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## Energy Efficiency: Choice Sets, Market Transformation, and Innovation<sup>1,2</sup>

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### MARKETS ARE SOCIAL INSTITUTIONS

Markets represent both the site of important energy-related transactions and a potential venue for reshaping energy-related behaviors. Market interventions aimed explicitly or implicitly at market transformation are frequently part of utility and government energy-efficiency programs. However, these interventions are rarely grounded in knowledge of the workings of real markets. As a result, potential energy savings are foregone and program resources are wasted. We have suggested elsewhere that better theory and models are needed to support market transformation (Blumstein, Goldstone and Lutzenhiser 2000). This paper attempts to advance that agenda. The central themes are to highlight the shortcomings of the most commonly employed frameworks for understanding energy-related markets and to emphasize the need for research on actual market conditions, contexts, and players. We begin with a discussion of how common conceptualizations of the market shape our thinking about market characteristics, consumer choice sets, and approaches to market transformation initiatives. The following section discusses innovation and the role of innovation in market transformation. The paper concludes with recommendations for market-related research topics.

#### Market Characteristics

Among the current initiatives to promote energy efficiency, many involve efforts to affect change in efficiency-related product and service markets. (These activities are often described as “market transformation” programs, which we discuss in more detail below.) Notably, however, such efforts stand only loosely on any foundation of information concerning “real” market conditions and dynamics. Instead, many designers of policies and programs have relied too readily on conceptions of “the market” as an abstraction, a place of exchange that, while it may suffer from some “imperfections,” approximates the textbook model of fully informed actors making costless transactions that exchange abstract products. This is a naïve view, to be sure. And it overlooks a significant amount of work in behavioral economics (Camerer and Lowenstein 2004) and institutional economics (Bowles 1998), and insights from other perspectives (Lutzenhiser *et al.* 2009, pp.43-64). Importantly, regardless of its shortcomings, this idealized model of the market

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<sup>1</sup> This paper appears as Chapter 20 in Ehrhardt-Martinez and Laitner (2010)

<sup>2</sup> Many of the ideas in this paper originally appeared in a conference proceeding (Blumstein *et al.* 2001). We have done some updating in light of recent developments in the literature, but have not attempted an exhaustive review.

continues to be very influential in the energy policy world in the U.S., although perhaps less in Europe.<sup>3</sup>

Real markets are more complicated than this. Real markets are not just the sum of transactions among individuals. Real markets have structure. This structure consists of rules governing the conduct of the market actors, relationships among the actors, and physical arrangements to facilitate exchange. Real markets are heterogeneous. Their structure varies greatly depending on the goods being exchanged. Markets for electricity are very different from markets for durable manufactured goods and markets for buildings. Also, markets evolve over time because of technological change and because of changes in the competitors, institutions, regulations, and supply systems involved.

The rules of conduct in a market are often quite complex. These rules may either be explicit or implicit, and most markets have both types of rules. Explicit rules include those that are clearly developed and formulated such as the laws prohibiting insider trading on stock exchanges. Implicit rules derive from custom—for example, the norms regarding tipping in restaurants involve implicit rules, which vary from culture to culture.

Similarly, and contrary to the idealized model, all markets involve an assortment of actors—not simply producers and consumers. In fact, the number of agents and intermediaries can be quite large. For example, in the buildings industry people quickly recognize the importance of builders and buyers, but other important actors include designers, bankers, appraisers, brokers, real estate agents, insurance agents, and lawyers, among others (Lutzenhiser and Biggart 2001). Finally, rules and actors are not the only aspects of the market that tend to become overly simplified in common conceptualizations of the market. The physical arrangements for markets are also complex and diverse. These arrangements include retail stores, online stores, wholesale distribution networks, commodities exchanges, and electronic communications networks.

In short, markets are not simple abstractions, they are complex social institutions.

