yet siting difficulties, public resistance to rate increases, and the diversion of utility capital to seek out higher returns in non-regulated businesses,<sup>6</sup> have led to widespread *underinvestment* in the energy delivery infrastructure upon which we depend. General Electric estimates that the average age of electric power transformers is 42 years, which raises concerns, given that the average operational life for which these assets were designed is 40 years. Failure rates rise sharply as such equipment approaches and exceeds its design life, and in an economy that is increasingly dependent on reliable electricity, this translates into more frequent and more expensive outages, to the tune of \$150 billion per year - roughly 1% of US GDP - in economic costs.

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<sup>6</sup> Examples include merchant generation, telecommunications, and real estate

## MITIGATING BRAIN DRAIN

In addition to an outdated infrastructure, the utility workforce is rapidly aging, driving utilities to invest in automation technologies to mitigate the impacts of the forthcoming wave of employee retirements. Line mechanics, field operations specialists, control room operators, and other skilled power sector personnel are set to retire in droves within the decade as the Baby Boomer generation departs from the workforce. Demographics alone render it difficult to replace this sizable generation of workers with the smaller labor pool of successive generations, and this is made more challenging by the lack of students and recent graduates who are trained in the appropriate fields. Even worse, relatively few young people today express interest in traditional power sector jobs that often are viewed as being dangerous, difficult, and/or unglamorous.

## Supporting Factors

We discuss here a number of factors that contribute to the emergence of the Smart Grid into mainstream of utility technologies.

## MATURING TECHNOLOGY

While Smart Grid technologies will continuously evolve, the fundamental building blocks have been established to move things forward. As the mixed experience with deregulation was running its course into the turn of the millennium, entrepreneurs began applying information and communication technologies to create a new class of digital technologies that have the potential to transform the analog, electromechanical grid. Solid-state meters, powerful wireless communications, sophisticated sensors, and consumer-friendly devices are becoming available at attractive price points, thanks to the falling cost of electronics. Mature standards, such as Internet Protocol, facilitate rapid progress toward network-effects,<sup>7</sup> which in turn accelerate technology development across a growing ecosystem of fresh market entrants, nimble technology innovators, and resource-rich technology incumbents, largely financed by venture capitalists eager to replicate or even outdo their successes in the 1990s. Smart grid applications are expanding well beyond smart metering to include distribution automation, demand response, home area networks, microgrids, consumer web portals, distributed energy resources, and networked electric vehicles, to name a few of the more recognizable applications.

## JOB CREATION OPPORTUNITIES

Not only are Smart Grid technologies maturing and becoming more affordable, but the clean-tech sector is increasingly being looked to as an engine for job creation. Renewable energy, energy efficiency,

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<sup>7</sup> The term "network effect" refers here to goods/services whose value rises as the number of users grows. Examples include telephones and online social networks.

building energy management, demand response services, energy storage, efficient lighting, smart appliances, and electric vehicles are but a few of the sectors poised for explosive growth to meet mounting demand in domestic and international markets for clean energy products and services. And each of these industries benefits from, in many cases even rely upon, the deployment of Smart Grid technologies.

#### EVOLVING POWER MARKETS

Since the California energy crisis of 2001, the FERC and regional transmission operators have made progress in restoring faith in competitive wholesale power markets. Recent financial reforms regarding derivatives trading have also placed greater scrutiny on speculative trading in commodity markets such as power and natural gas. These markets provide transparent, timely, and location-specific pricing for energy, capacity, and in some cases ancillary services. Where available, such pricing data will help consumers, energy service providers, and vendors plan and contract for energy services and Smart Grid investments.

#### CONVERGING POLICY

The policy environment of mainstream political and media attention is focusing more and more on climate change, energy security/independence, renewable power, and clean energy-based economic development. The attacks of September 11, 2001 and the ensuing military conflicts in Afghanistan and Iraq brought energy security and independence to the forefront of our political consciousness. The August 2003 blackout served as a stark reminder of the importance of the grid to our modern economy and way of life. Hurricane Katrina in 2005 illustrated the scale and magnitude of catastrophic risks potentially posed by weather events that could increase in severity and frequency in a changing climate. As the 2008-09 recession took hold, interest in the Smart Grid grew further, thanks to its ability to defer or even avoid costly peak capacity investments, to facilitate energy efficiency, and to integrate renewables and electric vehicles. The result was \$3.4 billion in federal stimulus funding for Smart Grid in the American Recovery and Reinvestment Act of 2009 and scores of Smart Grid projects getting underway at scale in states from coast to coast.

