

LBL-38059
UC-1322

Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency

William H. Golove and Joseph H. Eto

Energy & Environment Division
Lawrence Berkeley National Laboratory
University of California
Berkeley, California 94720

March 1996

The work described in this study was funded by the Assistant Secretary of Energy Efficiency and Renewable Energy, Office of Utility Technologies of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

Table of Contents

Tables and Figures	iii
Abstract	v
Acknowledgments	vii
Acronyms and Abbreviations	ix
Executive Summary	xi
Chapter 1: Introduction	1
Chapter 2: Market Barriers to Energy Efficiency	5
Overview	5
What is the “Efficiency Gap”?	5
What are Market Barriers to Energy Efficiency?	8
Questioning the Existence of the Efficiency Gap	12
Market Failures and the Efficiency Gap	18
Transaction Cost Economics: A New Contribution to the Middle Ground ..	22
Synopsis: The Contributions of Positive Analysis	24
Chapter 3: Rationale and Considerations for Public Policies to Promote Energy Efficiency	27
Overview	27
What is the “Market” for Energy Services?	28
Three Rationales for Public Policies Promoting Energy Efficiency	30
When are Public Policies for Energy Efficiency Appropriate?	31
A Framework for Assessing Future Public Policies	34
Chapter 4: Two Energy Service Markets: From Theory to Empiricism and Back ..	35
Overview	35
New Construction	36
Commercial HVAC and Lighting	41
Conclusion	46
References	47

Tables and Figures

Table 2-1. Energy Efficiency versus Economic Efficiency	13
Figure 2-1. Supply Curve of Conserved Energy (TWh/year)	7
Figure 2-2. Disaggregation of the “Efficiency Gap”	9
Figure 2-3. Heterogeneity of Consumers	14

Abstract

This report reviews current perspectives on market barriers to energy efficiency. Ratepayer-funded utility energy-efficiency programs are likely to change in scope, size, and nature as the deregulation process proceeds; our research focuses on understanding to what extent some form of future intervention may be warranted and how we might judge the success of particular interventions, especially those funded by ratepayers. We find that challenges to the existence of market barriers have, for the most part, failed to provide a testable alternative explanation for evidence suggesting that there is a substantial “efficiency gap” between a consumer’s actual investments in energy efficiency and those that appear to be in the consumer’s own interest. We then suggest that differences of opinion about the appropriateness of public policies stem not from disputes about whether market barriers exist, but from different perceptions of the magnitude of the barriers, and the efficacy and (possibly unintended) consequences of policies designed to overcome them. We conclude that there are compelling justifications for future energy-efficiency policies. Nevertheless, in order to succeed, they must be based on a sound understanding of the market problems they seek to correct and a realistic assessment of their likely efficacy. This understanding can only emerge from detailed investigations of the current operation of individual markets. We strongly recommend continued inquiry along these lines.

Acknowledgments

This work has benefitted immensely from the comments and reviews of the following individuals: Chuck Goldman, Shel Feldman, Sy Goldstone, John Harvey, Eric Hirst, Val Jensen, Jon Koomey, Doug Norland, Diane Pirkey, Ralph Prah, and Steven Stoft.

The work described in this study was funded by the Assistant Secretary of Energy Efficiency and Renewable Energy, Office of Utility Technologies, Office of Energy Management Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

Acronyms and Abbreviations

CAPM	Capital asset pricing model
CFL	Compact fluorescent lamp
DSM	Demand-side management
ECM	Energy conservation measure
EIA	Energy Information Administration
HVAC	Heating, ventilation, and air conditioning
SCCE	Supply curve of conserved energy

Executive Summary

The prospect of increased competition in the electricity industry, particularly retail wheeling, threatens to make obsolete the traditional concept of a retail monopoly franchise for the provision of electric service. In place of utility monopolies, markets will arise for a variety of products that we do not currently differentiate in the uni-dimensional product we call retail electric service. Consumers faced with these unbundled and competitively priced products will be able to choose freely among suppliers. Consumers' choices, rather than those of vertically integrated utilities, will reveal the appropriate balance between supply- and demand-side resources.

Proponents of government intervention believe that substantial market barriers prevent socially desirable levels of investment in energy efficiency. They maintain that it is unlikely that any future market structure for the utility industry will ameliorate these "market barriers to energy efficiency." This belief justifies continued government intervention in energy service markets to correct or overcome the distortions inherent in market-based resource allocations.

This report reviews current perspectives on market barriers to energy efficiency. Ratepayer-funded utility energy-efficiency programs are likely to change in scope, size, and nature as the deregulation process proceeds; our research focuses on understanding to what extent some form of future intervention may be warranted and how we might judge the success of particular interventions, especially those funded by ratepayers.