### **Choice Sets**

Efforts to understand how people and their institutions adopt energy-efficient innovations have relied upon competing theories of consumption. In these theories, people are variously believed to make choices for reasons of economics (e.g., utilitarian value), psychology (e.g., personality, impulse), or the search for social status and cultural conformity (Wilk 1999). Often the competition among the disciplines is more distracting than illuminating. We agree with Wilk that none of these theories tells the whole story,

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<sup>3</sup> Ideas can linger in the policy world long after they have been abandoned by scholars. As J.M. Keynes wrote in his famous comment about the power of ideas, “. . . the ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back.” (Keynes [1935] 1964, 383)

although each has something to contribute. But we want to go beyond the pros and cons of competing theories to suggest that an equally important shortcoming of past research has been its focus on consumer behavior and its failure to recognize the importance of markets in shaping that behavior. The result has been a lack of adequate guidance for designing effective energy-efficiency programs and policies (Wilhite *et al.* 2000).

The problem we highlight is that consumer choice is constrained by market structure. Consumers are not free to choose from among all of the technical possibilities. Rather, the market provides consumers with limited choices. We call the choices that are actually available to the consumer the choice set.<sup>4</sup> To make this more concrete, consider a consumer whose water heater has just failed. If she wants a quick repair, her choice set is typically limited to the one or two water heater models that the plumber has on hand. Conversely, an appliance purchaser who has unlimited time to shop has a set of possible choices, or “choice set” that consists of the universe of models on the market. But the typical appliance purchaser with limited time has a smaller choice set that consists of the models in stock.

How do we learn about what is in the choice set? How can we understand the factors that determine the choice set? Answering these questions requires a shift in focus from consumers to producers and the intermediaries who seek both to compete for customers and to routinize the choices presented in the market in order to simplify design and production, warehousing, merchandising, and supply chain management. The influence of these upstream actors and considerations often has more influence on the contents of particular choice sets than consumer demands.

### **Market Transformation**

In modern societies markets provide the venue for many decisions that affect energy consumption. This leads to the proposition that energy efficiency can be promoted by transforming markets. Since a market is, among other things, a set of choices, market transformation means modifying the choices, and in this case, including new, energy-efficient options while excluding old, inefficient ones from the choice set.

Here we note that one of the elements of an alternative paradigm of economic behavior is implicit in the idea of market transformation. That is, economic behavior is not just about individual action; economic behavior is mediated by markets. This means that it is usually not possible to understand economic behavior without some understanding of the market that provides the context for the behavior. The policy implication, and the rationale for market transformation, is that economic behavior can be changed by making changes to markets.

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<sup>4</sup> We are not the first to observe that only a limited set of choices is available in the market. For example, Lancaster (1979) approached the topic from the perspective of neoclassical economics. Lancaster focused on the role of economies of scale in limiting the variety of choices. More recent work in behavioral economics regarding “choice architecture” (Thaler and Sunstein 2008) focuses on consumers’ cognitive processes, not the configuration of products available to choose from selected by other market actors.

Our thesis is that policies designed to change markets will be more effective if these policies are grounded in an understanding of real markets. While this may seem obvious, surprisingly little material is actually available to provide the necessary understanding. A realistic understanding of any given market requires going far beyond an abstract model of markets. It requires a much more detailed model that incorporates knowledge of the particular characteristics of the products being exchanged and how these characteristics are shaped by the particular institutions in which that market is embedded. To obtain this detailed knowledge requires research on the specific dynamics of those markets that we wish to transform.

To elaborate this idea we examine the relation between markets and innovation. The reason for this focus on innovation is that causing innovation is one way to change (transform) markets and thus cause a change in the pattern of consumption. A rudimentary theory says that if markets provide a choice set, and the choice set defines what is available for consumers, then innovation changes the content of the choice set and thereby changes the pattern of consumption.

While this theory is rudimentary, it can provide some useful guidance in policy deliberations. That said, we are well aware of the theory's limitations. More research on markets and how markets mediate economic behavior is clearly needed. In our conclusion we discuss how elements of our rudimentary theory might guide a research program that will both lead us in the right direction and foster development of the expertise needed to create better theory.

