An 'Uber for Electricity': Institutional Theory and Practice for a Regulated Industry in a Technologically Dynamic Environment

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February 2015

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I. Introduction

Three drivers, two of them innovation-induced, are opening electricity distribution regulatory and business models to scrutiny and evolution. The first driver, the pace of digital innovation and the breadth of its impact in everyday life, makes electricity all the more important while also providing easier and cheaper ways to monitor, observe, and automate electricity consumption and production in a decentralized way. The resulting second driver has been the development of smart grid technologies, which provide a communication network on top of the distribution network and enable the creation of and observation of more information and knowledge at the distribution edge. A third driver is the change in the policy objectives over the past 40 years, adding environmental regulation to the century-old economic regulatory context.

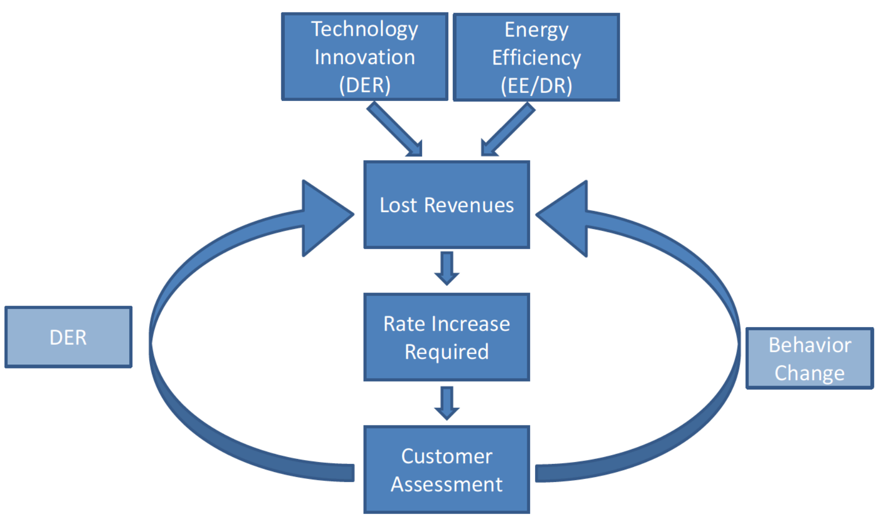
These three drivers converge in pointing toward a desirable policy objective: an electricity distribution model for the future that will enable resilient, sustainable electricity and reduce barriers to innovation. This paper proposes such a model, an electricity distribution platform, and uses work in entrepreneurial theory, institutional economics, and organizational economics to provide a theoretical framework for the model. Ultimately, the implication of this analysis is that regulatory institutional change is required to enable accomplishment of this desirable policy objective. An example of such change is New York's Reforming the Energy Vision (REV) process currently under way, and I apply this analysis to the REV's proposed institutional design and distribution platform business model.

In the past five years, general-purpose digital technologies have expanded greatly and been increasingly integrated into our daily lives. 2.0 billion users worldwide connect to the Internet daily, and across 13 major countries, the Internet accounts for 3.4 percent of GDP (McKinsey Global Institute 2011, p. 11). Slowly, these technologies are intersecting with the old industry that enables them: electricity. Smart grid technologies in electricity are applications of general purpose digital communications technologies within and around the electric power network; a smart grid is a digital communications integration and overlay on the existing electro-mechanical physical wires network.

Smart grid technologies embedded in the distribution network enable automated outage notification, fault detection and repair, and routing of current flows around faults to maintain service. They also enable the interconnection of increasingly heterogeneous types of devices, owned and operated by increasingly heterogeneous agents. In the traditional, linear electricity value chain, large generators send energy toward end-use customers (via high-voltage transmission and low-voltage distribution networks intermediated by transformers). With smart grid technologies, multi-directional connection and current flow in a physically stable distribution network are now possible.

Smaller scale distributed generation and other distributed resources are also increasingly economical, placing pressure on the historical regulated distribution utility model. A 2013 Edison Electric Institute analysis sparked an ongoing debate over the financial implications of disruptive challenges for the traditional distribution utility business model, focusing on the question of revenue generation for the distribution grid in an increasingly decentralized and distributed system and drawing parallels to the decline of the wires telephone industry (Edison Electric Institute 2013). Figure 1 illustrates the pressures that distributed technologies place on the traditional distribution utility business and regulatory model.

Figure 1. The "utility death spiral"

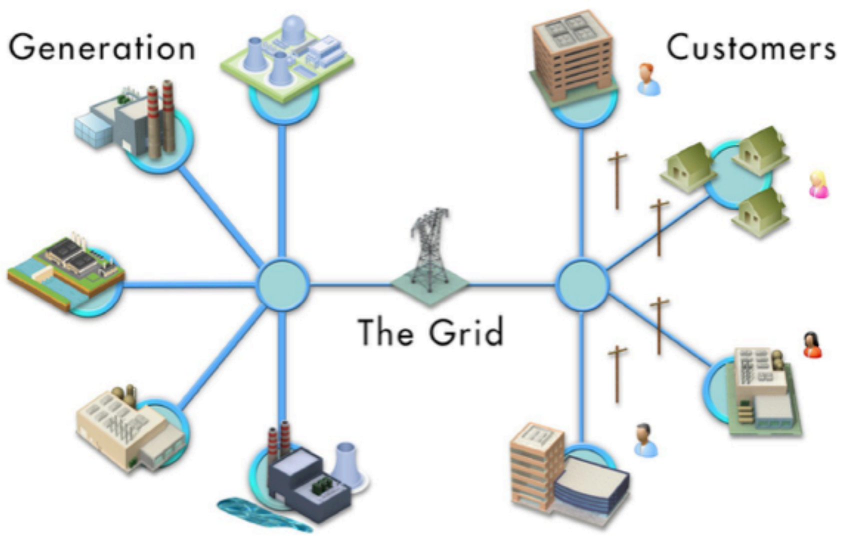


Source: EEI (2013), p. 12.

A May 2014 Barclay's report recommended down-weighting of electric utilities in investment portfolios due to the financial pressures likely to arise from "grid defection", although other analyses suggest that the economic value of the assets and functions in the distribution utility are not likely to erode as quickly as seen in the telecommunications industry (Barclay's 2014, Rocky Mountain Institute 2014).[1]

Figures 2 and 3 illustrate the differences in the existing and the potential distribution system resulting from technological dynamism in the form of smart grid and distributed energy technologies. Figure 2 represents the traditional, linear physical flow and value chain in the industry, while Figure 3 presents a schematic of the more meshed, multi-directional physical and value creation flows that are possible with such innovations.

