

# Are Investments in Energy Efficiency Over or Under?: An Analysis of the Literature

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Debate over the efficacy of the market for energy efficiency has tended to center around the notion of the “efficiency gap”. Some have argued that the gap is merely the difference between technical potential and economic efficiency, while others have claimed that the gap reflects market barriers and failures which lead to a sub-optimal level of energy efficiency investment. A third position has been that government programs to correct such flaws may not be cost-effective.

This paper examines a related issue which has received some attention, yet has not been treated systematically to date. It considers the various barriers and failures identified in the conservation literature in terms of the effect on the level of investment in energy efficiency.

For purposes of this analysis, the identified market barriers are assumed to be market failures. This assumption is made to address the issue of what investment pattern results from the existing market structure, rather than to resolve the controversy of which barriers actually constitute market failures. The primary conclusion is that, although there are some market flaws which promote investment in energy efficiency, the preponderance of barriers and failures tend to generate a systematic underinvestment.

The paper is organized by first considering clear-cut market failures, those conditions which a near consensus of neo-classical economists would agree constitute a distortion of resource allocation. The effect of each of these failures, considered individually, is to skew investment below economically efficient levels. Next, the paper looks at market barriers in various sectors, residential/consumer, industrial, transportation, and utilities. Although some of these barriers promote investment in efficiency, the predominant effect is to reduce investment in energy efficiency.

The paper concludes with some remarks about recent articles which offer alternative perspectives for framing the overall debate.

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## Introduction

One of the prominent debates in the energy policy literature concerns the efficacy of the market for energy efficiency. Neo-classical economists have argued that, while certain market failures exist, the market barriers identified by advocates of government conservation programs are merely ad hoc descriptions of a competitive market (Sutherland 1991) and, as such, do not require government intervention. A related position has been that government programs may not be cost-effective means of correcting the failures.<sup>1</sup>

On the other hand, technologists and other advocates of government intervention in this market have pointed to high implicit consumer discount rates and investment

levels below those suggested by cost-benefit analysis to conclude that flaws in the market are significant enough to warrant government involvement.

While the differences between these positions have yet to be resolved conclusively, this paper addresses a related question that must be answered as well before the rationale for government intervention is complete. This question may be phrased as follows: Given that market failures may well lead to various investment patterns, if we assume that the market barriers identified in the energy efficiency literature constitute market failures<sup>2</sup>, do we have reason to believe that the pattern of investment resulting from these distortions represents a systematic

underinvestment in efficiency? Clearly, appropriate policy responses will differ depending, in part, on which pattern we observe.

It is the purpose of this paper to evaluate the market barriers and failures in the energy efficiency market in terms of the sign of their effect on investment patterns. Economic theory will be used to show that while some of the barriers might be expected to produce an overinvestment, the predominant effect will be to produce a systematic underinvestment in energy efficiency. This paper will not, however, address the related questions of whether the market barriers considered actually constitute market failures or whether government programs have been or could be developed for which the benefits of the intervention outweigh the costs of the program.

### **Market Barriers and Market Failures: The Effect on Investment Patterns**

This section of the paper will examine the effect of the market barriers and clear-cut market failures on the pattern of investment in energy efficiency. Assuming the market barriers represent actual failures, the impact will be evaluated in terms of the distortion of investment patterns.

It is valuable to recognize that market failures are household or firm specific, rather than commodity specific. De Janvry et al. (1991) have argued that

Strictly speaking, a market fails when the cost of a transaction through the market exchange creates greater disutility than the utility gain that it produces, with the result that the market is not used for the transaction. Either a surrogate institution will emerge to allow the transaction to take place or the transaction simply does not occur... In a more general sense, the market exists, but the gains for a particular household (or firm) may be below or above cost, with the result that some households (or firms) will use the market while others will not... In general, markets exist, but they selectively fail for particular households (or firms), making the corresponding commodity a nontradeable for that household (or firm).