## THE ROLE OF INNOVATION IN MARKET TRANSFORMATION

The words “innovation” and “invention” are sometimes used interchangeably. Here we wish to make a clear distinction between them. We take innovation to include (1) the invention of new technology, new forms of organization and new institutional arrangements that support market action, as well as (2) the general adoption of these. To put it another way, innovation involves invention but not all invention results in innovation.<sup>5</sup> An invention could be a new electronic system to control heating and cooling in a building. New methods to insure that the control system was operating properly before it was placed in service (commissioning) could also be an invention. The innovation process would incorporate both of these inventions into new operating practices for buildings that would eventually come to be expected by building owners and managers as normal operating procedure.

Causing energy-saving innovation has been a major focus of energy policy at least since the Arab oil embargo of 1973. Since then efforts to secure adoption of new technologies have become increasingly sophisticated. The introduction of the phrase “market

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<sup>5</sup> The OED, quoting J.A. Allen, gives the following example of the use of the two words, “Innovation is the bringing of an invention into widespread, practical use. . . . Invention may thus be construed as the first stage of the much more extensive and complex total process of innovation.” (OED 1989, 7:998)

transformation” reflects awareness of the importance of markets as a context for decisions affecting technology adoption.

This was not always the case. In the early years following the Arab oil embargo the US Department of Energy (DOE) was focused on the invention phase of innovation. This approach relied on an implicit mental model for how inventions might be commercialized that might be called the “better mousetrap model”<sup>6</sup> The idea was that, if you invent something useful and you make it known that you have done so, then the potential users will find you.

This model of innovation derives in part from the view, prevalent after the Second World War, that innovation was a linear process, proceeding from research to development to demonstration to commercialization. It is now widely recognized that this linear model of innovation does not describe a real world process. Real innovation processes typically involve complex interactions and a lot of iterations among the steps (for example, Thomas 1994, Utterback 1996).

Attempts to commercialize new products reveal deficiencies that require additional development, which may reveal deficiencies that require additional research; and so on. In fact, successful innovation often depends critically on good communication of information about product deficiencies that is learned downstream (for example, by retailers, installers, end-users) back upstream (for example, to developers, designers, marketers).<sup>7</sup>

### **The Pace of Innovation**

The “better mouse trap model” of innovation now seems rather quaint, but the model may be appropriate for innovation in some markets. For example, the pace of innovation in information technology is truly astonishing and it seems as if there is an amazing appetite for better mousetraps in this area. Unfortunately, energy use, and particularly energy use in buildings, is an area where the pace of innovation is slow and the mousetrap model does not apply.<sup>8</sup>

Obviously the pace of innovation is determined not just by the rate of invention but also by the rate of adoption. If adoption is slow, then innovation will be slow, even if the rate of invention is rapid. But, it seems reasonable to suppose that the rate of invention and the rate of adoption are dependent on each other. A high rate of invention creates many

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<sup>6</sup> Apologies to our European colleagues who may not be familiar with this Americanism. It is attributed, perhaps erroneously, to Ralph Waldo Emerson. Emerson is reported to have said in a lecture, “If a man can write a better book, preach a better sermon, or make a better mousetrap than his neighbor, though he builds his house in the woods the world will make a beaten path to his door.” (Webber and Feinsilber 1999, 86)

<sup>7</sup> Research by economists on changes in energy and environmental technology recognizes that innovation may be stimulated by interventions “downstream” (Popp, Newell and Jaffe 2009). But, the emphasis of this work is on prices and command-and-control regulation and not on more nuanced market interventions, which require more detailed knowledge of the workings of particular markets.

<sup>8</sup> One question about innovation that needs more research attention is, what are the reasons for different rates of innovation in different areas of technology?

opportunities for adoption. Conversely, when rates of adoption are rapid, the incentives for invention are greater. That is, if the rate of adoption is high, then the likelihood that invention will lead to a payoff in the marketplace is greater. Under the right circumstances, the pace of innovation accelerates as rapid adoption stimulates further invention, and further invention spurs more rapid adoption. This is particularly the case where “first movers” can capture market share for mass produced goods (the newest razor or biotechnology product). This is hardly the case in commercial buildings markets, where there is little or no first mover advantage, since a well-received product cannot be quickly and exclusively produced to capitalize on market interest.