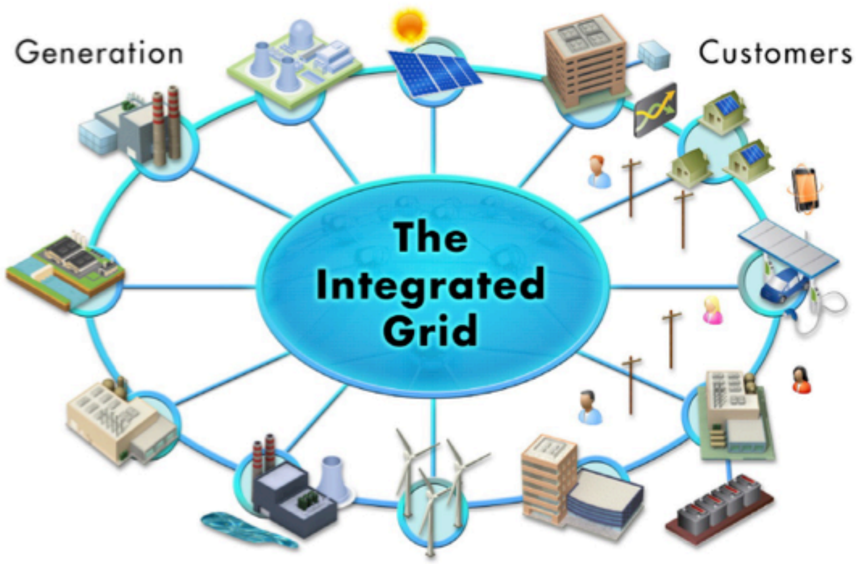
Figure 2. The traditional electricity grid



Source: EPRI (2014), p. 8

[1] In fact, the title for this paper was inspired by a Rocky Mountain Institute blog post, "An AirBnB or Uber for the Electricity Grid?", available at http://blog.rmi.org/blog_2014_09_02_an_airbnb_or_uber_for_the_electricity_grid; I wrote a response to that post at http://knowledgeproblem.com/2014/09/17/the-sharing-economy-and-the-electricity-industry/.

Figure 3. A meshed, integrated electricity network



Source: EPRI (2014), p. 31

These digital distribution technologies enable innovation at the edge of the network, in similar ways to what has occurred with the Internet over the past two decades. The Internet's open architecture (open communication protocols and interoperability) makes creating new devices and applications layered on top of the Internet easy and inexpensive. Internet pioneer Vint Cerf credits this value creation to the Internet's role as a platform for "permissionless innovation". Such welfare-enhancing creativity is possible in electricity as well, as seen in residential solar, microgrids, electric vehicles, and applications and devices for autonomous and mobile home energy management.

Adapting to these changes and enabling value creation from them requires regulatory institutional change to remove barriers to distribution business model evolution. The regulated electric utility business model faces technology-driven change, for which both the regulatory model and the business model are ill-suited. Both the theory and practice of regulation are maladaptive to technological dynamism; existing regulation may slow or prevent innovation within the industry by erecting entry barriers, mandating administered paths of technological and organizational change, and allowing persistent transaction costs.

This period of technological dynamism is also an opportunity to reexamine the regulatory footprint and whether the historical vertical integration in this industry is still economically reasonable (Kiesling 2015). Digital innovation, smart grid, and the increasing energy efficiency and smaller scale of distributed energy resources are changing the economies of scale and scope that drove the traditional vertically-integrated regulated monopolist.

II. Background and literature

A. Regulation, innovation, and recent electricity policy

Since the beginning of commercial electric power in the 1880s, vertically integrated firms have sold electricity as a bundled good with a fixed volumetric price to consumers to compensate both for the fixed costs of wires and equipment and the variable costs of generation. Separate real-time monitoring of electric current was technologically feasible by the 1950s, but bundling and vertical integration remained the status quo for the electric utility business and regulatory environment, until technological change in generation precipitated the regulatory and organizational changes that brought about competitive wholesale markets. Heretofore, monopoly utilities only traded with one another to meet emergency needs, which meant that few high-voltage interconnections existed among service territories. In the US, meaningful institutional change at the federal level occurred with the Energy Policy Act of 1992, creating the potential for wholesale electricity markets by reducing legal entry barriers to exchange, and allowing third-party generation and sales of electricity to distribution companies. This case illustrates how technological change can create potential value from organizational change; innovation changed the transactional boundary of the firm, reduced the benefits of vertical integration, and made generation unbundling possible. In a regulated industry, though, organizational structure is a function both of technology and of the regulatory institutions/framework. New technologies also made possible both centralized and decentralized generation, diversifying the means of energy generation and in turn providing further support for the regulatory unbundling of energy from wires. Yet the regulation of energy and wires as a bundled good persists in many regions to this day.

Since the 1990s and the changes wrought by technological change in generation and the liberalization of wholesale energy markets, an “elephant in the room” question has been the role, nature, and scope of the distribution utility, particularly in its transactions with residential customers.

Edge technologies become more feasible and heterogeneous in nature and scale

Agents participating in the network become more heterogeneous — used to just be utilities and customer types by class (industrial, commercial, residential), with regulators setting the rules. Then with CCGT and wholesale market liberalization agents were generators, utilities, and customer types by class, and increasingly over time as industrial retail markets were opened and industrial customers also self-generated (CCGT, CHP), network participants became more diverse. Also, ISOs/RTOs joined regulators in setting rules, as wholesale market operators and transmission system managers. Now, further technological change enables organizational unbundling of the vertically integrated distribution utility, self-generation at smaller scales for smaller customers, and organization of self-contained microgrid systems. Furthermore, in retail markets when consumers can self-generate with electric vehicles or other forms of distributed energy, the existence of a retail market platform would enable such a consumer to be a consumer in some conditions and a producer in other conditions, so the definitions of types of agents in the network are no longer static.

B. Entrepreneurship and experimentation

The underlying theory and practice of regulation within the electric utility industry so far does not consider experimentation processes that convert creativity, innovation, and technological change into new value propositions for consumers, perhaps revising market boundaries and creating economic growth in the process. Experimentation is among the most substantial drivers of value creation in an entrepreneurial theory of competition that emphasized competitive market processes—the ability of producers to bring new ideas to market, of producers to combine and bundle existing and new products and services in novel ways, and of consumers to discover these new value propositions and learn how much to value them. Yet despite the clear benefits, these concepts have not yet been integrated into the electricity sector. Rogers (1962) identifies experimentation as one of the primary factors influencing the diffusion of innovation. Greenstein (2008, 2012) argues that economic experiments played a significant role in creating value in the markets for Internet access; his analyses suggest that although economic experimentation is a driver of value creation, pre-1990s federal spectrum policy erected a regulatory barrier to such experimentation. The technological, entrepreneurial, and regulatory parallels between the Internet and the electricity industry are stark.

