Reducing "Search Cost" and Risk in Energy-efficiency Investments: Two Success Stories

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ABSTRACT

This paper focuses on two compelling arguments made in the literature regarding the efficiency gap: first, that consumers face significant transaction costs related to searching for and analyzing information on prospective energy-saving investments; and second, that even well-informed consumers still rationally perceive substantial risks — higher risks than with most financial investments — in making these purchases.

Two case studies of efforts to promote governmental energy-efficiency investment are presented. One is a volume-purchase of LED traffic lights by the city of Philadelphia, and the other an information dissemination program aimed at federal purchasers by the U.S. Department of Energy's Federal Energy Management Program. This paper asserts that these programs have been successful because they reduce the two market barriers of high "search cost" and high perceived risks.

Introduction

There is a substantial body of work that attempts to explain the well-documented disparity between the seemingly "rational" degree of energy-efficiency investment — i.e., the degree that meets the discount rates revealed by purchasers in their other, non-energy-related, investments — and those same consumers' actual degree of energy efficiency investing. This phenomenon is commonly referred to as the "efficiency gap."

Several arguments have been made to explain the efficiency gap. Among these are suggestions that, contrary to neoclassical economic theory, consumers may act irrationally in their investment behavior regarding energy efficiency. Sanstad and Howarth (1994) suggest that "bounded rationality" may systematically deter consumers' utility maximization, especially since the calculations involved in energy efficiency comparisons can be difficult. Fitzgerald (1996) presents persuasive empirical results showing subjects making choices that seem clearly inconsistent with rational economic behavior — varying discount rates over different investment time horizons and with different absolute dollar amounts at stake, as well as discounting potential gains at much higher rates than potential losses.[1]

While not discounting these arguments, this paper will focus on explanations of the seemingly rational components — particularly, perceptions of high "information 'search' costs" and high risk — of consumers' resistance to greater investment in energy efficiency, and then attempt to show how two governmental programs address these barriers.

[1] A partial explanation for this "gain-loss asymmetry" may be the economic principle of decreasing marginal utility: the more one acquires of a good, the less value that each additional unit holds.

Perspectives on Information Costs and Risk

Sutherland (1991) uses the well-accepted capital asset pricing model (CAPM) to show that consumers may not be behaving irrationally when they exhibit very high discount rates with respect to energy-efficiency purchases. CAPM posits that the seemingly high random (unsystematic) risk of an asset can be mitigated completely if the investment meets three criteria: it must be marketable, liquid (i.e., easily convertible into cash without substantial losses), and be part of a diversified portfolio. When these conditions are met, the only risk that remains with the investment is the "market," or systematic, risk — that which correlates with the performance of the overall market.[2] In keeping with Carlsmith et al. (1990), Sutherland asserts that the unsystematic risk associated with energy-efficiency investments is often very large, since the actual and expected returns (savings) have traditionally been highly divergent, and since these investments are largely unmarketable and illiquid. Further, especially for smaller purchases, conservation investments are generally not part of a diversified portfolio (of other conservation investments), so their unsystematic risk is not mitigated (comparable to individual stocks that are held singly, not as part of a portfolio).[3] Jaffe and Stavins (1994) corroborate Sutherland's view that the "market barrier" of high risk associated with energy efficiency investing does not necessarily constitute "market failure," since uncertainty and irreversibility of investments are natural economic causes of high discount rates among investors. The suggestion here is that policy intervention might not be warranted.

Another explanation for the efficiency gap is that more efficient replacement products may not provide equivalent performance to their less efficient counterparts. Examples of this are compact fluorescent lamps (CFLs), whose light color quality often does not match that of their conventional incandescent alternatives (though the industry has improved them considerably in recent years), and power-down ("sleep mode") computers and copiers, where network compatibility problems and delayed "wake-up" periods, respectively, have deterred acceptance. Even in the more common cases where more efficient alternatives provide equivalent, or better service, prospective customers may not believe this, and may be dubious about manufacturers' claims regarding the performance of novel technologies (e.g., electronic fluorescent ballasts).[4]

Much of the work on the efficiency gap has considered the concept of "transaction costs." Hein

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[2] This value of diversification is frequently touted by investment advisors and is widely regarded as one of the key factors in the enormous growth of mutual fund investing in the U.S.

[3] Howarth and Sanstad (1995) attack this premise incorrectly. Sutherland asserts only that the unsystematic risk — that portion that does **not** correlate with the market — is often large with these investments. This is the portion that is normally diversifiable if portfolio size is large, such as with mutual funds, but not often with energy-efficiency investing. Howarth and Sanstad, in a rebuttal to Sutherland, make the defensible proposition that the systematic risk of most energy-efficiency investments — the risk that correlates with the market and is not easily diversifiable — may be small or even negative; but this is not at odds with Sutherland's point. He almost states the same, in fact: "[energy-efficiency] investments are probably not risky in the sense of having high β values." β is a measure of systematic risk.

