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ELECTRICITY DAILY

A Revolution in Power: Where We've Come from, Where We're Headed

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Electricity Policy – the website ElectricityPolicy.com and the newsletter Electricity Daily – together comprise an essential source of information about the forces driving change in the electric power industry.

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Google used to be simply a leading internet search company, but it entered the electricity business by buying big blocks of renewable energy for its large data centers, and by acquiring Nest, the maker of smart thermostats and home devices. It sees opportunity and profits in using innovative technologies to help buildings better manage their energy use.

Walmart used to buy all its power from local utilities. Last year, it met 26 percent of its electricity needs from its own solar collectors and wind turbines.

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Johnson Controls used to focus on automobile parts. It moved into building controls 40 years ago when building management technologies were less sophisticated. Today it's helping commercial office buildings like the giant Merchandise Mart in Chicago save money through electricity management. By installing modern digital sensors and controls to adjust the Mart's electricity demand in response to changing conditions on the electric grid, Johnson Controls profits and the Mart expects to reduce annual electric expenditures by 35 percent.

Google, Walmart, and Johnson Controls are just part of the emerging roster of new players in the electricity industry, which utility monopolies dominated just a few years ago. These entrepreneurs are bringing innovation into what has been America's largest and most capital-intensive, but stodgiest, industry.

Most of us take electricity for granted, yet there's a revolution brewing in how we make, move, and use it. Innovation in energy technologies, both old and new, is driving this activity and its new players.

The resource mix is also changing. Fracking and horizontal-drilling capabilities have vastly increased the extraction of natural gas, which emits about half the carbon pollutants of coal. Coal prices have fallen, but so have most assessments of whether coal will rebound to its former glory days. Prices for solar power modules have fallen 70 percent in the past six years. Wind power costs have dropped 58 percent in the past five years. Battery prices have fallen approximately 14 percent annually since 2007.

Enabled by the proliferation of digital communication devices and the Internet, modern sensors and controls now allow small generators to integrate into the large electric grid. Smart meters are generating terabytes of data that clever companies are using to help consumers better manage their energy use in ways that save money and cut pollution. In short, this ain't your grandfather's power grid – it's just regulated that way.

Unlike historic industry shifts that have been spurred by policy, these technological advances have occurred largely despite policy. In the U.S., the electricity industry's regulatory structure –

designed when Edison's contemporaries were covering cities with wires – is woefully outdated. Although the country has long been electrified, monopolies still control most of the nation's distribution networks. State regulation and planning props up incumbents more than it encourages the dynamism of innovation and free enterprise.

A growing number of regulators recognize that as technologies change, so must our policies. Efforts to embrace the dynamism of these new players are flourishing in New York, Illinois, and a few other states. By welcoming new players into electricity markets, our energy regulatory system has the opportunity to help create a vibrant marketplace that rewards experimentation and efficiency.

The transition would be transformative, leading to enormous improvements in energy efficiency, reliability, and environmental protection. New products will be invented, new services developed, and jobs created. Dramatic change in the electricity industry will upend the status quo, while offering enormous service and profit opportunities in return.

The end of an era

Utilities have monopolized nearly everything about electricity for over a century: its generation, transmission over long-distance wires, and distribution to homes and businesses. Utilities were the sole electricity supplier over large geographic territories, while legal barriers to entry protected them from competition. This regulated-monopoly model electrified most of America relatively quickly and well, but it also enabled inefficiencies and pollution and discouraged innovation. Innovation thrives in a competitive environment; it's an indulgent luxury in a regulated monopoly.

Yet modern technologies are altering the traditional electricity grid. What was once a linear, one-way delivery of electricity from generators to customers is evolving into an integrated, two-way highway populated by new entrepreneurs. Digital communication is enabling innovation at the edge of the energy network, where customer-owned and installed solar has soared, plug-in hybrid vehicles are becoming mainstream, and people can control the energy in their homes from mobile phones.

