Project Energy Code

Markets, Technology and Institutions: Increasing Energy Efficiency Through Decentralized Coordination

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EcoAlign Project Energy Code

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INTRODUCTION

Project Energy Code focuses on understanding the "green gap"—the differences between individual statements of concern over energy and the environment and the actual decisions and behaviors of individuals with respect to their energy choices. Why does this green gap exist in our electricity consumption choices? This essay explores two sets of issues:

1. Technological change. New infrastructure technologies that increase transparency, consumer awareness of electricity consumption, and the ability to modify electricity consumption, and the institutions that enable adoption of such innovations.
2. Individual cognitive characteristics. How individual behaviors affect economic decision-making, particularly with respect to implementing the technological and institutional changes mentioned above. These characteristics include risk aversion, status quo bias, loss aversion, and the use of heuristics to make choices in an information-rich and complex environment.

Both of these approaches to the green gap question rely on the fundamental distinction between two different processes for economic decision-making: *decentralized coordination* and *centralized control*. Decentralized coordination is a paradigm in which distributed agents control part of the system, and in aggregate their actions produce order: emergent order, not the imposed order that arises from centralized control. Decentralized coordination is the outcome of market-based decision-making. Historically in the electricity industry, economic decision-making has taken the form of centralized control—that is, central control of investment decisions, retail prices, and the types of products sold to retail customers. Digital communication technology has made decentralized coordination possible, and possibly valuable, in an industry that has a history and culture of centralized control. It is time for regulatory institutions to reform by moving away from mandating centralized control and toward facilitating decentralized coordination.

The demand for electricity is a *derived demand*; electricity is an input into individual consumption of goods and services. We do not consume electricity for electricity's sake, but instead for the benefits, satisfaction, and utility we enjoy from its application. Electricity is an input into activities, goods and services that we value. Thus, not surprisingly, price and savings on the monthly bill are two primary motivators of electricity consumer behavior. Increasingly, though, many consumers are more conscious of the environmental effects of their energy consumption, and are thus motivated to alter their energy use by both economic and environmental incentives.

Information Technology and the Green Gap in Electricity Consumption

Information technology is a valuable tool for closing the green gap because it provides increasingly feature-rich, mobile, and customizable ways to create consumer awareness about electricity consumption, expenditures, and environmental impact. Information technology also provides ways to facilitate change and control in electricity consumption, either manually or automatically. For example, a home area network (HAN) connects appliances, heating and cooling equipment, the water heater, entertainment (stereo, TV, DVR, game console), and lighting into one communication network. The HAN is accessible through a computer screen in the home or a web-based portal that can be accessed via a computer or a web-enabled mobile device. The customer's electricity retailer can communicate real-time information about the quantity of electricity consumed, the energy price, and even the fuels mix of the generation resources consumed. The retailer can also communicate price signals to the customer, and the customer can program the different devices to respond autonomously to price changes: for example, if the price increases from 9 cents to 12 cents, then reduce the temperature in the water heater by 5 degrees, and increase the air conditioner thermostat setting by 5 degrees. Such functionality requires intelligent end-use devices, which are increasingly feasible and cost-effective as the costs of information technology fall. Furthermore, if the home has distributed generation installed, such as solar photovoltaic rooftop panels, the customer can program the network to reduce electricity use once the home's consumption reaches the generation capacity of the solar resource, thereby reducing the use of energy overall and reducing the use of fossil-fuel-generated power. These digital communication technologies facilitate value creation, reduce environmental impact, and increase decentralized coordination in the electricity industry precisely because they increase transactions in the network. We refer to this greater participation in decision-making as a more "*transactive*" network.[i]

The innovations in digital communication technology have transformed our daily lives (in ways other than electricity-related!), and the incentive and decision processes that have brought them about have been a consequence of decentralized coordination, not centralized control. Most of the economic aspects of our daily lives involve some form of decentralized coordination.

Take the example of the iPod: as a product it is a combination of ingenuity and innovation from the U.S. with components and labor from China and other countries, and it is made available to us for purchase through retail stores or online. Apple's decision to manufacture the iPod (and all of the associated input decisions), and a consumer's decision about whether or not to purchase it, provide a textbook example of decentralized coordination. In all likelihood none of the parties in this extensive value chain has a personal relationship with the other parties. This is a system of impersonal exchange, and yet, these parties work together to create vast amounts of value. A consumer's decision to purchase an iPod at a particular price communicates valuable information to the retailer, to Apple, and to Apple's suppliers—all using a system of price signals in market processes to coordinate their individual, private, decentralized actions.[ii] Our understanding of decentralized coordination is grounded in Hayek's (1945) work on the use of knowledge in society, where he argues that prices serve as a focal coordinating device for the choices of millions of actors with diffuse private knowledge about preferences, opportunity costs, etc.