This distinction becomes especially important in understanding those market barriers that impact the investment pattern because of their differential effect on potential investors, rather than because of across-the-board affects. Using this conception of market failure, we must consider the impact of market failures and barriers on the number of firms and households participating in the market and on the level of participation by those firms and households.

For example, barriers are usually greater among households and small firms than among large companies, who generally have more knowledge about energy-efficiency options and the technical staff to evaluate and implement them (Schipper et al. 1992). Thus, investment patterns can be skewed, not only because of a complete absence of a market, but also because certain potential and other wise viable investors may be wholly or partially excluded from the market.

### **Market Failures**

The most widely agreed upon form of market failure in the energy efficiency market results from externalities. Externalities are costs or benefits which result from a particular economic transaction, but do not accrue to the participants in the transaction.

The presence of negative environmental externalities in the energy market are well-established. Although the magnitude of the effect is disputed, there is little argument that the price of energy does not fully reflect the social costs associated with energy production, distribution, and consumption (Holdren 1992). The effect of this market failure is to promote the consumption of energy. Once it is recognized that energy and energy efficiency are substitutes at the margin, it can easily be concluded that this effect leads to an underinvestment in energy efficiency.

An additional negative externality identified in the literature is referred to as the national security externality and results from national dependence on foreign sources of energy. Most industrialized economies are dependent on foreign sources of fuel. Yet, private markets do not provide for contingencies at the national level (Sutherland 1991). Because individual firms will not invest adequately in the defense of those sources, the cost of energy to the users does not reflect the full social cost. The recent Persian Gulf War, and the prior and on-going costs of providing military defense in the Middle East and other oil-producing regions suggest that the national security externality is far from nil. Although some recent work has attempted to minimize the magnitude of this effect, there is little argument that it results in an underpricing of energy and an underinvestment in efficiency.

A further market failure exists with respect to the production of electricity. For most of the century, economies of scale have led to average costs which were above the marginal costs of electricity production. However, in the last two decades, marginal costs have risen above average costs. Despite this shift, most utilities have continued to sell electricity to consumers at a price equal to average production cost. The result has been an overconsumption of electric power (Fisher and Rothkopf 1989) and a underinvestment in electricity end-use efficiency.<sup>3</sup>

Although not unique to the energy efficiency market, the public goods nature of basic research in efficiency is recognized by economists to lead to an underinvestment in research of this kind (Howarth and Andersson 1993). The connection between a shortfall in research and a constraint on investment opportunities in improved efficiency technology, is obvious.

### Market Barriers

Jaffe and Stavins (1994) have provided a convenient definition of market barriers which will be used in this analysis, namely any factor which seems to account for the discrepancy between the level of investment in efficiency technology suggested by engineering analyses (which include cost-effectiveness) and the level observed in the market.

*Residential/Consumer Sector.* A number of market barriers to investment in energy efficiency have been identified in the residential sector. These include a lack of consumer awareness, third party purchases and short-term ownership of appliances, liquidity constraints, and inseparability of features.

Despite efforts to disseminate information about energy efficiency options, information about the cost, reliability, and performance of efficiency technologies is not widely diffused, particularly among consumers (NAS 1992). There is also a lack of understanding of how correctly to use the information that is available (Kempton and Montgomery 1982). Clearly, consumers are unlikely to purchase that which they do not know exists. Additionally, the high cost of information limits the ability of less well-capitalized consumers to acquire the information necessary to make well-informed investment decisions. Because increased efficiency tends to add to the purchase price of a good, consumers unfamiliar with the implications of increased efficiency are very likely to be influenced away from the higher priced option, especially if the only difference between purchase options is efficiency. Even in the more common case where efficiency differences are only one of a number of feature differences, studies have shown that consumers pay more attention to features such as size, warranty, and brand name (Unterwurzacher and McInnes 1991).

Although not yet investigated in the literature, one aspect of the information problem may tend to skew the investment decision towards efficiency. Public attention to the issue has the potential to create a climate in which certain consumers will purchase efficiency in an attempt to conform to political pressure. The magnitude of this effect is unknown.