[4] An important caveat here is that a "novel" technology need only be so in the eyes of the prospective user. Koomey and Sanstad (1994) and Levine et al. (1995) make reference to the "time and effort" necessary to become educated on new technologies, and characterize this as a potential "hidden cost," but then explicitly reject the prospect that this factor may have played a role in the slow acceptance of, among others, Energy Star (power-down) office equipment. Several years after this claim, the "sleep" feature still seems unknown, or at least puzzling, to those not in the energy-efficiency field. Another example of this is desiccant air-conditioning, which has been in use for several decades, but is still widely unknown to, and unadopted by, most of the users whose facilities would benefit from it.

and Blok (1995) succinctly define these as "the costs of collecting information on, making decisions about, and monitoring the performance of investments." In one of the few studies to actually attempt to quantify this factor, they found that transaction costs amounted to between 3% and 8% of the energy-efficiency investments made by 12 large, energy-intensive, Dutch industrial firms. Most of this, 2-6%, was accounted for by "information costs," as opposed to decision-making or monitoring. Andersson (1993) has dubbed this information-seeking effort the "search cost." He presents a model showing that consumers have expected returns (vis a vis energy savings) for prolonging their searches. Therefore, they weigh the value of their time against these expected savings; hence, energy efficiency will be invested in less as the expected length of the search is prolonged, or if the expected savings are underestimated. Jaffe and Stavins echo this insight:

> It is by no means costless to learn how a technological improvement fits into one's home or firm or to learn about reliable suppliers. Even after basic information about a technology has been disseminated, the purchase price of a new product is only a lower bound on its adoption cost.

Energy-efficient products often involve new technologies. Given that new and less-proven technologies are likely to require greater search costs (Levine, et al.), this may help explain their slow diffusion into the market.[5] Also, consumers' uncertainty (i.e., their perception towards the undiversifiable, "unsystematic" risk identified by Sutherland) is most likely to be higher with these newer technologies; and this perceived risk is probably present in relation to the non-energy-related performance of these products, as well as their energy-savings features.

Sutherland has characterized these phenomena — the potentially high cost of information and high risk associated with new energy-efficient products — as market barriers to the entry of these products, but not market "failures," in that they are indicative of "real costs in a competitive market." He does concede, however, that because information on product energy efficiencies is costly to obtain and has the qualities of a public good, it may be beneficial for governments to foster it. The two case studies portrayed below represent examples of government programs, one at the federal level and the other a joint effort between a city and a consortium of municipalities, that take two different approaches to effect reductions in search costs and risks associated with energy-efficient product procurement.

Philadelphia's LED Traffic Lights Conversion

The city of Philadelphia spent $2.1 million in 1994 for electricity to run its roughly 28,000 traffic lights. That year, the city's Municipal Energy Office (MEO) applied for and received a grant for $39,000 from Public Technologies Incorporated (PTI) to carry out a pilot demonstration project for LED red traffic lights.[6] The project's intention was to demonstrate the technical and practical feasibility of using these LEDs in lieu of the city's (and country's) previous incandescent standard.

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[5] A close colleague has offered a convincing qualification of this assertion: the novelty is an obstacle only when the "user-interface" of the product is new and untried. Good examples of this point are scroll compressors in residential central air conditioners, and vacuum panels in refrigerators, both of which elicited little resistance in the market upon their introduction.

[6] PTI is the non-profit technology research and development arm of the National League of Cities, National Association of Counties, and the International City and County Management Association. This grant, from Department of Energy funding that PTI administers, was issued through its Municipal Energy Management Program.

The initial (Phase I) demonstration project included "blind" tests in which subjects were asked to drive through an area where random change-outs to LEDs had been made, and report on the visible qualities of the traffic signals. Subjects either reported no differences or favorably rated the 27 LED-retrofitted signals. Another element of Phase I was the accelerated testing of the lights, to help assess their energy savings and longevity. The conclusion of the Phase I study was that the LED traffic lights had no negative safety features, were brighter and lasted longer than their incandescent counterparts, and used substantially less energy. An additional benefit of the LEDs resulted from their burnout pattern. Since the LEDs emit light from many identical sources within a single unit, burn-outs are not simultaneous; in effect, this gradual diminution of light provides a warning to streets maintenance personnel that the light needs changing.

Upon the successful completion of Phase I, a second stage project (Phase II) was initiated, with the help of another grant from PTI (for $25,000). Given the success of the feasibility demonstration, this effort was primarily aimed at producing a specification for the LED signals, using testing and evaluation of four manufacturers' products. The specification development focused on meeting the luminance and safety standards of the Institute of Traffic Engineering (ITE), as well as the presence and persistence of energy savings. The plan was to use this specification to issue a request for procurement (RFP) in order to fully re-lamp the city's signals. Additionally, PTI, as the grantor, could then offer the specification to other member cities, obviating the need for similar demonstrations and pilots for those governments.