Despite the fact that the value chain in electricity is more complicated in some ways—due both to the physics of current flow in an alternating-current system with little storage, and to its history of retail rate regulation—such decentralized coordination is increasingly possible in the electric power industry. Imagine a vibrant, rich retail market with rival retailers competing to serve end-use customers by offering them menus of contracts from which to choose; these contracts can provide differentiated products and services, depending on the form of pricing and how it varies over time (fixed, time of use, real time), the type of generation resource (green/grey mix), the other goods and services with which the electricity service is bundled (security, health monitoring, entertainment), and other potentially valuable product dimensions that I cannot conceive of, but that entrepreneurs will strive to create through these retail market incentives. Intelligent end-use devices make these products and services both feasible and attractive to consumers, because they provide consumers with information about their consumption, their expenditure, and the environmental impact of their consumption, and because these devices are transactive.

The real value from a network of transactive devices and retail consumers is not limited to consumer and producer benefit in retail markets. Consider the aggregation of the (autonomous and manual) decisions that these customers have their devices make—dynamic prices increase when costs increase, and when demand is close to system capacity. If consumers set their transactive devices to respond autonomously to price signals, aggregate demand will fall precisely when the demand reduction is most valuable for maintaining system reliability. Price signals provide the focal point, the coordinating piece of information to which consumers can respond, and in aggregate their responses generate system reliability. In other words, this transactive process of decentralized coordination leads to the kind of system-level order that has historically only been feasible through strict centralized physical control.

Such technology-enabled decentralized coordination is desirable because it connects the values and preferences of consumers to the dispatch and investment decisions of generators, using a system of price signals in market processes to coordinate the decisions of all of the parties involved in the consumption of electricity by retail consumers. This connection and coordination leads to economic efficiency, and can induce consumers to reduce their electricity use, leading to reduced resource use and reduced environmental impacts from electricity consumption.

The primary driver making such decentralized coordination increasingly possible in the electricity industry is technological change. In particular, advances in digital communication technology over the past 20 years can both improve efficiency and give customers the tools to reduce their own electricity demand. They enable remote sensing and fault detection, as well as greater intelligence capabilities within substations to deter outages or to detect them and limit their duration. From the retail consumer's perspective, such technologies create the possibility for a home communications gateway as described above that gives the consumer user-friendly current information and access to a variety of activities in the home—heating and cooling, lighting, appliances, home entertainment, home security, laundry, and so on. Furthermore, such a home automation system can provide remote access through an Internet portal. This type of technology and variety of retail products and services can even allow price-responsive appliances to trade in real-time retail markets, because the consumer can program his/her preferences into the trigger price settings of the appliances.

REGULATORY INERTIA THROUGH THE LENS OF BEHAVIORAL ECONOMICS

Very few such information-rich products and services exist in electricity, despite their prevalence, sophistication, and value in transforming most other aspects of our lives. In part this dearth of value creation in retail electricity is due to the institutional environment. Economic regulation affects the ability of competitive firms to create new technology-enabled products and services, and it affects the incentives of existing regulated incumbents to offer them. Regulation embeds risk aversion and conservatism in the regulated firms, which at the margin decreases new technology adoption and new product development. It has also balkanized and fragmented equipment markets more than they would otherwise be, driving up costs, retarding standardization, and ultimately isolating the market from innovation due to the lack of market size for vendors.

The processes by which human creativity and technological change lead to the most value creation for the most consumers are market processes—an example of decentralized coordination. While other, more centralized, processes have been beneficial (such as the Manhattan project), since the agricultural revolution of the 17th century and early industrialization in Britain, distributed innovation and markets have driven unprecedented economic growth and increased standards of living. No market process exists in an institutional vacuum, though; the web of formal rules and informal norms in which market occur shape their incentives and outcomes, and the distribution of those outcomes among consumers. The interaction of technology, market processes, and institutions determines the extent to which new value creation is possible through decentralized coordination.