Another important barrier which is prominent in the residential sector results from the prevalence of third party purchases of appliances and equipment in rental property. In instances where tenants pay the utility bills, landlords have little incentive to install energy efficient equipment. Although it might be assumed that tenants would have adequate incentive to invest in efficient light bulbs and other appliances and equipment, the short average residence time means that tenants may be unable to capture the benefits of reduced costs.

In those cases where landlords pay for the utilities, landlords will have adequate impetus to install efficiency equipment, but other barriers, such as lack of access to the tenant's apartment to replace light bulbs and the need to replace equipment quickly on breakdown, limit the landlord's ability to act in an economically efficient manner. Further, when the tenant is not responsible for the utility bill, they have no motivation to use energy efficiently (Levine et al. 1994). The same type of mismatch occurs between builders and landlords. In part because the energy efficiency of buildings has not yet become an important sales characteristic, builders face the incentive of building as cheaply as possible relative to the quality they seek to achieve. This condition limits the incentive for builders to provide energy efficient equipment.

An additional restriction facing many residential consumers and some small firms is the liquidity constraint. Because of the high first cost associated with energy efficient equipment, limited owned capital and lack of access to loans, many consumers are unable to make purchases that are economically efficient. Thus, the potential of reduced future costs becomes an irrelevant consideration, since consumers are unable to finance the initial purchase (Fisher and Rothkopf 1989). The high first cost alone has also been identified as a barrier to investment as many consumers are either unable or uninterested in evaluating life-cycle costs and compare products primarily on the basis of first cost (Reddy 1991).

One final barrier facing purchasers of residential appliances is the so-called "gold-plating." This refers to the lack of availability of highly efficient equipment without costly, additional special features which may be undesirable to the average purchaser. Again, the effect of the barrier is to reduce the level of investment in efficiency (Ruderman 1987). The inability to select features separately, while not unique to the consumer sector or the energy efficiency market in general, does represent a barrier to investment which reduces mean investment levels.

It must also be noted that ex-post evaluations of cost-effectiveness are inadequate to conclude that the initial

decision-making process was inefficient. All purchase decisions incorporate uncertainty into the process; the random walk of prices insures both that some investment decisions will subsequently appear incorrect and that the mean levels of investment will be economically efficient. *Ceteris paribus*, a lack of information is equally as likely to promote overinvestment as under. In light of inadequate information, however, other market conditions, such as the incremental cost of increased efficiency, first-cost orientation on the part of consumers, and liquidity constraints argue persuasively for a systematic underinvestment in energy efficiency.

*Industrial Sector.* The conservation literature suggests that the fewest barriers exist within the industrial sector. Nonetheless, first-cost sensitivities and liquidity constraints of consumers translate into production decisions of manufacturers. Manufacturers, distributors and retailers respond to the first-cost sensitivity of consumers with offers of low first-cost devices and equipment with low efficiencies (Reddy 1991). Although this may be interpreted as primarily a consumer issue, producers have not chosen to educate their consumers and compete on the basis of the efficiency of their products.

Decanio (1993) has shown that a variety of factors including bounded rationality, principal-agent problems, and moral hazard lead firms to establish internal hurdle rates for energy efficiency investments above the cost of capital to the firm, resulting in a systematic underinvestment in energy efficiency. This is not to suggest that government regulation is the appropriate means of addressing these barriers. It is quite conceivable that competition, at least with respect to the intra-firm barriers will be adequate to motivate improvement in the decision-making process. It is also possible that government programs would prove more costly than beneficial. It is nonetheless worth observing that existing market barriers tend to promote an underinvestment in energy efficiency both for the internal investments of industrial firms, as well as for the goods produced by the industrial sector.

*Utility Sector.* One might reasonably expect that the utility industry would act as the most rational economic actor in the energy market. Their expertise in the field, along with high levels of capitalization and access to large cash flows suggest that utilities should be in a position to make extremely well-informed and economically efficient decisions vis-a-vis investments in energy efficiency.