As might be expected, most electric utilities are challenging competitors and trying to protect their monopolies. Yet taking a lesson from modern phenomena like Apple, Uber, and Airbnb, traditional power

companies could thrive in the new environment by participating in this evolution rather than fighting it. By providing new players access to their distribution systems (and customers), utilities could establish the mother of all platforms – one that connects nearly every person in the country. What's at stake in this transformation is not just lower-cost electricity and a cleaner planet, but ultimately, millions of jobs in new industries we cannot even begin to imagine today.

Lessons from the internet

Our economy and political institutions have a great deal of experience adapting to transformative technologies. The internet, for instance, taught us that incentives for innovation and minimal barriers to entry lead to an astounding array of goods and services.

Vint Cerf, one of the web's creators, attributes such advances to the network being a platform for "permission-less innovation." Netscape, AOL, and other internet pioneers didn't have to secure regulatory approval to change the world, they just had to adopt the internet's technical standards to be able to offer their compelling new services. The internet was a wide open platform with limitless space. In contrast, digital innovations were slow to enter the electricity industry, in large part because our monopoly-regulatory structure discouraged or even prohibited innovation.

But our electricity distribution network is finally getting smarter, with capabilities like automated outage notification, fault detection and repair, and the interconnection of increasingly heterogeneous devices, owned and operated by increasingly heterogeneous agents. Innovators need to obtain less permission to enter the electricity industry, as evidenced by the growing number of electric vehicles that both consume and provide energy. Small-scale and distributed resources – such as batteries, smart thermostats, and intelligent appliances – are empowering people and providing increased security and resiliency.

The "smart home" of the future, for example, features digital sensors that enable lighting, air conditioning, and refrigerators to adjust automatically as electricity prices change, or when renewable power is most abundant. Electricity, in fact, is becoming just one component of a smart home that offers security, internet access, streaming movies, and an array of consumer services.

As a result, the power grid is beginning to resemble the internet's open architecture, essentially becoming a technology platform with common protocols that encourage entrepreneurs to create new ideas, products, services, markets, and applications around the network edge. It also confronts these players with a provider-customer relationship that has changed little in 100 years.

Utility monopolies are worried. In 2013, the largest utilities' trade association, the Edison Electric Institute, issued a report lamenting the financial implications of disruptive technology to the traditional regulated business model. Seeing an increasingly decentralized and distributed electricity system that offers customers the real option to leave the grid, the report warned of a "utility death spiral" reminiscent of the decline of the telephone monopoly. Some analysts suggest the electricity transition will occur more slowly than with telecommunications. Yet in May 2014, Barclay's encouraged investors to reduce their exposure to electric utilities due to the financial pressures likely to arise from "grid defection."

No doubt Google, Johnson Controls, and other new competitors in the electricity market recognize its emerging potential. But some utility executives are beginning to recognize the benefits of a new business model – one that leverages the grid as a platform for innovation and services, not merely a commodity delivery system.

Insull's monopolies and the 20th century grid

Electricity began as a competitive enterprise. Thomas Edison said, "I can only invent under powerful incentive. No competition means no invention." In Edison's day, experimenters struggled to devise and market better lamps and gizmos. Lawyers battled over patents. Bankers viewed the new technologies as means to enormous riches. Gas companies, meanwhile, retrenched to protect their market.

Early competition in the electricity industry, undoubtedly, was messy. It involved bribing city council aldermen for the permits needed to string wires across or under streets. It resulted in incompatible standards – different-sized plugs or varying voltages – so that people moving across town from one power supplier to another often would not be able to use their fans, irons, and other early appliances unless they rewired the plugs.

Competition was also not pretty. Some twenty electric light, telegraph, and telephone companies strung separate wires on poles and buildings throughout Manhattan. According to *The New York Times*, the downtown streets were "darkened by wires, carried upon towering structures erected on the roofs of fatuously good-natured owners." Faulty insulation and exposed wires threatened linemen and tram-pulling horses with metal shoes.

Taking advantage of new technologies that allowed for larger power generators, Edison's secretary, Sam Insull, sought to bring structure to the industry. Beginning with Commonwealth Edison, which he bought in 1892 when it was one of 40 firms generating power in Chicago, he acquired his competition and created multi-state holding companies. By 1912, Insull's electric empire encompassed 400 communities throughout 13 states. It eventually served more than four million customers in 32 states and produced one-eighth of the nation's electricity.