Competition creates value through trial and error while exploring new technologies, innovations, business models, product differentiation, and commercial and profit opportunities. Both producers and consumers are entrepreneurs insofar as they discover new profit opportunities through their alertness. This experimentation-based theory of competition combines the Schumpeterian disruptive entrepreneur who generates creative destruction with the Kirznerian alert entrepreneur who interacts with those changes.

Schumpeter's (1934) pioneering work examines how disruptive innovation creates economic growth via individuals who create "new combinations" of materials and forces, leading to change away from economic equilibrium (1934, p. 65). Individuals come to discover these "combinations" by experimentation. Existing producers differ from these experimenters in their tendency to initiate dynamic, growth-generating change by participating in existing markets, producing existing goods and services, using existing techniques at lower prices. Schumpeter defines fives methods for creating dynamic change in markets: introducing a new good or service, or adding new features to an existing one, introducing new production technology or methods, opening new markets, and capturing new sources of raw materials or new methods of industrial organization (1934, p. 75). Competition in dynamic, free-enterprise societies is a process of change and creative destruction, with new combinations making previous ones obsolete (1942, 84). Dynamic competition often takes the form of product differentiation and bundling to compete for the market. Rivalry occurs among differentiated products; innovators and entrepreneurs change market definitions and boundaries by creating new products and services as well as new bundles of products and services. That dynamic discovery of new value propositions necessarily takes place in an experimentation process in which different producers interact, as do old and new combinations, to meet the market test of consumer value creation.

Schumpeter's disruptive innovator finds its complement in the activity of Kirzner's alert, aware, entrepreneur. The "entrepreneur-as-equilibrator" (2009, p. 147) uses differential alertness to profit, at least speculatively, from an existing opportunity to create net value. Differential alertness means awareness of and openness to a business opportunity that has not yet been widely noticed. This entrepreneur is not a Schumpeterian disruptive creator but engages in trial-and-error experimentation, playing a coordinating role by adapting to underlying changing conditions. Commercializing new products and service – as well as new bundles of products and services– is an example of “equilibrating entrepreneurship”.

These ideas of entrepreneurship and experimentation are relevant to regulatory institutions and institutional change in electric power because decentralized coordination through market processes offers forward-looking coordination of future behavior that is not available to central authorities, including regulators. Smart grid and distributed energy innovations make these decentralized processes cheaper and easier. Markets offer agents of all types opportunities and incentives to make profitable discoveries through experimentation. Regulation as it is currently practiced does not. Regulatory institutions are based on equilibrium models grounded in static concepts of cost recovery that do not incorporate or allow for perceiving opportunities and making discoveries. Unleashing the benefits of experimentation and decentralized coordination in this regulated industry requires institutional change to accompany and facilitate technological change.

C. Vertical integration, unbundling, and vertical foreclosure

In a standard neoclassical competitive model, with full information, no incentive alignment problems, and zero transaction costs, the existence of firms is entirely an artefact of the cost functions in the industry, of such associated issues as economies of scale and scope, and of the size of the relevant (well-defined) market. This approach undergirds the natural monopoly theory and the definition of subadditivity of costs that is the hallmark of electricity regulation.

Work in new institutional economics and organization theory demonstrates that this standard approach overlooks the incentive and governance reasons for having some transactions occur within firms and some occur in markets. Principal-agent problems, the difficulty of writing complete contracts, and other transaction costs determine the transactional boundary of the firm, and when transaction costs change, the profit-maximizing firm’s boundary should change to incorporate the new tradeoffs. The form and magnitude of the change in the firm’s boundary is a function of the expected benefit and cost of rearranging how the transaction is realized, and also of the cost of bringing about the change. As Coase (1937) and others have shown, the desire and ability to decrease transaction costs shapes vertical integration and contracting in a variety of industries (see, for example, Joskow 1988; Klein, Crawford, and Alchian 1978; Baker, Gibbons, and Murphy 2002; Bajari and Tadelis 2001; Bresnahan and Levin 2012).

Vertical integration can have both beneficial and harmful welfare effects. Vertical integration's benefits can include exploiting economies of scale and scope, cost savings, and managerial and transaction cost benefits up to a point (e.g., Klein, Crawford, and Alchian 1978, Bresnahan and Levin 2012). Vertical integration can harm consumers if the firm's pricing includes cross subsidies that distort demand patterns, deadweight loss if the related market is a monopoly, and deadweight loss from regulatory evasion (Brennan 1987). It can also be a source of vertical foreclosure, in which the vertically integrated firm's participation in a downstream market with rival firms exerts an anti-competitive influence in that related market.

Integrated asset ownership and regulation have essentially been a form of insurance against wholesale price volatility while also providing a business model for earning a normal rate of return on the assets used to reduce physical (outage) risk. One difference between vertical integration and contracting is the identity of risk bearer in the case of system failure. In a vertical structure with one firm owning upstream and downstream assets, that identity is likely to be clearer, and the costs of internalizing any harms arising from failures may be lower as a result. With contracting, given the inevitability of incomplete contracting, no contract will be able to stipulate all of the contingencies that might arise between the parties, and unforeseen consequences might lead to costly renegotiation or harm internalization. Damages to or failures of the electrical system harm various suppliers and utilities, but also harm electric customers and the economy at large. One virtue of the historical regulatory regime for electricity is the extent to which it prioritizes reliability of supply over innovation.

The value of vertical integration as insurance, though, is the opportunity cost of alternative institutional arrangements to provide similar functions. Innovations like smart grid technologies change the opportunity cost of vertical integration by creating alternative ways for consumers to protect themselves against price volatility.

Transaction costs, the transactional boundary of the firm, and the feasibility of creating new markets forms the framework for understanding the potential for unbundling energy retail transactions from electricity distribution, a potential that smart grid technologies catalyze. Innovation, including but not exclusively technological innovation, changes the efficient transactional boundary of the firm because it affects the transactions costs, economies of scale, and economies of scope that make vertical integration a profitable organizational structure. These technological changes have created the opportunity to change transaction costs in the industry, thereby creating opportunities to do two dynamic things: change the boundary of the firm in accordance with the change in transaction costs, and create new markets where they previously failed to exist because of transaction costs.

However, the organizational structure of firms in the industry is also a function of the regulatory environment. Technological change has created the potential for shifts of the transactional boundary of the firm and for market creation, but regulatory institutions reinforce the use of antiquated or sub-optimal, but known and familiar, technology. These institutions fail to integrate new technologies adequately into regulatory planning. The investment in existing electro-mechanical technology that is a sunk cost, yet creates an information monopoly for the regulated utility, reinforces an inertial lock-in and reduces the incentives to develop technology feedback effects.