Surprisingly, this is not necessarily the case. A number of features of the market and the regulatory environment act to skew utility investment in efficiency below the economically efficient level. The financial incentives embedded in the current regulatory process for most electric utilities are an important barrier to investment in energy efficiency on

the part of utilities. The rate-setting process which produces profit based strictly on kilowatt-hour (kWh) sales and reduces profit for each kWh saved provides dramatic incentive for utilities to avoid promoting efficiency wherever possible. Of course, there are mechanisms to overcome this difficulty, such as providing a return on conservation and load management investments, but these have not been widely adopted by utility regulators.

The current regulatory regime also discourages utilities from investing in the efficient production of power. To insulate utility shareholders from the impact of fluctuating fuel prices, nearly all states allow utilities to adjust customer prices periodically so that the cost of fuel is fully recovered, and changes in fuel prices, or the quantities of fuel used, do not affect profits (Moskovitz et al. 1991). On the other hand, if utilities were forced to bear the full risk of fuel price changes, the number of rate cases might increase dramatically. Risk sharing arrangements may offer a viable compromise approach.

There is a growing financial incentive, however, for utilities to invest in consumer efficiency. Increasingly, regulators are encouraging utilities to make such investments with the threat of revenue disallowances. There is some evidence that such pressure has led to overinvestment in demand side management and other efficiency-promoting programs by many utilities, but the data are inconclusive at this time.

*Transportation.* In the transportation sector, notions of energy efficiency are particularly complex and are frequently difficult or impossible to disaggregate from issues of safety and other features. Nonetheless, certain obvious market barriers affect the level of investment in efficiency.

First cost concerns and liquidity constraints are prominent in the purchase of personal vehicles. Financial institutions do not consider operating costs when calculating loan eligibility, so the initial costs of increased efficiency may block consumer purchases regardless of future benefits. Automobile manufacturers, already concerned with trade-offs between vehicle features, safety, performance, fuel efficiency, and competition from other manufacturers have no incentive to improve the efficiency feature of vehicles when this will not clearly result in increased sales (Buderer et al. 1991).

Subsidized costs and externalities limit the cost burden experienced by consumers who, faced with a constrained total travel budget, have less incentive to reduce other travel-related costs. Although the actual value of environmental damages associated with emissions from gasoline combustion are uncertain, there is no doubt that the value is non-zero, and yet these costs are not borne by the

gasoline consumer. Likewise, less than half the costs of highway construction and maintenance are financed by the users and parking is also subsidized via tax policy (NAS 1991). While rationalizing these costs might reduce total consumption of transportation or affect choice of transportation modes, currently, the incentive to purchase energy efficiency is reduced as a result of the lower total transportation costs that result from not fully internalizing environmental and other costs and from tax subsidies.

### Understanding the Gap

The notion of the “efficiency gap” has generated considerable controversy and a variety of explanations have been developed to understand it. Sutherland (1994), a prominent contributor to the debate has written

Conservation advocates use the notion of an energy efficiency gap—the difference between actual and maximum potential efficiency—as a target variable for energy conservation policies . . . (However) energy efficiency is not useful either as a target for energy policy analysis or as an indicator of energy policy success.

Putting aside shortcomings in the work of “conservation advocates”, it is apparent that Sutherland misstates the position of most such advocates and misunderstands the important insight provided by recognition of the efficiency gap.

First, few, if any, observers of the gap advocate energy efficiency independent of all economic considerations. While there are clear differences in how cost-effectiveness is determined, virtually all conservation advocates recognize decreasing and ultimately negative returns to investments in energy efficiency (Kooimey et al. 1991, Fickett et al. 1990).

Second, the efficiency gap—the difference between observed levels of adopted energy efficiency and cost-effective levels of energy efficiency—provides prima facie evidence of market failure. Although not conclusive, this evidence is clearly sufficient to justify investigation of flaws in the market for energy efficiency and attempts to overcome these flaws by means of cost-effective government intervention.