### **Innovation: Changing the Choice Set**

The idea of choice sets can be helpful in thinking about market transformation policies and programs. In essence, market transformation is changing a choice set.<sup>9</sup> This can mean including something new in the choice set, eliminating something old from the choice set, or both. Successful market transformation usually involves permanent, or at least long lasting, changes. If something is added to the choice set that benefits the consumer, then the expectation is that consumer self interest will tend to maintain the change. If something in the choice set (say inefficient refrigerators) is proscribed by setting standards, then the expectation is that legal sanctions will maintain the change.

Innovation is one process that changes choice sets. Market transformation focuses on the latter stages of the innovation. The objective is to find efficient (that is, both low-cost and effective) methods for introducing new elements into the choice set. An early example of this approach was the Super Efficient Refrigerator Program (SERP). SERP was an effort of a consortium of electric utility companies that offered a large prize to the appliance manufacturer who was prepared to produce and market the best very efficient refrigerator. The idea was that offering an incentive to a manufacturer to produce an efficient model was cheaper than trying to elicit the production of efficient models with consumer incentives for the purchase efficient models (L'Ecuyer *et al.* 1992; Feist *et al.* 1994)

While SERP succeeded in bringing an energy-efficient model to market, the program had its critics. The SERP refrigerator was a high-end, side-by-side model, although one that may not have competed very effectively even in that niche, and its influence on other refrigerator models has been questioned. Still it serves as a useful example of a strategy for putting something new into the choice set.

The strategy pursued with SERP has come to be known as “technology procurement.” This strategy has been refined in several different market contexts (Hollomon *et al.* 2002; Nilsson 2003). A recent example involves a very successful intervention in the

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<sup>9</sup> More precisely we might say that market transformation is changing the probabilities of selection of elements from the choice set. [Eliminating something from the choice set makes its probability of selection zero.] Note that this changing of the probabilities might be accomplished by modest means (for example, the introduction of a new product into existing distribution channels) or by more far reaching measures (for example, a restructuring of a market).

refrigerator market in China (United Nations 2007). In spite of the political differences between the US and China, there are striking similarities between the Chinese efforts and SERP.

Improvements in refrigerator technology made it possible to implement another strategy for changing a choice set—that is, using standards to *eliminate* certain choices. In the case of refrigerators, U.S. efficiency standards have been wildly successful; over a period of twenty-five years the electricity consumption of the average new U.S. refrigerator has been reduced by around seventy-five percent.

Thus refrigerators provide a nice example of a market transformation strategy that relies on both consumer benefits and legal sanctions. Subsidies for innovation provide consumer benefits by encouraging the addition of more efficient products or practices to the choice set. The gains are institutionalized by performance standards that remove inefficient products from the choice set. Innovation establishes the feasibility of new technology; standards make the new technology mandatory. The result is a choice set that provides a range of products that are more energy efficient through the elimination of inefficient technologies and the addition of more efficient technologies.

## A RESEARCH PROGRAM

Simply put, some of the elements of theory that would inform market transformation efforts include the following:

- (1) markets are heterogeneous,
- (2) markets mediate economic behavior, and
- (3) one of the ways that markets mediate behavior is by providing a choice set from which consumers adopt highly energy-efficient or less energy-efficient technologies.

One of the things that theories do is help us to decide which research topics are worthy of attention. The elements of theory listed above suggest the need for a research program on markets. Below we describe some of the topics that might be included in such a research program.