Insull was one of the few business leaders to join progressive politicians to oppose municipal corruption, to advance "scientific" approaches to managing government and business, and to argue that electricity companies were natural monopolies that required public oversight. They declared that state oversight would take politics out of the electricity business, implement uniform accounting standards, and achieve the lowest cost for consumers.

Insull's less vocalized motivation was a desire to deal with only one state agency rather than hundreds of city councils with which his expanding empire was doing business. He also understood that public oversight meant utilities would gain protection from competitors as well as the right of eminent domain, which previously was reserved for the state. According to Insull, "There is one great advantage that must follow regulation, and that advantage is protection."

In fact, utility monopolies have been protected from competition for a bit more than a century. Regulation has been a pervasive construct that shapes their incentives and cultures. No doubt the regulated-monopoly model fulfilled many of its initial goals. Although rural areas needed to wait for a federal rural electrification program, utilities quickly provided power to virtually all corners of America, offering low and stable retail rates for much of the 20th century. These successes led the National Academy of Engineering to name electrification as the century's crowning engineering

achievement.

Protected progress

Regulation was well-suited to guide the industry's growth. It provided a stable infrastructure and investment environment in which debt led to lower production costs and lower retail rates. Over much of the 20th century, process innovation also made large-scale generators more energy efficient, which meant large coal-fired plants could generate more energy (and profit) from a given amount of fuel. This process continued until the energy efficiency and productivity of large-scale generation reached a plateau in the mid-1960s.

Between the 1950s and 1970s, nuclear power promised to alter economies of scale, and therefore the cost structure, of electric generators. Atomic power was expected to be "too cheap to meter." Yet construction cost overruns resulting from complicated engineering and strict safety regulations exposed the limits of public utility regulation and sent electricity rates soaring.

The Federal Power Act of 1935, amended many times since, recognized that provision of electricity is a multistate industry that must be federally regulated to provide service at rates that are "just and reasonable." Energy crises in the petroleum sector in the 1970s, as well as realization that economies of scale in power generation had reached their limit by the 1960s and '70s, challenged the assumption that only vertically-integrated electric utilities could provide power and energy efficiently. Congress's partial response to these energy dislocations was passage of the Public Utility Regulatory Policies Act of 1978. PURPA opened provision of electricity to non-utility providers of cogeneration, renewable energy, and hydropower, requiring that utilities purchase these "qualifying facilities" pay developers the utilities' avoided cost. PURPA thus broke the utilities' monopoly over power generation.

The Energy Policy Act of 1992 opened wholesale markets further under supervision of the Federal Energy Regulatory Commission (FERC), and encouraged efficiency and renewable energy development. As wholesale markets developed, several states implemented policy changes that allowed independent power producers to compete with traditional utilities that had long been vertically integrated to provide generation, transmission and distribution, and retail sales. PURPA and the effect of

FERC's opening of transmission access under open access tariffs in a series of orders accelerated regulatory restructuring at the federal level. These measures opened wholesale markets to competition more widely by reducing entry barriers, leading to potential unbundling of the generation portion of the supply chain from the vertically integrated firm.

Embracing wholesale competition, 15 states and the District of Columbia then implemented retail restructuring and have some form of retail competition for customers today. As a result, two-thirds of the electricity consumed in the U.S. today is transacted competitively through one of the eight organized regional wholesale power markets.

Today, we are experiencing a second wave of innovation-induced unbundling, this time with production process innovation and new products and services in digital smart grid and distributed energy technologies. Digital technology is further decentralizing the electric power industry. Rival retailers in restructured states now offer customers menus of differentiated products and services. Some provide green electricity generated from solar collectors or wind turbines. Some offer lower rates during late evening hours when the demand for power is low. Some offer free weekend energy. And some bundle electricity with security, health monitoring, or entertainment services.

Technological innovation is an evolutionary process, a discovery process with outcomes that no one can fully anticipate. Thus, if we want to learn what, if any, of these digital energy innovations people find valuable, experimentation is crucial. This evolutionary process is the real reason market competition creates value: decentralized markets are simply processes of learning, discovery, and error correction. As they evolve, markets create system-wide efficiencies and outcomes that are otherwise impossible if centrally planned.