A different perspective on the question of the gap is provided in a recent work by Bhattacharjee, Cicchetti, and Rankin (1993), which suggests that utility theory, one of the traditional underpinnings of neo-classical economics, does not conform empirically to consumer behavior in certain classes of transactions. They use prospect theory, which observes that consumers weigh gains and losses differently, to better understand consumer behavior in the

energy efficiency market. Their insight provides an important step in understanding why consumers appear to act irrationally in terms of traditional economic assumptions and may provide significant impetus to changes in the way firms view consumer behavior and governments create regulatory programs. The implications of their findings are broad, suggesting, on one hand, that the reluctance of consumers to invest in efficiency is consistent with their preferences, yet, on the other hand, providing a clear rationale for government intervention in the market.

### Conclusions

Flaws and imperfections in a market stand in the way of efficient outcomes. Numerous market failures and market barriers have been identified in the market for energy efficiency. Although some of these effects may be to increase investment in energy efficiency beyond the economically efficient level and quantification of the aggregate effects is highly problematic, analysis of the individual failures and barriers identified in the literature strongly suggests that we are underinvested in energy efficiency.

This conclusion does not, however, provide a complete rationale for further government intervention in the energy efficiency market. Regulatory proposals must also face a cost-effectiveness test. It is, nonetheless, an important step in developing sound energy policy to recognize that a systematic underinvestment in energy efficiency exists and to understand which factors and institutions play a role in skewing investment patterns.

### Endnotes

1. It is interesting to note that a similar debate exists with respect to other markets as well. For example, in the long-term-care insurance market, the failure to purchase private coverage is generally attributed to “unawareness”, while some have sought to explain the level of investment in terms of rational, utility maximization (Pauly 1990). Thus, although the debate over the investment gap is not unique to the energy efficiency market, it is nonetheless central to the policy process.
2. A market failure is defined as a condition in the market that results in an inefficient allocation of resources (Sutherland 1991).
3. Government policies may skew investment in efficiency through impacts on energy prices. In the United Kingdom, for example, the prices of nearly every consumer product or service except for gas,

electricity, and coal include a value-added tax. This unequal treatment increases the cost of energy efficiency relative to energy costs (Schipper et al. 1992). It must be recognized, however, that tax policy may encourage investment in energy efficiency as well. For several years, the U.S. tax policy on depreciation of capital investments, known as the Accelerated Cost Recovery System (ACRS), allowed firms to write-off the costs of capital expenditures in as little as five years. This policy accelerated replacement times for capital goods and, because succeeding generations of equipment tend to be more energy efficient than the previous, encouraged investment in energy efficiency (Boyd et al. 1993). No studies to date have evaluated the implications of this policy on investment in energy efficiency. ACRS was subsequently replaced by the Modified Accelerated Cost Recovery System (MACRS) which required substantially longer depreciation terms.