Unlike other industries and other consumer goods, widespread implementation of such information technologies in the electricity industry has been slow. In part this failure to implement information technology in electricity is a result of the heavy role regulation plays in the economic decisions of consumers and firms in this industry. Traditional electricity regulation in the U.S. determines the form that investment takes, based on compensating the regulated firm through a cost-based rate of return. It also uses that cost-based return to determine the retail prices, or rates, that residential, industrial, and commercial consumers pay; these rates are typically fixed and reflect only the average cost of serving the average customer in each customer class.

This institutional design succeeded at achieving widespread electrification—one of the greatest policy challenges of the 20th century (Hirsh 1999).

However, it has not adapted well to technological change, and it is ill-suited to addressing the 21st-century challenges of increasing environmental concerns and climate change, because of its embedded incentives for consumers to consume more electricity and for regulated firms to sell more electricity to increase their profits. Attempts at "rate decoupling" strive to change the regulated firm's incentive structure toward performance and away from volume-based profit, but in general these decoupling attempts are small tweaks of an increasingly maladaptive and obsolete regulatory environment. A more effective way to "decouple" rates from sheer volume of electricity consumption would be to implement dynamic pricing in the form of a menu of retail contracts. Such a service portfolio would create the opportunity for the regulated firm to make more profit by selling less electricity, through dynamic pricing and the mutual benefit of price discrimination to both the consumer and the firm.

Retail customers still overwhelmingly face guaranteed average prices in the form of rate caps, even in states that have implemented some measure of restructuring. This retail price regulation makes the broader consequences of individual consumption choices opaque to consumers—few residential customers realize that the incremental cost of providing them with service on a hot weekday afternoon is substantially higher than at other times. Most customers do not know how much electricity the different devices in their homes consume, nor can they articulate how much electricity they consume per hour. They do not know how much they have spent until after the end of the month when the bill arrives, and even then, the consumption figure is often an estimate, not an actual amount. Consumers typically receive no information about the pollution and greenhouse gas emissions associated with their electricity consumption.[iii] Many of the drivers of consumer electricity consumption behavior are not transparent to the consumer, nor are they aware of the impacts of their consumption decisions in a timeframe in which they can make meaningful changes to their behavior. This drastic disconnect between their economic and environmental drivers and their consumption behavior is the primary cause of the green gap in electricity consumption.

The way that institutions have evolved in electricity restructuring in the states, and the political compromises struck to move restructuring forward, have led to an environment in which wholesale electricity markets and retail rates are still largely disconnected. The states that have not implemented any restructuring do not have wholesale price signals, in addition to retaining fixed retail rates. The artificial environment of fixed retail prices largely removes the price signals that would enable consumers to respond and act on those price sensitivities, if they chose to do so. Fixed retail rates also ignore the diversity among customers in their demand, and exploiting that diversity would lead to better information in the market, lower costs, more reliability, and well-served customers. They are also the consequence of our use of electricity regulation as de facto social policy, subsidizing residential customers at the expense of commercial and industrial customers, and using overall rate regulation as a substitute for more targeted low-income energy assistance. Using overall rate regulation to protect specific customers obscures the relationships among service values and costs, and creates a wedge between consumer incentives and the environmental consequences of their electricity use.

Regulatory institutions are slow to adapt to technological change, much slower than market processes. In part regulation's lack of adaptive capacity reflects deeply-embedded cognitive and behavioral characteristics of humans; regulation reinforces some of the most important cognitive aspects of individual decision-making that lead to the persistence of the green gap. In particular, regulation increases both risk aversion and status quo bias among regulators and the regulated firms. In the standard neoclassical economic model of natural monopoly regulation, these behavioral factors are irrelevant because a fully-informed, neutral regulator makes a decision based only on the net benefits of the choice. In this model the firm is a black box, and the regulator makes decisions based solely on a net benefit calculation. A circumstance such as the incumbency of a particular alternative is irrelevant to the decision in the standard neoclassical framework, although risk aversion in the face of unknown outcomes can be represented in the neoclassical natural monopoly model. However, incorporating these behavioral characteristics into a model of regulatory inertia means that the firm is no longer a black box, and the behavioral aspects of individual decision-making within the firm and by the regulator can affect their decisions.