The grid as a platform

A useful outgrowth of the internet, one that exploits the concept of permission-less innovation, is a business model for the electricity distribution company as a technological and economic platform that enables innovation at the edge of the network.

A platform provides an exchange for transactions. The stock market, for instance, is a platform for buyers and sellers to exchange shares. Video game

platforms are another common example: the core technology (the console) contains a set of (usually proprietary) elements working in conjunction with other, diverse elements (software) to enable gaming. These diverse elements around the periphery include games written to play on the console, and other devices like joysticks that complement the core. A set of common components allows for economies of scope in production to develop around the platform, which is one of the main drivers of innovation in technological platforms. For example, Microsoft makes and sells the Xbox environment as a platform that enables people to play video games together using the peripheral technologies of the game itself, game controllers, etc.

Platform firms connect distinct and distant users in the network, yet not all network firms operate or think of their business models as platforms. That will change as decentralizing digital technologies evolve further. The network or platform firm facilitates connection, enabling exchanges between two or more parties. This idea is not unique to the digital age. Our transportation network is a quintessential, non-digital network platform: rail networks bring together transportation providers, passengers, and freight; postal networks bring together correspondents; pipeline networks bring together buyers and sellers of oil or natural gas; electric wire networks bring together energy generators and consumers.

At its core, a platform monetizes interconnection among market actors — a driver and a passenger, a homeowner and a visitor, and soon, a power producer and consumer — and allows users to choose a new service provider (Uber or Airbnb) over the central incumbent (such as a taxi service, hotel, or electric utility).

As millions of consumers gain more experience and build trust with Airbnb, Uber, and other disruptive platforms, they may begin to ask why they have such an inflexible electricity system. Why couldn't a consumer share, sell, or buy their own energy (or that of their neighbor) produced by rooftop solar panels, for example? The answer may lie in emerging business models that enable peer-to-peer sharing of distributed energy resources. An electricity distribution platform is one such a model.

Both Uber and Airbnb generate revenue by charging one or both parties for facilitating private transactions that were previously impossible or cost-prohibitive.

This is the very definition of a platform business model.

The reduction of transaction costs through centralization, facilitation, and market-rule-making, allows owners of underutilized assets (cars, apartments, solar panels, and whatever else will evolve in the future) to make others better off by selling them the use of that asset, while benefiting from the financial transaction that makes it possible. Deregulation catalyzed this process in the airline industry, and digital technology is catalyzing it now in rides and rooms. This prospect is exciting for those interested in accelerating the growth of distributed energy resources, particularly by some means other than taxpayer subsidies and government renewable energy mandates.

The role of a distribution platform would be multi-faceted in the electricity industry, due to the core function of infrastructure in electricity distribution. Its primary role would continue to be its traditional value proposition: the physical distribution of energy to people and businesses. For doing so, it would charge a wires tariff, in much the same way that unbundled wires charges are now assessed in restructured markets. Physical reliability and supply security in the distribution network would remain a priority, and a wires platform company would be an appropriate party to assume this responsibility (as distribution utilities are today).

Beyond watts: A new business model for utilities

Beyond its physical role, the electricity distribution platform firm would also be a *market* platform. As energy technologies become more diverse, the distribution company would create additional value by facilitating the interconnection of consumers and their technologies to the distribution network, layering a market platform on top of the physical distribution network. The very existence of these retail market platforms would generate incentives and opportunities for entrepreneurs to develop devices that could operate on this platform and applications that connect the owners of those devices to other agents via the platform. For example, a platform would allow home energy management providers to offer an array of services, including security, internet connections, as well as energy controls. For this market facilitation, the distribution platform would earn a service fee.

The distribution wires network has always had economic value, but the nature of that value is changing with technological

advances. In the early decades of the electricity industry, the distribution network helped local electric companies increase their generation capacity and reduce their average cost by supplying electricity for lighting to homes in the evening, and for streetcars and industrial motors during the day. The network made large-scale, remote generation possible, enabling electric companies to create and exploit economies of scale and scope to reduce the average cost even further. For most of the 20th century, the benefits of centralized generation and the relatively low cost of maintaining the distribution grid extended its value.