## Bibliography

- Bhattacharjee, V., C.J. Cicchetti, and W.F. Rankin. 1993. "Energy Utilities, Conservation, and Economic Efficiency." *Contemporary Policy Issues*, Vol XI, January, pp. 69-75.
- Boyd, G., S.H. Karlson, M. Neifer, and M. Ross. 1993. "Energy Intensity Improvements in Steel Minimills." *Contemporary Policy Issues*, Vol XI, July, pp. 88-100.
- Buderi, R., E.T. Smith, M. Shao, G. Smith, and P. Hong. 1991. "Conservation Power: The Payoff in Energy Efficiency." *Business Week*, September 16, 1991.
- California Energy Commission. 1993. *Energy Efficiency Report*. Sacramento, CA.
- Chu, H. Q., M.T. Shealy, and A.E. Smith. 1994. "Energy Conservation: Barriers, Models, and Policy Options." EPA Contract No. 68-W1-0009. U.S. Environmental Protection Agency, Washington, DC.
- DeCanio, S. 1993. "Barriers Within Firms to Energy-Efficient Investments." *Energy Policy* 21(9):906-914.
- De Janvry, A., M. Fafchamps, and E. Sadoulet. 1991. "Peasant Household Behavior with Missing Markets: Some Paradoxes Explained." *The Economic Journal* 101(409):1400-1417"
- Fickett, A. P., C.W. Gellings, and A.B. Lovins. 1991. "Efficient Use of Electricity." *Energy for Planet Earth*, pp. 11-23. W.H. Freeman and Company, New York, NY.
- Fisher, A. C., and M.H. Rothkopf. 1989. "Market Failure and Energy Policy: A Rationale for Selective Conservation." *Energy Policy* 17(4):397-406.
- Geller, H .S. 1983. *Energy Efficient Appliances*. American Council for an Energy Efficient Economy, Washington, DC.
- Hassett, K. A., and G. Metcalf. 1993. "Energy Conservation Investment: Do Consumers Discount the Future Correctly." *Energy Policy* 21(6):710-716.
- Holdren, J.P. 1992. "Prologue: The Transition to Costlier Energy." *Energy Efficiency and Human Activity*, pp. 1-51. Cambridge University Press, Cambridge, UK.
- Howarth, R. B., and B. Andersson. 1993. "Market Barriers to Energy Efficiency." *Energy Economics*, October.
- Jaffe, A. B., and R.N. Stavins. 1994. "Market Barriers, Market Failures, and the Energy Efficiency Gap." Draft report.
- Kempton, W., and L. Montgomery. 1982. "Folk Quantification of Energy." *Energy* 7(10):817-827.
- Koomey, J. G., C. Atkinson, A. Meier, J.E. McMahon, S. Boghosian, B. Atkinson, I. Turiel, M.D. Levine, B. Nordman, and P. Chan. 1991. "The Potential for Electricity Efficiency Improvements in the U.S. Residential Sector." LBL-30477. Lawrence Berkeley Lab, Berkeley, CA.
- Levine, M. D., E. Hirst, J.G. Koomey, J.E. McMahon, A.H. Sanstad. 1994. "Energy Efficiency, Market Failures, and Government Policy." LBL-35376. Lawrence Berkeley Lab, Berkeley, CA.
- Lohani, B. N., and A.M. Azimi. 1992. "Barriers to Energy End-Use Efficiency." *Energy Policy* 20(6):533-545.
- Moskovitz, D., S. Nadel, and H. Geller. 1991. "Increasing the Efficiency of Electricity Production and Use: Barriers and Strategies." Energy Efficiency Issues Paper #5, American Council for an Energy Efficient Economy, Washington, DC.
- National Academy of Sciences. 1992. *Policy Implications of Greenhouse Warming*. National Academy Press, Washington, DC.
- Pauly, M .V. 1990. "The Rational Nonpurchase of Long-Term-Care Insurance." *Journal of Political Economy* 98(1):153-168.

Reddy, A.K.N. 1991. "Barriers to Improvements in Energy Efficiency." *Energy Policy* 19(12):953-961.

Ruderman, H., M. Levine, and J. McMahon. 1987. "Energy Efficiency in the Purchase of Residential Appliances." *Energy Efficiency: Perspectives on Individual Behavior*, pp. 41-50. American Council for an Energy Efficient Economy, Washington, DC.

Sanstad, A. H., and R.B. Howarth. 1994. "'Normal' Markets, Market Imperfections, and Energy Efficiency." Draft Report.

Schipper, L., S. Meyers, R.B. Howarth, and R. Steiner. 1992. *Energy Efficiency and Human Activity*. Cambridge University Press, Cambridge, UK.

Sutherland, R.J. 1991. "Market Barriers to Energy-Efficiency Investments." *The Energy Journal* 12(3): 15-34.

Sutherland, R.J. 1994. "Energy Efficiency or the Efficient Use of Energy Resources?" *Energy Sources*, Vol. 16, pp. 261-272.

Unterwurzacher, E., and G. McInnes. 1991. "Environmental Improvement and Energy Efficiency in Buildings: Opportunities to Reduce CO<sub>2</sub> Emissions." *Energy Efficiency and the Environment: Forging the Link*, pp. 71-88. American Council for an Energy Efficient Economy, Washington, DC.