D. Platforms

As in other industries, digital technologies create the potential for the electricity distribution utility to operate as a platform. Baldwin and Woodard define a platform as "…a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components." (2009, p. 19) The distribution utility as a platform is a market design implication of technological change and the increasing complexity of the economic and technological environment in which firms in the electricity industry operate, and it is a consequence with implications for regulatory institutions as well. The organizational and business model of the distribution utility is a consequence of how regulation has been implemented, with the distribution utility having a legal monopoly over the physical distribution of an unchanging, well-defined product in a specific market with clear boundaries. In other words, only the distribution utility has the legal right to transport and sell energy of a particular voltage and quality to residential customers. Regulatory restructuring that enables retail competition has led to organizational change in some jurisdictions. Although here I focus on a design for the distribution platform mode, the changes required to enable such a model are regulatory changes.

Following Gawer (2014), I synthesize three complementary definitions of a platform in the distribution platform model:

1. *Technological*: A technology platform is a common core of technologies within a modular architecture, with variable technology elements around the periphery that interoperate with the core technologies and architectures.
2. *Economic*: An economic platform is a means for facilitating and coordinating mutually-beneficial exchange or transactions in a two-sided or multi-sided market (Rochet & Tirole 2003).
3. *Organizational*: A platform can provide institutions that enable the coordination of the actions and plans of agents (be they individuals or firms) within a technology platform for mutual economic benefit, and it can have different organizational form in different industries and contexts.

Technological platforms

The technological definition of a platform emphasizes its technology elements and the architecture that shapes the system that these elements create. A platform is a collection of technology elements, typically with a stable, common technological core and a variable, heterogeneous periphery (Gawer 2014, p. 1242). Video game platforms are a canonical example – the core technology is a set of (usually proprietary) elements that work in conjunction with other, diverse elements to enable game playing. Those diverse elements include games written to play on the platform, and other devices like joysticks that complement the core system and the other periphery elements to create a game experience. A core of common components allows for economies of scope in production to develop around the platform, which is one of the main drivers of innovation around technological platforms. These economies of scope can be realized both within firms and across firms, and analyzing the implications of vertical integration and firm ownership around a platform is one good reason to extend the analysis of platforms in the organizational-institutional direction.

The common core and variable periphery technology elements interrelate in a modular fashion. Modularity means that when thinking about the system (or, as it is increasingly called, ecosystem), the design of the elements enables substitutability and ease of interconnection within the system. Modular systems have standardized physical sizes and interconnectivity rules, which makes each element less interdependent with the other elements in the system. In a technology platform, then, elements within the platform and at the periphery are independent in the sense that, for example, replacing an element in the core does not necessitate replacing other core elements or the elements at the periphery. Modularity entails breaking up an otherwise complex system (in the technical sense) into discrete components, and having the components interact is what yields the complex system and the desired outcomes. The function that most users would associate with modularity is "plug-and-play" functionality.

Such modular architecture makes platforms well-suited to facilitating innovation. Modularity makes designs more discrete, and implements common rules for interfaces that can act as focal points around which designers can create new designs. This approach simultaneously helps manage complexity and facilitate beneficial complexity, given heterogeneity and subjectivity of preferences and opportunity costs, as well as diffuse private knowledge.

This discussion demonstrates why interfaces are important technological aspects of platforms. With modular elements, a set of common core elements, and variable periphery elements, in order for the elements to work together to achieve the desired objectives they have to be able to communicate and share information across interfaces. Interfaces serve dual roles, as dividers between elements and between the core and the periphery, and also as connectors between elements and between the core and the periphery.

INTEROPERABILITY

Economic platforms

An economic analysis of platforms views them as transaction facilitators and intermediaries. By using technologies that reduce transaction costs, economic platforms create value by enabling parties to connect for mutual benefit, typically in the form of a transaction or exchange. Platform providers create markets, connecting producers and consumers (Rochet & Tirole 2003, Armstrong 2006, Rysman 2009). Such a framework views agents as having specific roles (buyer, seller, platform provider) and exchanging a specific good or service. In the video game platform example, the platform provider creates value by providing a technology (the game console and its operating system) that acts as a focal point (Schelling 1960) for a game seller and game buyer to transact; the exchange yields mutual benefit, and the existence of the platform provides incentives to the seller to develop games for the platform and the buyer to purchase the games. Thus an economic analysis of platforms analyzes the platform as a two-sided market or multi-sided market, where the platform provider coordinates agents through transactions and price signals.

Economic platform models generally rely on several assumptions. First, they assume an exogenous, fixed platform (Gawer 2014, p. 1241), a restrictive assumption that rules out analyzing dynamic evolution of the platform itself. Economic models also assume that the cross-platform relationship is buyer-seller, which rules out analyzing differentiation and heterogeneity in both the roles of agents around the platform and technological aspects of the platform. For example, a strictly economic model has a hard time analyzing a situation in which a platform complement firm then becomes a competitor (e.g., Facebook starting to offer search that competes with Google), or a competitor becomes a complement by choosing to adopt interoperable standards and architecture for its own products and services

However, these strict assumptions do allow some analysis of product differentiation and innovation at the edge of the platform (such as new, different games or complementary devices). But that analysis takes place within a transactional framework that abstracts from the process of innovation itself, and cannot provide an analysis of how a platform can facilitate innovation. That process must include experimentation, trial and error learning, and social learning through engaging in the market process.

Platforms as institutional-organizational elements

Platforms arise and evolve in different organizational contexts, so an organizational lens is a worthwhile complement to the technological and economic platform analyses. Gawer's integrated theoretical framework for analyzing platforms starts from the observation that "… in order to create value, platforms rely crucially on economies of scope in supply and innovation (for the engineering design view), and economies of scope in demand (for the economics view).” (2014, p. 1244) Agents who constitute the platform ecosystem may take on multiple roles; they may be individuals, households, firms, or some other organizational form that is endogenous to the system.

Agents can be individuals or firms, and can play a variety of roles; those roles can change over time, as environment changes, as interactions in a complex system yield new patterns and outcomes. Both the technological analysis and the economic analysis abstract from how the roles of platform owners and platform complementors can evolve between complementarity and competition. They also abstract from the ability of an agent to have different roles in the ecosystem at different times, but this heterogeneity is a novel feature that digital technology enables, and that can have significant institutional and organizational implications.