#### **Square Peg, Round Hole?**

Despite the convergence of driving factors that are accelerating the adoption of Smart Grid technologies, organized resistance to the Smart Grid is emerging, ranging from legal challenges raised by consumer advocates to media flare-ups over individual citizens' grievances. Litigated disagreements between regulatory stakeholders in utility commission hearing rooms over such matters as cost recovery mechanisms and risk allocation measures have coincided with impassioned public debate over concerns

regarding impacts on human health and personal privacy. Elected officials also have begun expressing concerns about the costs of Smart Grid investments during this period of economic hardship.

Because the vast majority of the US population is served by regulated utility monopolies at the distribution level, and because the preponderance of Smart Grid projects are considered distribution level investments, state utility regulation has become the battleground between Smart Grid advocates and opponents. However, it is increasingly difficult for utility regulation to determine whether or not Smart Grid investments are in the public interest, because utility regulation relies upon analytical tools that are built upon a paradigm that is, in turn, premised on traditional power systems and may be poorly suited to evaluate Smart Grid technologies and projects that enable such advances as unprecedented data resolution, multi-directional power flows, and widespread deployment of small-scale generation and energy storage.

This paper seeks to identify these underlying assumptions and propose fundamental opportunities to better align Smart Grid technologies and utility regulation. We posit that change, in the form of the implementation of Smart Grid technologies, is to a large degree inevitable, given the driving factors discussed previously in this document. For the Smart Grid, it is more a matter of *when* and *how*, and not *if*. Accordingly, we hope that the opportunities for alignment identified here can serve as a starting point for discussions in the energy policy community on how to rethink regulation to help advance, rather than constrain, our energy future with the Smart Grid.

#### *TIME HORIZON*

Utility regulation generally works on a time horizon measured in decades. This is appropriate for slow-to-change technologies, such as power plants, transmission towers, and distribution wires. Versions of these systems being installed today are not fundamentally different from those built in preceding decades.

In contrast, Smart Grid investments, such as smart meters, communication networks, and distribution automation equipment, may be more appropriately held to a 5 to 10 year time horizon. Rapid evolution of these technologies means that even though assets installed today might operate for 20 years or more, the versions available 5 to 10 years from now will almost certainly far outperform the versions installed today. The pace of change brought about by the Smart Grid also requires more sustained commitment (e.g., robust, multi-year funding) to technology research and development, an area long underfunded in the utility sector.

This shorter time horizon for many Smart Grid investments often causes utility regulators to question the appropriate regulatory treatment of these assets. Are they part of regular, ongoing capital refurbishment,

not unlike the normal replacement of meters – just smarter? Or do these projects represent a fundamental and perhaps permanent acceleration of the turnover rate of large swaths of utility infrastructure? Or something in between? How should such (relatively) rapid technology obsolescence be understood and managed by regulators?

### *EXTERNALITIES*

Historically, utility regulation encourages the examination of costs and benefits within the silos of generation, transmission, and distribution. Furthermore, utility-side costs and benefits generally are weighted most heavily in most utility regulation systems, either by practice or by statute, often leaving other benefits to customers and society out of formal cost-benefit analyses used to evaluate Smart Grid project proposals.

In contrast, the costs of Smart Grid technologies today are mostly incurred at the distribution-level, whereas many of the benefits manifest themselves through reduced/avoided generation and transmission costs, as well as customer- and societal-benefits that are well outside the traditional boundaries used in utility rate case cost-benefit analyses. Furthermore, the Smart Grid foster new linkages between energy, telecommunications, and even water infrastructure and policy – all areas treated independently of one another by conventional utility regulation.

As an example, we observe a historical reliance on analyzing projects “above” or “below” the substation, which introduces silo effects that often exclude benefits that materialize beyond the cost “bucket” into which Smart Grid investments are made. What changes can be made to identify and value benefits that reach across the silos of generation, transmission, and distribution? How and to what extent can regulators be encouraged and/or empowered to consider customer- and societal-benefits when evaluating Smart Grid proposals?