Risk averse preferences can affect incentives facing both regulators and the regulated firms. Knowing that their decisions will be subject to public acrimony and political repercussions if they lead to unpopular outcomes, regulators are extremely conservative in the investment and pricing choices they allow. Regulated firms see these incentives, and also know that their proposals will face *ex post* prudence review as well as public criticism. As long as their incentives are determined by cost-based regulatory institutions, they will make investment and pricing decisions that reflect risk aversion, and will thus be slower to innovate than firms in industries not subject to economic regulation. This risk aversion on both parts leads, for example, to continued proposal of and approval of flat-rate retail pricing and to investments in new fossil-fuel generation capacity instead of allowing dynamic pricing and intelligent technologies to enable a transactive electricity network. The risk aversion of the regulator and the regulated reinforce each other, leading to the following dilemma: as long as we rely on a regulatory institution based on historic cost recovery for investments in innovative technology to close the green gap, those investments will be extremely slow to materialize, and may not be optimal because of the politicized nature of the decision process.

Another cognitive feature of decision-making that reinforces risk aversion and the slow adoption of new technology is *status quo bias*. Status quo bias occurs when individuals choose to maintain a status quo situation, even if they can reasonably expect to be better off under an alternative to the status quo. In general, status quo bias is an inclination to continue with an established behavior in the face of compelling alternatives, and a dramatic benefit is required to induce a move away from the status quo. Samuelson and Zeckhauser's classic study of decision-making with and without status quo framing found status quo bias in a variety of situations, even in a simple, hypothetical situation in a laboratory experiment.[iv] Their observations lend some insight into the relevance of status quo bias to electricity consumers, regulators, and regulated firms:

> *The individual may retain the status quo out of convenience, habit or inertia, policy (company or government) or custom, because of fear or innate conservatism, or through simple rationalization. … Moreover, many real-world decisions are made by a person acting as part of an organization or group, which may exert additional pressures for status quo choices. Finally, in our experiments, an alternative to the status quo was always explicitly identified. In day-to-day decision making, by contrast, a decision maker may not even recognize the potential for a choice. When, as is often the case in the real world, the first decision is to recognize that there is a decision, such a recognition may not occur, and the status quo is then even more likely to prevail.*[v]

Status quo bias arises in many contexts, from brand loyalty to choice of retirement plan to regulatory inertia. Status quo bias can be a rational response to decision-making in a situation with high transaction costs. For example, if the transition from traditional electricity technologies to high-intelligence digital technologies is costly, or if that transition is substantially irreversible, those costs can explain the unusual persistence of the *status quo*. Similarly, making a decision in the presence of uncertainty can reinforce the status quo; note that this cause of status quo bias reinforces the risk aversion discussed above.

One of the psychological foundations of status quo bias is loss aversion, which occurs when an individual perceives avoiding the loss of an asset as being more valuable than acquiring an asset that has the same financial value. For example, someone with loss-averse preferences would rather avoid a $10 fee than receive a $10 discount; such a person places more weight on retaining value that s/he already possesses.

Status quo bias and loss aversion are powerful ideas for understanding the persistence of our regulatory model in electricity, despite its inertia in addressing the 21st-century challenges of increasing environmental concerns and climate change. Its embedded incentives for consumers to consume more electricity and for regulated firms to generate and sell more electricity to increase their profits perpetuate the green gap. Notwithstanding our general increasing knowledge and awareness of the environmental implications of our electricity use over the past two decades, the incentives facing consumers, regulators, and regulated firms to retain the status quo have persisted.

Regulatory inertia slows the adoption of technologies that could help close the green gap in electricity consumption, but a regulatory mandate for new technology investment could be even more problematic, if the mandate specifies technologies and functions that subsequently become obsolete or irrelevant.

The dramatic technological changes of the past 40 years have reduced transaction costs in the electricity industry in ways that make market-based transactions (and therefore decentralized coordination) more possible than before, and the costs of implementing digital technologies continue to decrease. However, achieving the benefits of technology-enabled decentralized coordination requires focusing on institutional change and the creation of new institutions that take human behavior into account.

INSTITUTIONS MATTER

Overcoming risk aversion, status quo bias, and loss aversion in electricity regulation would be valuable because it would remove some of the barriers to thinking differently about retail electricity products and services, their economic value, and their environmental impacts. New technologies can create consumer value without the traditional "iron in the ground" investments. In this context, reducing risk aversion, status quo bias, and loss aversion means thinking about institutional change. As long as the regulatory institutions perpetuate the same incentives that they have for the past century, thinking differently about electricity technology, investment and consumption will be exceedingly difficult. The opportunity cost of this regulatory inertia is high—the longer these institutions persist, less new value creation occurs through new products and services, including products and services that make electricity consumption and its environmental effects more transparent and transactive to the individual consumer.