The technology literature models agents as having fixed roles as collaborative innovators around the platform, while the economics literature models agents as having fixed roles as producers and consumers in multi-sided markets. Empirically, agents can and often do play different roles, and those roles can change as transaction costs and opportunity costs change (Gawer 2014, p. 1243). Modeling the platform as an institutional-organizational element draws on both the entrepreneurship literature and the organizational economics literature on vertical integration, both discussed above.

Raises the subject of governance, which in this context means not just the organizational and managerial questions, but also the regulatory institutions. ELABORATE

III. A platform model for electricity

Using Gawer’s framework, I model electricity distribution platforms as “… evolving organizations or meta-organizations that (1) federate and coordinate constitutive agents who can innovate and compete; (2) create value by generating and harnessing economies of scope in supply and/or demand; and (3) entail a modular technological architecture composed of a core and a periphery.” (2014, p. 1240) Applying that model to electricity distribution suggests some clear roles and scope for a distribution platform – electricity distribution and retail market platform – while still leaving some questions open for analysis and debate.

A. Core functions of a distribution wires company

A core function of a distribution platform will continue to be providing the distribution wires network. Given existing technology, and given initial conditions of existing physical distribution wires network, a "central backbone" distribution network is likely to continue to have economic value into the foreseeable future. To the extent that economies of scale and scope still exist in electricity distribution, a grid that is a central backbone will have value.

The distribution platform firm is the load serving entity (LSE), with the operational and regulatory requirement to deliver electricity service to end users. Accompanying that role are a reliability requirement, with some administrative definition of what constitutes reliability, and the physical real-time network balancing function. The distribution platform is the orchestrator of grid needs, i.e. reliability, voltage regulation, and capacity. The distribution platform earns a normal rate of return and the revenue to maintain and modernize infrastructure through a wires charge to retail customers.

B. Proposed model

The defining feature of a platform firm is that it acts as an intermediary connecting two or more agents for mutual benefit, and the most common economic role of a platform firm is intermediation in transactions by providing a market platform that brings together potential buyers and sellers and makes it easier for them to find each other. Consider the analogy to financial market exchanges, such as stock exchanges or futures exchanges, which provide trading platforms. By being attentive to the interests of both buyers and sellers, they define standard products and rules by which exchanges will occur, and provide timely information and a way for buyers to bid and sellers to offer, opening or closing new markets as the interests of buyers and sellers wax and wane. The distribution platform firm would be in large part a market platform.

As the end users become more heterogeneous and can possess more diverse technologies, the distribution company would create additional value by facilitating the interconnection of those agents and their technologies to the distribution network and the connection of agents, most likely in transactions. In that sense a distribution platform would layer market platforms on top of the physical distribution network. The existence of these retail market platforms would generate incentives and opportunities for entrepreneurs to develop devices that can operate on that platform (e.g., vehicles, home energy management) and applications that connect the owners of those devices to other agents via the platform. For this market facilitation the distribution platform would earn a service fee (details about per transaction or per kWh remain an open question).

This definition of the primary roles of a distribution platform company may appear straightforward, but the scope of distribution platform that would enable it to fulfill these roles may involve the distribution platform itself being involved as a market participant in roles that could have anticompetitive effects. For example, given the load serving entity requirement, should the distribution platform engage in energy market transactions for backup energy generation to enable it to fulfill that role in the cases where decentralized contracts do not give it confidence, or other extenuating circumstances? To maintain system balance in the presence of sufficient diverse and intermittent energy sources like wind and solar, should the distribution platform own and control “behind the meter” residential solar? In both of these cases the presence of a large, regulated buyer or seller could lead to anticompetitive vertical foreclosure.

The distribution wires network has always had economic value, but the nature of that value is changing as technology changes, and the distribution utility's business model can, and should, change to continue creating value from this central backbone. In the early decades of the industry, the distribution network helped local electric companies increase their generation capacity utilization and reduce their average cost by supplying electricity for lighting to residences in the evening and for transportation and industrial motors during the day. The distribution network made large-scale remote generation possible, enabling electric companies to create and exploit economies of scale and scope to reduce 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 meant that it continued to have value.

Smart grid and distributed energy technologies are changing that century-long calculus, along with the changing policy objectives that have expanded to encompass environmental quality along with the traditional social policy goals of universal electrification and low, stable prices for least-cost standard service. As distributed generation at smaller scale becomes more economical, the potential benefits from independence, reliability, and resiliency by disconnecting from the grid become more salient.

But even in a decentralized, meshed network rather than the traditional linear network, the distribution network as a central backbone still has the potential to provide value to being interconnected. The two main value categories are insurance and exchange. A distributed energy installation that disconnects completely from the distribution network is independent and likely to be reliable and/or resilient, but in the case of system maintenance or an unexpected system failure, that system's owner/user(s) bear all of the cost incurred in the outage. A reasonable range of risk aversion is consistent with wanting some insurance, some backup for the times when such an outage will occur. An insurance contract for such backup would be valuable, depending on the relative risk aversion of the distributed resource owner. Backup entails some form of external distribution of energy to that system, and thus entails use of the distribution network. The distribution platform company would have to factor that probability and capacity into its investment plans for maintenance and expansion. One form this transaction could take in a platform model would be for the distributed system owner to contract with a retailer for energy backup, a transaction that would require wires backup, so the insurance charge would be an energy price and a wires charge. There are lots of different ways to price this contract -- an annual fixed fee split between energy and wires (with the wires charge being part of an open-access tariff, along with the other standard distribution wires charges), and a pre-negotiated per-kWh energy price and wires price that would be incurred in the case of having to use the backup. Given how contentious the fights have been over the past two decades over standby charges and fixed fees charged to distributed system owners, the details of this insurance transaction are likely to be fraught and difficult to work out, but this form of insurance is one of the main benefits of a distribution network as a central backbone in a decentralized system.

The other, related, benefit is exchange. A distributed resource owner can benefit only from self-generation if not interconnected to other agents via a distribution network, and only the owner of that asset can benefit from it. Having some means of interconnection enables voluntary, mutually beneficial exchange. In the electricity context, this means of interconnection is multi-layered -- exchange requires a data connection for the exchange of information and a physical connection for current flow. If an agent is considering whether or not to purchase a distributed energy system, or what size of system to install, the possibility of exchange influences that decision greatly.

Deciding to buy a rooftop solar system or an electric vehicle provide examples. The potential to sell excess energy from a solar system, or to sell stored energy from a car battery, increases the probability that a consumer would be willing to buy the asset, knowing that s/he can monetize some of the value of the asset. Similarly, in making that decision the consumer may decide to purchase a larger-capacity solar system. Note how these opportunities, to purchase distributed energy assets and to exchange the energy derived from those assets, creates the opportunity for the homeowner to be both consumer and producer. The DER purchase calculus then becomes one of evaluating the discounted present value of the revenue stream that is likely from the asset, in addition to the consumption value that the owner will derive from consuming the energy and/or transportation services of the asset.