The smarter digital grid and distributed energy technologies are changing that century-long calculus, along with the policy objectives that have expanded from universal electrification to environmental quality and sustainability. As distributed generation at smaller scale continues to become more economical, its potential benefits from independence, reliability, and resilience become more real.

By providing market platforms with user-friendly interfaces and open-access product definitions and data standards, the wires platform company would enable retail energy service providers to offer a range of contracts and differentiated products. Time-variant pricing that reflects the true cost of electricity, which varies by time of day, month, or year – while not yet common, is a proven concept and would be easier and potentially more valuable if such a retail market platform existed.

Consumers would also be increasingly able to buy different types of energy, and from different sources. Not only could retailers offer renewable products, as many do today, but budget-conscious consumers could set trigger prices below which they would purchase renewable energy, and otherwise either purchase fossil-fuel-generated energy, or have their devices use less energy, or turn off. This "green-grey mix" of energy becomes possible only when a market platform can recognize different sources of generation and facilitate exchanges based on that information. Note also how such an array of products would create more precise aggregated knowledge regarding the environmental preferences of electricity customers. Markets and price systems could give consumers opportunities to make environmental choices based on their preferences, rather than the highly politicized and costly process of administrative agencies making

regulations to enforce uniform environmental policies.

The burgeoning residential solar market is an example of the kind of market that can grow at the edge of the electric utility platform. Through a combination of technology, market, and policy drivers, the residential solar market has grown substantially over the past decade. Three-quarters of U.S. utility, commercial, and residential-scale PV systems went online between 2011 and the first half of 2013. The installed cost of distributed photovoltaics fell 44 percent between 2009 and 2014, with distributed solar installations comprising 31 percent of all electric power installations completed in 2013. In that same year, overall residential solar PV capacity increased 161 percent in California and 68 percent nationally. The residential solar market is showing how it can be competitive without vertical integration, and its growth would be facilitated by its technological and economic location at the edge of a distribution network with transparent, autonomous interconnection and competitive retail electricity markets.

Community solar, in which groups of consumers – many of which cannot install their own solar panels because their roofs are shaded or they rent an apartment – is also an area of growth. This model allows customers to buy a share of output from a larger solar array, perhaps placed atop a school or in an abandoned lot.

If the utilities do in fact fear a "death spiral," they should reconsider how they create value. With the evolution of smart grid and distributed energy resources – but without any institutional or organizational change – the relative value of wires distribution falls. The utility is not creating as much value as it once was. But it can change by altering some aspects of its business and its role in this social-technical system. For example, distributed energy resource owners could get value out of wires distribution if, by staying connected, they could benefit from selling their excess energy to others in the system, or purchasing energy when the market price is lower than costs. These potential value streams suggest the distribution company could continue to provide value in a distributed-energy world – if it evolves. But these ways of operating are counter to that of a traditional vertically integrated utility.

A distribution platform model and competitive retail market have environmental implications, largely because they encourage efficiency and allow the integration of clean, distributed generation. Electricity markets have long encouraged utilities to sell as much

electricity as possible and to maintain control over electricity generators. Opening those markets to competitors will attract both investment and innovation. Competition and platforms, moreover, will create markets for an array of grid services, such as payments for energy storage technologies that can respond quickly to voltage fluctuations, thereby ensuring system stability.

Regulation and the platform model

Given existing technology, fulfilling the core distribution role in the foreseeable future is likely to be a regulated function and its primary performance objectives will be reliability, stability and affordability, as they are now. The role of the regulator will be to define, monitor, and evaluate performance metrics and to evaluate the distribution platform's estimate of its costs to maintain and invest in necessary assets that satisfy these functions. The distribution company's role as a retail market platform provider also suggests a role for the regulator in market monitoring, and consumer protection through information requirements and fraud reporting procedures.

Enabling a distribution platform business model will require the evolution of the regulatory compact from overseeing "*electric service* to all who request it in the utility's geographic service territory, while earning the utility a fair rate of return" to "*facilitating interconnection and transactions* among all who request them in the utility's geographic service territory, earning the utility an incentive rate of return."