The persistence of barriers to these entrepreneurial ideas and technologies may be very costly. However, innovation will continue, and may supersede inertial regulation. Imagine, for example, an innovation in battery capacity that enables consumers to power their homes entirely from their electric vehicles, through a stationary battery in the home and a mobile battery in the vehicle. In that scenario, a retail market for home energy management products and services would arise. Consumers could be autonomous and the regulated electric distribution utility business model would be obsolete. The form that regulatory institutions take into the future, and how well they adapt to technological change and our changing values (including environmental values), will affect our future well-being and our ability to close the green gap.

Institutions are the rules that structure the contexts and situations in which economic actors (producers, consumers, etc.) interact. Ostrom gives a broad definition of institutions:

> *Institutions are the prescriptions that humans use to organize all forms of repetitive and structured interactions including those within families, neighborhoods, markets, firms, sports leagues, churches, private associations, and governments at all scales. Individuals interacting within rule-structured situations face choices regarding the actions and strategies they take, leading to consequences for themselves and for others.*[vi]

This definition encompasses both formal and informal rules in a variety of contexts, addressing a range of different challenges that arise in social interaction. Such rules include property rights and use rights; they govern contracts, and they shape the extent to which agents organize transactions through firms or through market processes.

Formal institutions, including economic regulation, shape incentives and therefore affect behavior and decisions. Other important institutions that influence individual behavior are more informal, such as culture, peer pressure, and status-seeking. In fact, these informal institutions may be quite powerful in closing the green gap in electricity. Tendril's Vantage™ home energy management portal gives an example of the use of informal norms to inform and shape behavior. Through the Vantage web page a consumer can manage the electricity use of the home, and can choose to see various types of information about the home's consumption, including average hourly consumption, consumption by individual devices, price and expenditure data, and carbon footprint data. Tendril also provides the consumer with information on the consumption behavior of others—neighbors, others with similar-sized houses—and an evaluation of the consumer's consumption behavior relative to those benchmarks. Tendril executives anticipate that such benchmarking will induce consumers to use the detailed information available to them to manage and reduce their electricity consumption relative to that benchmark.

Institutional change arises from one of two places:

1. Technologies may be easy enough to implement that consumers will adopt them readily. Regulatory incentives then adapt in such a way that firms (regulated or competitive) have incentives to pursue these technologies; or
2. Regulatory mandates (which are themselves fraught with costs) attempt to pick the technology winners and the bundles of services that consumers prefer.

The former typically results in decentralized coordination with market mechanisms dominating. In the latter instances, government attempts to use centralized control to anticipate the technologies and services that are most desirable. Since government cannot muster the same entrepreneurship as market participants, this approach is likely to succeed only in instances where consumer preferences are well defined and fairly consistent, and where the rate of technological change is slow.

CONCLUSIONS

Our traditional regulatory institutions were premised on, and designed for, a static economy with little technological change. In that world, by construction, the only value proposition to consumers is provision of a single service at a low, stable price. That world no longer exists in the electric industry, and the failure of our regulatory institutions to adapt to unknown and changing conditions is costly, in terms of economic inefficiency, of greater resource use than may be optimal, and of long-term environmental quality.

Digital communication technologies create opportunities for market development and product differentiation in the electric industry. One dimension of product development and innovation is the reduction in environmental impact of electricity generation and consumption. Rivalrous competition in restructured electric markets can lead to the development of products and services that enable consumers to control and manage their electricity use in several dimensions, including environmental impact. Devices and appliances with digital intelligence allow consumers to connect their electricity consumption decisions with environmental impact more directly, allow for the communication of price signals directly to consumers, and allow for the autonomous response of those devices to price signals based on settings that reflect the individual preferences of consumers. In this sense smart grid technologies are enabling the development of an increasingly dynamic, complex, adaptive system due to the coordinated and often autonomous responses of heterogeneous individual producers and consumers.

Economic and technological change has, however, also enabled differentiation in consumer preferences, and more granularity and more individuality to be expressed more affordably via markets. These changes have created the means by which firms could serve those preferences by offering differentiated products and services, different bundles of the energy commodity with other services than just transportation of the commodity to the point of use via wires. Technological change has enhanced the potential for entrepreneurship in this industry, both by applying technology to manage energy use and by re-bundling the electricity commodity sale with other goods and services that consumers might value. New technology has made radical change possible, and maybe even inevitable.