Importantly, this value proposition is precisely the same as that seen in other platform companies. Ride sharing platforms, for example (Uber, Lyft, Sidecar), give vehicle owners an opportunity to monetize an underutilized asset they own -- seat space in their cars -- while giving others an opportunity to get rides. Ride sharing platforms change the vehicle purchase calculus, at the margin affecting the decision of when to buy a new car, how nice a new car to buy, and how many hours to spend on the platform and available to give rides.

Note that the availability of these potential decentralized transactions may also serve the insurance role, because an interconnected DER owner could transact with another DER owner in the case of an individual system problem. In that case exchange enables DER owners to insure each other mutually, and the beneficial role of the distribution platform is facilitating the data and current connection, for which the distribution company earns a (per kWh) wires charge.

The potential benefits arising from exchange are the biggest reason for the distribution business model to be a platform, which lends itself naturally to providing the data and physical interconnection required for exchange. The mission of the firm evolves from providing reliable commodity electric service to all end users in geographical territory to facilitating their mutually-beneficial connections. Those connections are not necessarily only transactions, but most likely to be transactions. Thus a distribution platform company would provide market platforms for energy products, would provide standard terms and definitions (e.g., time-delimited, green-grey, ancillary services).

Everything else is done by agents operating around the edges of the platform. That includes wholesale markets that are upstream from the platform, but most importantly includes independent retailers who are energy service providers. The technologies enable them to offer energy services that are as customized or as generic as individual consumers prefer, as automated or manual as they prefer, bundled with other services or not as they prefer.

The burgeoning residential solar market is an example of the kind of market that can grow at the edge of such a platform (Kiesling & Silberg 2015). The residential solar market has grown substantially over the past decade, through a combination of technology, market, and policy drivers. Three-quarters of U.S. utility, commercial, and residential-scale PV systems went online between 2011 and the first half of 2013 (GTM Research 2013). Installed cost of distributed photovoltaics fell 44% between 2009 and 2014, with distributed solar installations comprising 31% of all electric power installations completed in 2013; in that same year, overall residential solar PV capacity increased 68% across the nation. California led this growth with a 161% increase in 2013 (Sherwood 2014). 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.

Implications for utility business models and regulatory models – a platform-mediated network, and the compatible regulatory institutions that enable resiliency, value creation, flexibility, investment, innovation – retail competition, low entry barriers, technology-agnostic performance-based environmental policy

C. How is a platform model different from a traditional wires-only model?

A platform model emphasizes the role of the firm as an intermediary facilitating the interactions of agents in the network. A platform model does imply some technological differences in the distribution network compared to the traditional distribution grid architecture. The architecture of the distribution grid is designed for one-way current flow, from generator to end user. In a technological context with few large-scale generators and many users, one-way flow was a cost-effective architecture choice. But smart grid and distributed resource technologies have the potential to enable smaller-scale generation and distribution throughout the network, and to enable small-scale transactions between distributed agents, which would require a network capable of two-way current flow. Digital sensors and other distribution automation technologies allow for more transparent monitoring and balancing of two-way flows in a distribution network, but the distribution grid as currently built, configured, and operated cannot provide the central backbone for a platform utility; thus moving to a platform model

D. Challenges for proposed model

1. Risk and physical reliability
2. Financial risk
3. Cybersecurity and privacy
4. Political economy -- status quo bias, incumbent bias, transitional gains trap, even as a platform the firm has an incentive to expand its footprint

Challenge: should P2P wires be legal? Say, connecting neighbors? First priority should be public safety. As P2P wires become safer, and that will happen, that's when the value of the central backbone starts to erode. But that's likely to be a slow process. The regulatory emphasis here should be attentiveness to the pace and direction of technological change, and setting in place public safety policies that have to be renewed regularly so that they don't become maladaptive and stifle beneficial change as technologies and ecosystems evolve.

E. Regulation and the platform model

Given existing technology, fulfilling the core distribution role in the foreseeable future is likely to be a regulated function, retaining the legal entry barriers.[2] With this core role, the primary performance objective will be a measure of reliability and how well the distribution platform delivers reliable service. The role of the regulator will be to define, monitor, and evaluate performance metrics, and to evaluate the distribution platform's estimate of its infrastructure costs to maintain and invest in the assets to enable it to perform these functions satisfactorily. The distribution platform's role as retail market platform suggests a role for the regulator in information provision, market monitoring, and consumer protection through information requirements and fraud reporting procedures.

Enabling a distribution platform business model will required the evolution of the regulatory compact from "electric service to all who request it in the utility's geographic service territory, earning the utility a normal rate of return from averaged rates" to "facilitating interconnection and transactions among all who request it in the utility's geographic service territory, earning the utility a normal rate of return".

One critique of retail regulation is its inability to adapt to unknown and changing conditions (Kiesling 2008). Because regulation stipulates product definitions, product quality, and market boundaries, it rigidifies processes that are usually dynamic and fluid in other markets. Regulation erects legal entry barriers into the distribution and (in many places) retail sale of electricity to residential customers, so it entrenches the historical vertically integrated organizational structure of the regulated firm, despite the very real possibility that innovation has changed the transactional boundary of the firm. In this sense the utility business structure is a regulatory construct. Traditional electricity regulation is static and formulaic, as befits a set of institutions designed to foster infrastructure investment in specific technologies with an objective of universal service at lowest financial cost. Procedural protections, such as the process of pursuing rate cases and rule changes allowing time for public comment (Administrative Procedure Act), increase the transparency of regulation in striving for this objective while also

[2] That said, however, the existing regulatory prohibition against any private distribution wires connections across public rights-of-way is worth reconsidering, given that the prohibition is an entry/growth barrier for the construction of distributed systems such as microgrids and combined heat and power (CHP).

providing some bulwark against the public choice dynamic of concentrated interests being able to control processes and determine outcomes. These procedural protections mean that change happens slowly, which has its benefits because these investments are costly and long-lived, so prudence is a high-priority virtue. Prudence is also a virtue here because regulators are acting as agents, custodians, stewards of ratepayer resources. They are not making investment decisions using and risking their own capital alone.

But courage is a virtue too. Courage enables innovation and entrepreneurial attitudes, and imagining the distribution network, industry, and regulation as different from the 20th century model. In this case regulatory courage manifests itself in adaptability in the face of inevitable technological and economic dynamism. Regulation's opportunity cost is the foregone alternative value propositions that entrepreneurs would create and consumers would try if the retail market were not constrained.