In April, 1997 the city began a two-year replacement project with the intention of changing out all 28,000 of its red signals. The expected energy savings of nearly $1 million per year will result in a payback period of less than 2.5 years. The city is also expecting substantial maintenance cost savings — over $150,000 per year — mostly because the projected change-outs will occur every six years (or more), as opposed to two years for the best incandescent alternatives. An additional benefit is reduced liability; since the LEDs' burn-out is gradual, this will essentially give the city's streets maintenance team a warning regarding the necessity for replacement of the lights. The MEO's chief engineer conducted an informal study of Philadelphia's liability for traffic accidents caused by burnt-out red (only) signals and calculated that this was costing the city about $500,000 per year. Given the LED's longer lives and this "warning" feature, he is conservatively estimating the liability savings at $100,000 per year, one-fifth of the potential benefit. Adding maintenance and liability benefits, the payback period drops to 1.7 years, with an internal rate of return of approximately 125% over the lamps' 6-yr. warranted life (though the city expects the useful lives to be greater).

Given that Philadelphia's LED foray is proving to be an enormous success, several questions come to mind regarding the policy implications. Perhaps the most relevant is, what prevented Philadelphia (or other large cities) from re-lamping their traffic signals before (or since, in the case of other municipalities)? In other words, given the presence of the proverbial $100 bills lying in the street, why weren't they being picked up? There are two primary answers. First, there was a search cost barrier to overcome. This was not a product with which anyone in the MEO was familiar, and there was almost no precedent for its use. In keeping with Andersson's model, the expected search cost was high. Correspondingly, the expected return was small — the MEO's chief engineer stated that he had not anticipated that the project would result in the city changing out its signals.

Second, the perceived risk was high. When the proposal for the first grant was being written, in 1993, LEDs were already becoming established as the technology of choice for exit signs, but they had been used as traffic lights in only a few rare instances. Enhancing the perceived risk was the fact that the MEO's chief engineer was well aware of the restrictiveness of the ITE standards. Another risk-related factor tending to dampen the prospects for the project is institutional: the number of city departments necessarily involved in the change-out decision — energy, streets, motor vehicles, and legal — was high. Objections by any of these groups might have killed the project.

What allowed the project to overcome these potential impediments? Among many factors, most prominent was the grant funding from PTI. This served to reduce the information search cost considerably. Although all three people interviewed from the MEO felt that, largely due to the success the project was having as it progressed, the MEO spent more than the PTI grant money in Phases I and II, all three independently asserted that, without this funding, the city would not have embarked on the pilot and specification stages that were essential for the project. They agreed that the study and pilot would have been deemed too costly, especially given the improbability that the effort would ultimately result in a full change-out of the city's signals.

The grant money from PTI was also a hedge against the risk of the project, since even if the technical feasibility demonstration (Phase I) had not shown promise, the city itself would have faced little to no financial loss. The same can be said of Phase II — the city accepted the grant knowing it was still not committed to proceeding with the procurement, but had the financial resources it needed to continue on the path to doing so. The risk associated with interdepartmental barriers was also addressed in part by the grant subsidies, since both Phases of the study focused on safety, ease of maintenance (change-outs take equal time to incandescents, as well as needing to occur much less frequently), and the liability aspects of switching to LEDs, in addition to the energy savings. Indeed, from an institutional standpoint, the project seems to be Pareto-efficient: there were no losers across the various city departments. Though this was not necessary for the project's purely economic justification, it may well have been for its political acceptance within the city bureaucracy.

On further inspection, Philadelphia's traffic light conversion may be a much broader success. PTI, for a small investment, has enormous leveraging potential with this project. The specification developed by Philadelphia, along with the study outlining the success of the pilot project, is now taking on a "public good" quality. Though Philadelphia and other cities may have been averse to initiating the kind of background effort necessary to effect such a successful volume purchase — both because of the search effort required and the risk — Philadelphia's specification and experience can now serve to reduce these obstacles for other governments. Indeed, San Diego and New York City are presently making use of the specification to also purchase LED signals.

DOE/FEMP's *Product Efficiency Recommendation* Series

The U.S. Department of Energy's Federal Energy Management Program (FEMP), through its "Procurement Challenge" program, produces a series of buyer guides — called *Product Energy Efficiency Recommendations* — designed to inform federal purchasers about efficient levels of performance for various commonly purchased energy-consuming products, ranging from exit signs to room air conditioners to centrifugal chillers. The primary intent of the series is to help government agencies implement a provision in an Executive Order signed by President Clinton in 1994, directing them to purchase products, "to the extent practicable and cost-effective, in the upper 25% of efficiency for all similar products, or at least 10 percent more efficient than the minimum level that meets federal standards."