Decentralized coordination is good, and is preferable to centralized control because it harnesses the dispersed knowledge of many market participants, it honors differences in individual preferences, and it enables discovery of individual preference and cost differences, through differences in consumer willingness to pay and producer willingness to accept. Decentralized coordination leads to more robust and resilient economic efficiency in the face of change and has more adaptive capacity over time than a system that relies on centralized control.

Institutional change is proceeding, and regulatory institutions are evolving, in ways that incorporate our changing knowledge and beliefs about the environmental effects of electricity consumption. Institutional changes have particularly active over the past five years. These changes have not come about easily or without risk.

Overcoming status quo bias and loss aversion in firms and in regulatory institutions requires something really drastic. These drastic changes are occurring because there is a growing realization that the changes are necessary to bring about increased customer participation in markets, and increased expression of consumer preferences for environmental quality.

FUTURE RESEARCH NEEDS

More research is needed on actual consumer preferences and behavior with respect to electricity consumption, budgets, and environmental preferences. Moreover, little research has been undertaken on how we can design regulatory institutions that take into account actual human behavior and can adapt over time to the dynamics of technological change.[vii] Although some pilot projects have explored how consumers use and value intelligent devices and contractual/product choice, there is still a large knowledge gap with respect to the interrelated issues of human decision-making, technological innovation and regulatory institutional design.

The most effective research methodology for generating this new knowledge is experimental economics. Whether testing a set of hypotheses in a controlled laboratory setting or in a field experiment, we will only learn about the interaction of human behavior, technology, and institutions by constructing an environment in which individuals make choices and face salient payoffs and costs associated with those choices. This claim is particularly true in light of the importance of information provision and the environmental implications of individual electricity consumption choices that are the focus of forward-looking institutional design.

PROJECT ENERGY CODE BACKGROUND

EcoAlign, a strategic marketing agency, was launched to understand, document and develop strategies to close the “green gap” between consumers’ stated intentions and their actual purchasing behavior in connection to energy consumption and the environment. We deeply believe that for the “green gap” to be addressed a massive societal behavioral change is required, one that will be driven by more than good green products. For this reason, EcoAlign is now working with social scientists to start a discussion on customer behavior towards sustainable energy consumption and conservation by identifying emotional, social, instinctual, psychological, subconscious codes that shape human actions and perceptions. This initiative is called “Project Energy Code.”

EcoAlign: The Energy and Environment Agency

EcoAlign is the energy and environment marketing agency. We develop and execute marketing strategies for utilities, renewable energy providers and companies operating in the energy and environment space. We are uniquely suited to help companies achieve their business objectives, from reaching efficiency program targets and improving customer satisfaction, to launching new products, increasing market share and repositioning for growth in the green tech space.

The Author

L. Lynne Kiesling is a Senior Lecturer in the Department of Economics at Northwestern University, and in the Social Enterprise at Kellogg (SEEK) program in the Kellogg School of Management at Northwestern University. Her publications include *Deregulation, Innovation, and Market Liberalization: Electricity Regulation in a Continually Evolving Environment* (Routledge, 2008). Her specialization is industrial organization, regulatory policy and market design in the electricity industry. In particular, she examines the interaction of market design and innovation in the development of retail markets, products and services and the economics of smart grid technologies. She is also a member of the GridWise Architecture Council, and the owner and editor of the web site Knowledge Problem (www.knowledgeproblem.com).

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ENDNOTES

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[i] For an extension of this point and an analysis of the GridWise Olympic Peninsula Testbed project that demonstrated the potential for networked, transactive, price-responsive appliances and a menu of retail contracts with dynamic pricing, see Chassin & Kiesling (2008).

[ii] For an extended analysis along the same lines as this idea, see Rivoli (2006), which examines the transactive relationships and international trade aspects in the manufacture and sale of a t-shirt.

[iii] Electricity production is the largest source of stationary emissions contributing to climate change.

[iv] W. Samuelson and R. Zeckhauser, “Status Quo Bias in Decision Making,” *Journal of Risk and Uncertainty* Vol. 1 (1988), pp. 7-59.

[v] Ibid., p. 10.

[vi] Ostrom 2005, p. 3

[vii] Kiesling (2008) suggests a framework for pursuing such research.

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