The technological dynamism of the 21st century is a broad expansion of general-purpose technologies with powerful decentralizing forces. These forces are changing what people see as valuable and how they achieve what they want to in their lives. One thing they are changing is the opportunity cost of electricity regulation. When few alternatives exist to the electro-mechanical distribution grid and standard commodity electricity service, that opportunity cost of regulation is relatively low. As digital and distributed energy technologies have evolved, more alternatives are available or could be available through entrepreneurial action. Consumers could prefer those alternatives, if they had opportunities to experiment with, say, in-home transactive devices that could automate appliance responses to electricity price changes, or a retailer bundling home energy management with home security, or residential rooftop solar. But the only way producers have incentives to create and consumers to try is through their mutually beneficial interactions in markets.

IV. Application: The New York Reforming the Energy Vision Proposal

A. Summary

We can apply this analysis to a regulatory proposal under consideration currently in New York called *Reforming the Energy Vision* (REV). On December 26, 2013, New York State Public Service Commission (PSC) issued an order[3] to consider how the state's "regulatory paradigm and retail and wholesale market designs either effectuate or impede progress toward achieving the policy objectives underlying our system benefit programs and our regulation of electric distribution utilities.[4]" REV aims to align utility practices and regulation with the changes in IT, generation, and distribution of electricity. The PSC acknowledges that "these developments promise improvements in system efficiency, greater customer choice, and greater penetration of clean generation and energy efficiency technologies, but only if barriers to adoption are eliminated and proper regulatory incentives are established.[5]" Case 07-M-0548, the "EEPS Changes Order", identified two key questions:

- What is the role of the distribution utility with respect to market-based deployment of distributed energy resources (DER)?
- What regulatory, tariff, market, and incentive changes can align utility interests with the state's myriad policy objectives?

The policy objectives of the commission are:

1. Enhanced customer knowledge and tools that will support effective management of their total energy bill;
2. Market animation and leverage of ratepayer contributions;
3. System wide efficiency;

[3]Case 07-M-0548, Proceeding on Motion of the Commission Regarding an Energy Efficiency Portfolio Standard, Order Approving EEPS Program Changes (issued December 26, 2013).
[4] CASE 14-M-0101 - Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, Order Instituting Proceeding, Issued and Effective April 25, 2014. See also: Case 13-M-0412, Petition of New York State Energy Research and Development Authority to Provide Initial Capitalization for Governor Cuomo's New York Green Bank, Order Establishing New York Green Bank and Providing Initial Capitalization (issued December 19, 2013) and Case 03-E-0188, Retail Renewable Portfolio Standard, Order Authorizing the Redesign of the Solar Photovoltaic Programs and the Reallocation of Main-Tier Unencumbered Funds (issued December 19, 2013).
[5] CASE 14-M-0101 - Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, Order Instituting Proceeding, Issued and Effective April 25, 2014.

4. Fuel and resource diversity;
5. System reliability and resiliency; and
6. Reduction of carbon emissions.[6]

These two questions are answered along two parallel tracks, both of which engage public and private stakeholders to answer these fundamental questions. On May 12, 2014, the PSC held a collaborative meeting to clarify the opportunities for improvement and key questions facing each track of the proposal.

Track 1 focuses on issues related to the distributed system platform provider (DSPP), its functions, issues, and pathway to rollout, as well as separately customer engagement with the new market. Track 1 aims to help utilities focus on overall system efficiency to reduce long-term costs, to be more "customer centric," including ensuring high quality and reliable power for an increasingly tech-reliant population, and to encourage DER participation in the market.[7] The track is also tasked with identifying barriers and opportunities to customer participation in the distribution system and markets, and to clarify the role of energy service providers in these markets. In order to implement REV, the track recommends that each utility establish their priorities and file implementation plans in 2015, "ideally in the context of rate case filing." During that May 12 meeting, the following issues relevant to Track 1 were announced:

- What products and services will the DSPPs purchase/sell from/to DER providers and customers? How will they be priced?
- Should utility be allowed to own/control DER resources? If so, above the line or below the line?
- How should benefits and costs be defined, measured and evaluated?
- How should advanced utility Distribution Management Systems and Communications Infrastructure be deployed?
- What strategies will maximize customer engagement?
- Should the incumbent distribution utilities serve as the DSPP or should the DSPP function be performed by an independent entity?

[6] Reduction of carbon emissions was originally not included, but was recommended by the staff and agreed to by the PSC.
[7] REV Collaborative Meeting PowerPoint, 5/12/14.

To answer these questions, Track 1 has further demarcated working groups, one analyzing DSPP markets and pricing and customer engagement, and a second on platforms, hardware and software, micro- and community- grids.

The second track is concerned with regulatory reforms, especially outcome based ratemaking and rate design issues, in order to support and realize the decisions of track 1. This includes better planning and efficiency incentives to develop longer-term (and less volatile) rate plans, and to enact outcome based incentives for efficiency, carbon reductions, and other policy objectives. To these ends, the track will examine both existing incentives as well as new ones, and will analyze the effect of these modifications on captive customers, including issues of default service, and impacts on the stability of electric utilities, explicitly "bond ratings and the ability of utilities to raise capital."

Over the spring/summer 2014, the first track held two public technical conferences and one public symposium, and is currently subject to public hearings and a comment period for its August 22, 2014 staff straw proposal, which answers questions related to the identify of the DSP, participation of electric utilities in DER, access to customer data, and energy efficiency programs.[8] Originally, it was expected that the track 1 straw proposal would be codified in the fourth quarter of 2014, and the track 2 would be finalized the first quarter of 2015. However, on July 25, 2014, the PSC revised the track 2 schedule, calling on the staff to release a straw proposal by January 30, 2015. Now, the track 1 comment period has been extended as of a January 28 notice, with hearings on Feb. 11 and 12 in Rochester and Binghamton.

B. Public comments

Particularly in late 2014, many comments centered on procedural complaints, namely the lack of public awareness and participation in the PSC rule-making process. Some of these submissions simply read, and in bulk can be summarized as, "slow down". Some stakeholders, most notably local governments, continue to call for extension of the process as well as comment periods. Several PSC notices allude to these concerns, and accommodate them by adjusting the scheduling and rules for comment submissions (e.g., clarifying comment limits for co-authored

[8] PSC Seeks Public Input on Energy Regulatory Reform Initiative, 1/7/15

comments, etc.). In light of this drama, the proposal has solicited (as of Feb 15) a total of 942 public comments.