### *JURISDICTION*

Unclear legal jurisdiction for Smart Grid regulation is a consequence of the difficulty utility regulation has in addressing many of the externalities introduced by Smart Grid. While electric distribution and retail service always has been and is expected to continue to be regulated by the states, the impact of Smart Grid technologies on generation and transmission— the former of which is unregulated in many states and the latter of which is almost always considered a matter of interstate commerce – blurs the lines between states and the federal government with regard to Smart Grid regulation. Moreover, the growing importance of consumer engagement with the Smart Grid adds an entirely unregulated aspect to this already complicated equation. Add the fact that communication utilities have one foot regulated at the federal level and the other at the state level and the complexity increases further.

To what extent does the Smart Grid require new cooperation and/or realignment between federal and state utility regulators? Who has jurisdiction over the consumer-side of the Smart Grid? How should it be resolved when new entities and services in the Smart Grid space span different jurisdictional boundaries (e.g., a third-party service provider might interface directly with consumers to offer demand response products to a regional wholesale power market, using regulated utility Smart Grid infrastructure to do so).

### *[DE]CENTRALIZATION*

Utility regulation is generally built upon top-down driven, deterministically planned, and centrally dispatched supply-side resources to meet mostly passive demand. Information flows from load projections – which are almost always imperfect – to utility planning, where decisions are made and plans drawn up, and finally infrastructure is built.

In contrast, the Smart Grid enables bottom-up interaction between customer and supplier and decentralized optimization between available supply, supplemental energy storage, and responsive demand. The Smart Grid introduces distributed intelligence to drive democratized decision-making at the consumer edges of the grid, and may merit consideration between centralized<sup>8</sup> and decentralized<sup>9</sup> paradigms for energy regulation, options that may turn out to be difficult to reconcile or even mutually exclusive.

This also will merit deliberation between stakeholders about the complex relationships, roles, and responsibilities that will arise among the many new actors in the Smart Grid, ranging from incumbent utilities, to large third-party service providers, to cloud-computing agents, and individual consumers that own and operate distributed energy resources. The Smart Grid will create new challenges for utility regulation to balance the responsibilities to protect consumers and safeguard the integrity of the power system against the needs to encourage innovation and create jobs.

### *UNCERTAINTY*

The heavy reliance on planning and the widespread application of “least-cost” methodologies underscore the regulatory system's inherent discomfort with uncertainty. Indeed, the mathematical link between risk and reward – the higher the risk, the greater the reward – appears to have been all but severed in some states, where the sharing of risk between utilities and customers through the regulatory compact has been questioned in the courts and by stakeholders focused on short-term gain over long-term stability.

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<sup>8</sup> Central station generation, high-voltage transmission, and radial distribution

<sup>9</sup> Microgrids with distributed generation, building-scale energy storage, localized sensor and switching technologies

Smart Grid technologies, by virtue of being a system of networked devices that enables applications and delivers services, are inherently more similar to the highly-dynamic, ever-changing Internet than to any power plant, transmission tower, or distribution wire, the likes of which have not changed significantly in decades. This characteristic of rapid evolution and uncertain benefits (with both downside *and* upside risk) fits poorly with “least-cost” planning approaches, which are better suited for less-dynamic, more-static technologies.

Discourse within utility commissions often centers on the uncertainties of potentially higher-than-expected costs or lower-than-projected benefits, often without acknowledging the very real possibilities of opposite outcomes. Option theory suggests that flexible resources, such as Smart Grid, will have a relatively higher value than large, inflexible resources when considering rising volatility in energy supply costs.

### **Conclusion**

How do we rethink regulation for the inevitable Smart Grid future? We posit that energy policy stakeholders can and should harness opportunities to better align utility regulation to be more compatible with Smart Grid technologies, so as to help regulators execute the important responsibilities with which they have been entrusted with greater breadth of scope and increased flexibility. Accordingly, we recommend that the process for rethinking regulation in the context of the Smart Grid take place in a collaborative forum of energy policy stakeholders, including but not limited to Governors’ offices, state legislatures, policy think tanks, academic institutions, utilities and related energy and communications firms, environmental organizations, utility commissioners and staff, and consumer advocates. Other states, such as Illinois, have begun working in this direction. We recommend that this collaboration of energy policy stakeholders begin by defining overarching goals that the energy system should help society to attain, consider various metrics to measure progress toward these goals, and establish principles to guide appropriate evaluation of Smart Grid proposals toward these ends. Together, we can rethink regulation to advance, rather than constrain, our energy future by taking full advantage of new opportunities made possible by Smart Grid technologies.