The *Recommendations* are generally two pages (one sheet) in length, and have five main sections: 1) the efficiency recommendation itself, identifying the cutoff level for compliance with the Executive Order (e.g., a Seasonal Energy Efficiency Rating of 12 for residential central air conditioners); 2) identification of the source(s) of supply in the federal sector — i.e., the General Services Administration (GSA) and/or the Defense Logistics Agency (DLA); 3) a buyer/user "tips" section, emphasizing selection and use considerations to help facilitate energy conservation; 4) a cost- effectiveness example, to give the buyer a sense of the magnitude of energy cost savings from selecting an efficient product, in order to determine if a price premium is justified; and 5) a "For More Information" section, to inform buyers where they can find lists of complying products, as well as more detailed design and selection information. The *Recommendations*, which are available in print and on the World Wide Web (www.eren.doe.gov/femp/procurement), are actively marketed at conferences and expositions, as well as through articles and notices in FEMP's newsletter, and other publications.

To reiterate, the impetus for the *Recommendations* was the purchasing provision in the Executive Order; but compliance with Executive Orders is limited among federal agencies (there is no enforcement mechanism). Additionally, in this one's case, the language allows for ample "wiggle room," particularly because of the qualifier, "to the extent practicable and cost-effective." Consequently, the *Recommendations* are marketed as an information tool to help federal buyers easily recognize which products qualify as "efficient," where to find them, and how to assess the cost-worthiness of any price premiums. Hence, the program is aimed at reducing buyers' search costs for these products. The *Recommendations* also target the risk associated with purchasing more efficient products, since they provide credibility to the savings potential, helping to justify to supervisors or procurement personnel the added first costs that may be associated with a more efficient product.

Has the program been successful? This is not yet clear, but the initial indications are very positive. The first *Recommendations* were released in September, 1996, and now cover 26 product categories. Over 2,000 binders containing the printed *Recommendations* have been ordered through FEMP, and there are nearly 1,000 monthly "hits" on their home page on the Web. Additionally, two federal agencies, the Army and Navy, have inserted some of the recommended efficiency levels into their guide specifications for these products. The Recommendations' incorporation into guide specifications is also a risk-reduction strategy, since this removes the responsibility from the individual project specifier or buyer to justify the product's greater cost.[7]

However, though this will soon change, no survey data has yet been compiled on the actual levels of use of the *Recommendations* and the savings attributable to them. They were very well received in a series of inter-agency roundtables (in which about half of the 23 participants were previously familiar with them). The most common compliments regarded their brevity and ease of use. However, consistent with the idea that their main utility is in diminishing search costs, the frequently voiced complaint about the *Recommendations* is that they do not provide lists of actual complying products, such that users can immediately order the products by manufacturers' model numbers. Accordingly, effort is being made to help sponsor the establishment of electronic product lists that would be linked to the *Recommendations* on the Web and referenced in the print versions.

Conclusion

The two case studies presented here are, at first glance, very different. Philadelphia's re-lamping of its red traffic signals, with the grant assistance from PTI for a pilot project and specification development, was aimed at a specific large-volume purchase of an emerging energy-saving technology. The other, an information dissemination program to promote the purchase of energy-efficient products in

[7] As well as reducing risk for agency buyers by making a more efficient product a "default" choice, efficiency levels in guide "specs," depending on how they are presented, may bear some resemblance to mandatory standards. However, project specifiers can, and commonly do, choose not to follow all provisions in guide specifications.

the federal government, has a much broader intended scope, but is not focused on any single specific purchasing action. However, the ultimate result of both programs may be very similar: to increase energy-efficient purchasing by reducing the barriers of search cost and high risk. In both cases, efforts by a single lead agency have led to the creation of public information that will allow multiple users to avoid significant search costs, and risk, by piggybacking on the work.

One key difference between the two programs lies in the types of products they address. Philadelphia and PTI focused on an emerging, largely unproven product. FEMP's program has, to this point, only addressed common "off-the-shelf" products. It is worth pointing out that a demonstration project and specification development may be a more appropriate emphasis for an information program designed for a breakthrough technology. A simplified information guide, like FEMP's *Recommendations*, is probably more appropriate for products with which users are already quite familiar, where (usually) the only change is the level of energy efficiency.

Successful programs such as these make a compelling argument for government programs to help buyers make better-informed decisions on energy-related products. Private sponsoring of these information efforts is unlikely, since the benefits to any given user are not often sufficiently large. Centralizing the effort to spread the cost is eminently defensible, since the collective benefit of these programs can be enormous. Though there is a significant challenge in tailoring information products so that they are actually helpful to users, there are proven programs that may demonstrate how best to structure these tools.

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