At least 200 of the comments are copied and pasted text from a coalition of environmental groups, and offer no substantive critique of the process or its contents. Instead, these comments emphasize the need for the state to meet Governor Andrew Cuomo's aforementioned carbon reduction targets, and for the PSC to design REV to meet these pre-determined targets. REV does not replace or circumvent the state's current renewable portfolio standard (RPS), and has explicitly identified carbon reductions as an aim for the new markets.

Perhaps the third most frequent comment category raises issues related to fairness and equity, including the concept of "energy democracy" – a movement to merge the technological energy transition with the strengthening of public participation and democracy, and eroding utility and monopoly control and decision-making in energy.[9] Similar issues are raised in this context, including utility market control and power, the relationship between the PSC and incumbent utilities, the impacts of market changes on low-income ratepayers or rates in general, and the extent to which pro-industrial or profit incentives are fundamental irreconcilable with broader climate goals. Along these lines, some commenters have called for the PSC to levy antitrust cases against incumbent utilities for abuse of their market power (showing a deep misunderstanding of the current regulatory agreement), and fear that mandatory smart metering will cause cancer and harm to those who are particularly sensitive to microwave radiation.

Most substantively but least frequently raised comments address the debate around the fundamental question between the PSC's aspirations for a fair distribution-side marketplace, and the transition to that market. Jon Wellinghoff and his firm Stoel Rives LLP have participated throughout the REV process. In partnership with his firm and Jeffrey Cramer and Katherine Hamilton of 38 North Solutions (who also filed on behalf of the Energy Storage Association), the two argue that the DSPP should not be the responsibility of incumbent utilities, but should instead come from an independent entity. The transition to that marketplace is not dissimilar from the creation of wholesale markets under FERC two decades ago. They argue that "Opening up the regulatory system in New York to competition through the creation of an

[9] See more at http://cleantechnica.com/2013/05/14/energy-democracy-video-campaign/

Independent Distribution System Operator ("IDSO") will (1) enable distributed energy resources to be fully deployed while improving the utilization of existing grid resources; (2) allow for greater consumer choice and participation in the electric grid of the future; and (3) spur the development of a more transactional energy framework for the distribution system that can realize lost value through the emergence of an entirely new energy market model. Our recommendations ask that the Public Service Commission open a new proceeding to consider this regulatory option; require that utilities submit a plan for how they would turn operational management of their assets over to an IDSO; develop a system of monitoring and analysis to ensure that consumers and the grid benefit from the new structure; and propose an operations system that ensures reliability and safety of the electric grid in New York."[10]

SolarCity's (an independent retail solar system company) comments, submitted on the same day, imply a similar underlying distrust of incumbent utilities to develop a fair marketplace for third party providers and other technological and financial competitors. SolarCity's comments can be summarized as follows:

1. Enable consumer choice: Disallow utilities from having monopoly power of DER
2. Analogues to ISOs and RTOs should govern the DSPP structure to facilitate fair and equal competition
3. Net energy metering (NEM) and interconnection should be maintained in order to capture environmental and other values of DER, "If NEM cost shifts become manifest through empirical, evidentiary based determinations, then changes to rate design are the appropriate regulatory response – not full-retail-credit NEM dismantling."
4. Allow "seamless integration of DER into the grid": DER should not be owned by distribution utilities, and should pursue new mechanisms to facilitate DER deployment by consumers. Utilities should incorporate DER into distribution planning, and avoid unnecessary financial burdens like standby charges.

The Track 1 straw man proposal was released on August 22, 2014, and it "reaffirms" the original recommendation of the April 2014 staff proposal that incumbent distribution utilities should serve as DSPs. They write, "The market operations, grid operations, and system planning functions

[10] Comments of Jon Wellinghoff, Stoel Rives, LLC, and Katherine Hamilton and Jeffrey Cramer, 38 North Sollutions, LLC on July 18, 2014

described above could theoretically be carried out either by incumbent utilities acting as the DSP, by a newly- created independent DSP based on the NYISO's model of an independent system operator, or by some combination of both. Under any of these approaches, however, the structure envisioned under REV would not eliminate the need for integrated reliability planning, or the natural monopoly of distribution system operations. Informed by the extensive input on this issue from parties, Staff reaffirms the recommendation originally set forth in its April 2014 Report and Proposal, and recommends that the incumbent distribution utilities serve as the DSPs."[11]

C. Analysis of REV proposal and comments

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V. Conclusion

Digital innovations, largely exogenous to the electricity industry, have created the opportunity to apply digital innovation within the industry itself. These smart grid technologies encompass sensing, monitoring, and automation technologies embedded in the wires network as well as end-use devices that consumers can use to automate changes in their electricity consumption in response to price changes (transactive response) or other triggers. This distributed digital capability for decentralized, autonomous response also makes the electric power network more of a complex adaptive system – more adaptive in the sense that by programming their preferences and actions into digital devices, decentralized, autonomous response enables individual agents to create feedback effects that will largely be negative and equilibrating in nature.

Smart grid technologies and the increasingly decentralized capabilities of a physical and digital smart grid network also change the nature of the types of actions, interactions, relationships, and organizations that are possible in the electric system. Types of generation technologies become more heterogeneous, both in fuel type and in scale, and can be situated differently in

[11] DEVELOPING THE REV MARKET IN NEW YORK: DPS STAFF STRAW PROPOSAL ON TRACK ONE ISSUES August 22, 2014.

the network. Types of consumption can become more heterogeneous too. Agents in the network are no longer only generators, consumers, or transporters (i.e. wires owners) – specifically, agents can now be both generators and consumers due to electric vehicles. Economic agents can take on multiple roles where before each agent had only one role. By changing what role agents could take, the scales at which they can operate, and the knowledge that is now accessible at the edge of the network, digital technologies change the role that the distribution utility can play in the system. It thus changes both the possible utility business models and regulatory institutions.

Three related literatures inform this analysis of a distribution platform model. The transactions cost theory of the firm and of vertical integration suggests that smart grid technologies will have substantial implications for the role, scope, and nature of the electricity distribution company of the future. We analyze these regulatory institutions and business models using a more dynamic theory of competition grounded in experimentation and emergent social learning, and building on the NIE and entrepreneurship literatures. We use that theory to examine platform-based proposals for regulatory and business models, and incorporate into the analysis the development of residential rooftop solar power markets in key US states. By emphasizing experimentation and the role that institutions play in the technological change process, this paper draws on new institutional economics to provide a new analysis of innovation processes in a capital-intensive historically regulated infrastructure industry.

Shift in the value of network connection from distribution utility providing value as a vertically-integrated electricity generator, distributor, and retailer, to the distribution utility providing value as an intermediating platform as a distributor and market platform provider.

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