### Descriptive studies

Since markets are heterogeneous, an understanding of how markets mediate economic behavior requires the study of many different and specific markets. Much fieldwork needs to be done to develop descriptions of how specific markets actually work.<sup>10</sup> A nice

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<sup>10</sup> We recognize that a number of efficiency industry studies of “market effects” and “market baselines” have been conducted over the past two decades (see, for example, some of the reports archived at <http://www.calmac.org/>). We have reviewed some of that work and believe that it holds potentially valuable findings. However, many of the studies are focused narrowly on particular technologies at the retail level, and most results are available only in consultant reports that are often difficult to access. This body work should be more carefully assessed and synthesized through future meta-analyses, as should the experiential knowledge of energy efficiency program implementers working “upstream” from the point of consumer choice (Lutzenhiser et al. 2009). However, the grey literature and undocumented expert knowledge are not substitutes for rigorous comparative studies of markets.



example is contained in (Lutzenhiser and Biggart 2001) where the market for new “class A” office buildings is described. Studies like this can help to determine how choice sets are constructed and where there may be points of leverage for changing choice sets. Examples of markets that would be of interest are electricity supply, appliances, automobiles, existing housing, and building maintenance services.

### Taxonomy

The language for describing markets needs to be refined so that descriptions of markets can become less amorphous. Analysis of descriptive studies of markets should lead to the construction of a taxonomy that can make description more systematic and comparison more precise. The economic discipline of industrial organization (IO) is a possible starting point for taxonomy. IO is concerned especially with the degree of competition in markets. Some of the characteristics that IO has identified as important in the description of markets are

- Entry (how difficult is it for new firms to enter the market? what are the barriers to entry?)
- Concentration (how many sellers and buyers are there? what is their relative size?)
- Transparency (is it possible to know all prices and product variants? how much effort is required to know them?)
- (Cross-)ownership (are there particular formal (legally binding) ties among sellers or with other stakeholders?)
- Government regulation (also the sometimes double role of government as owner and regulator is relevant.)
- Delineation and separability (how well can the market be distinguished from markets for substitutes or complements; are there a lot of spill-over effects to or from other markets or non-markets including environmental effects?)<sup>11</sup>

To these characteristics we might add

- Homogeneity of goods (this can range from very homogeneous (for example, electricity) to highly differentiated (for example, buildings)).
- Transaction repetition (do buyers make often repeated transactions (for example, grocery purchases) or infrequent transactions (for example, automobile purchases)?)
- Production modality of the market goods (there is a continuum here from craft-based production (for example, buildings) to mass production (for example, refrigerators)).
- Social networks (what is the nature of the informal relationships among market participants?)
- Norms (what are the agreed upon standards of conduct for market participants? what sanctions are applied to those who violate the norms?)

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<sup>11</sup> This list, slightly modified, was suggested by an anonymous reviewer.

This list is meant to be illustrative, not exhaustive. The purpose of the list is to suggest the variety of descriptors that may be important. The research task is draw upon existing theory in economics, sociology, and other disciplines to create a framework that will aid in the interpretation of descriptive studies.

#### The Evolution of Markets

More research is needed on the ways in which consumer culture and choices in the marketplace interact with producer/retailer decisions and efforts to shape consumption. As Wilhite et al. (2000) point out, we know a good deal more than we did two decades ago about energy use behavior, but we know relatively little about the codetermination of demand and how social “needs” are created. This knowledge is required in order for us to assess whether, when and how “social marketing” might appropriately (and effectively) be undertaken in this arena. It would also greatly benefit nascent efforts to “transform” those consumer-producer systems (Blumstein et al. 2000, Lutzenhiser et al. 1998, Lutzenhiser and Janda 1999).

#### Government Policy and Choice Sets

The continuing expansion of societal energy consumption is evidence of growth in the development and diffusion of energy using devices and technologies. It is also evidence of the effects of state policies that are formulated without regard for their energy and environmental consequences—for example, zoning and land use regulations, fuel subsidies, transportation planning, building codes, industry protection arrangements, and so on. The effects of these policy approaches in erecting and maintaining constraints on consumer choice and assuring an escalation of consumption should be examined (Wilhite et al. 2000).

While many other research efforts can be imagined, those given above can make a significant contribution to the development of a theory of market transformation. It is worth observing that the development of such a theory would ramify far beyond energy policy, providing a significantly greater understanding of economic behavior in modern society.

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