Energizing the electricity sector

Innovation is a crucial part of the electric industry's history. It must also be a part of its future. Digital innovation has thrived in a permission-less environment, and a similar environment is likely to yield the kinds of new energy-related technologies, products, and services that consumers value, that producers profit from creating, and that can reduce pollution and other uncompensated environmental costs. That will require a significant change to status quo regulation that largely favors protecting incumbents over innovation and disruption.

Changing regulatory institutions so that they prioritize those dynamic benefits, while also implementing clear, transparent rules regarding safety, reliability, interconnection, and market access, will better enable this social system to foster a clean and prosperous future.

Changing technology is the primary driver to reduce transaction costs and enable decentralized coordination in the electricity industry. Today's digital innovations will change how we make, move, and use electricity. Advances in digital communication technology over the past 20 years can improve efficiency *and* give customers the tools to reduce their own electricity demand. They also enable remote sensing, fault detection, and smarter substations that can deter outages or detect them, limiting their duration. For customers, such technologies create the possibility for a connected home that offers user-friendly information and access to heating and cooling, lighting, appliances, home entertainment, home security, laundry, and home health care services from the palm of their hand.

Today's technological dynamism and its application to the energy industry has transformative potential, yet very little of it has originated in this sector or affected how most people engage with electricity. Digital technologies now exist that consumers could use to observe and manage their electricity use in a more dynamic way, but the rates and other policies of regulated utilities that sell them energy give them little incentive to do so. Instead of waiting until the end of the month to see their energy use and its cost, customers could select services they value, such as different pricing options, clean energy fuel sources, and automation of their home appliances and systems to respond to changes in price or source, without human intervention. The service convergence in telecom (telephone, television, internet) has provided consumers with opportunities to experiment with and learn the value of bundling services. This same frame of mind needs to scale to electricity.

The cost-reducing impacts of smart grid technology, combined with the recent and projected improvements in distributed generation technology, have the potential to enable decentralized exchange and network reliability to a degree never before seen in this industry. Facilitating this exchange would require a new regulatory framework that enables flexibility and adaptation to unknown and changing conditions. In addition, it should remove barriers to alternative business models, including the model of the distribution company as a facilitating, coordinating platform.

For electricity policy to focus on facilitating behavior that is socially beneficial, regulation should emphasize clear, transparent, and just physical rules

for the operation of the grid. Such regulation would reduce entry barriers that prevent producer and consumer experimentation and learning, while enabling a legal and technological environment in which consumers can use competition and technology to protect themselves from higher costs, rather than relying on outdated economic regulation to do so. By facilitating the connections of increasingly diverse and distributed users, a distribution platform company would lower transaction costs and interconnection costs for energy production and use, which would provide opportunities and incentives for experimentation in both.

The distribution utility can and should operate as a platform and think about innovative platform strategies as its business model evolves. As distributed resources proliferate, the platform firm must rethink how it creates value and reaps rewards by facilitating beneficial transactions in multilateral markets. By reducing barriers to innovation and reducing market entry barriers to distributed energy resources, a distribution platform design can and should align economic and environmental incentives leading to a clean and prosperous future.

A few states are beginning to envision that future. New York's Reforming the Energy Vision seeks to align utility business models with the creation of a more efficient, resilient, and clean electric grid. California's governor wants to provide incentives for entrepreneurs to help the state obtain 50 percent of its electricity from renewable sources by 2030. Illinois policymakers are considering legislation to create more effective markets for electricity's attributes. Some industry leaders describe this emerging convergence of technologies and policies as "transactive energy." However it's described, new markets are being created for "prosumers," be they buildings, electric vehicles, batteries, or microgrids.

No doubt these state initiatives will face opposition and even experience setbacks and adjustments. Yet they demonstrate a growing awareness that public policy must change in order to keep up with – and encourage – technological change. The new players entering the electricity industry are demonstrating the power of markets to stimulate investments and innovation. Their introduction of competition into an industry long dominated by risk-averse monopolies promises to vastly increase the power system's efficiency as well as dramatically expand services to consumers. ■