We begin by summarizing the history and current status of the debate on market barriers to energy efficiency. Challenges to the existence of market barriers have, for the most part, failed to provide a testable alternative explanation for the evidence, which suggests that there is a substantial "efficiency gap" between a consumer's actual investments in energy efficiency and those that appear to be in the consumer's own interest. The challenges, nevertheless, have clarified the original discussions on market barriers. In particular, it is now widely accepted that many of the original market barriers can be understood as examples of market failures, which, in contrast to market barriers, do provide a *prima facie* basis for government intervention.

Powerful insights into the nature of many market failures have emerged from the discipline of transaction cost economics. Transaction cost economics, in contrast to neoclassical economics, starts with the assumption that transactions are rarely costless and concludes that much of the current structure and organization of today's economic institutions can be explained by efforts to minimize transaction costs. High transaction costs appear central, for example, to explaining the difficulty consumers face in acquiring and acting on information about the value of energy-efficiency investments. In addition,

EXECUTIVE SUMMARY

the issues of asymmetric information and opportunism pervade the relationships found in the energy services market and can also now be seen as important for reducing transaction costs.

In our discussions of market barriers, we are careful to separate questions of whether market failures exist from questions of what should be done about them. We articulate three broad, but not necessarily mutually exclusive, rationales for government intervention that emerge from the market barriers debate: (1) government should intervene to counteract the effects of market failures; (2) government should intervene to reduce transaction costs; and (3) government should intervene to help individuals help themselves.

Although these rationales provide a basis for some type of intervention, we acknowledge that they do not justify any particular intervention. The choice of particular interventions is a separate problem that cannot be solved in the abstract. For example, we suggest that differences of opinion about the appropriateness of public policies stem not from disputes about whether market barriers exist, but from different perceptions of the magnitude of the barriers and the efficacy and (possibly unintended) consequences of policies designed to overcome them. These considerations lead us to conclude that:

1) There is no single market for energy services; instead, the “market” consists of hundreds of end uses, thousands of intermediaries, and millions of consumers. As a result, we do not believe the debate about market barriers or the debate about appropriate public policies to overcome market barriers can be settled by ideological fiat; instead, these issues must be addressed in a highly disaggregate fashion, considering the workings of individual markets.

2) Markets are not perfect, but neither are the institutions that seek to improve them. When government intervention is appropriate, it is unlikely that there will be a single best policy solution (e.g., government minimum efficiency standards). Instead, we believe multiple, complementary approaches tailored to particular circumstances are more likely to succeed in overcoming market failures or reducing high transaction costs. In addition, they must be based on a pragmatic assessment of the limitations of particular institutions and policies.

3) Technological and institutional change is an enduring feature of energy service markets. Public policies must be constantly scrutinized for their continuing appropriateness in view of technological advances and the emergence of new market institutions. Indeed, an important role of government may be to create new market institutions that will be self-sustaining following an initial stimulus from the government.

In the final section of this report, we identify the types of information currently available to support the development of approaches to overcoming market barriers to energy efficiency. Using the formal concepts developed earlier in this report, we review descriptions provided by practitioners (rather than academics) on the functioning of two large energy end-use markets: new construction and commercial heating, ventilation, and air conditioning (HVAC) and lighting. We demonstrate that more in-depth analysis of individual markets has the potential to settle many important questions regarding the need for, design of, and likely efficacy of future public policies to promote energy efficiency.

We conclude that the existence of market barriers provides ample justification for future government intervention in energy service markets. Nevertheless, for any particular policy to succeed, a sound understanding of the market barriers to be addressed and a realistic assessment of the likely effectiveness of a policy are required. This understanding can only emerge from detailed investigations of the current operation of individual markets. We strongly recommend continued inquiry along these lines. Without this information, the debate over market barriers to energy efficiency and the appropriateness of public policies quickly reduces to an ideological battle between irreconcilable views on the role of government in society.

Introduction

The prospect of increased competition in the electricity industry, particularly retail wheeling, threatens to make obsolete the traditional concept of a retail monopoly franchise for the provision of electric service. The “obligation to serve” and the associated least-cost resource planning and acquisition responsibility of the retail franchise have been among the most important principles grounding regulatory policies that encourage utilities to promote improved customer energy efficiency. These policies call for utilities to acquire demand-side resources whenever they are cheaper than new sources of supply. If the current obligation to serve is replaced by an obligation only to connect, then utilities as we know them will cease to exist. In place of utility monopolies, markets will arise for a variety of products that we do not currently differentiate in the uni-dimensional product we call retail electric service. Consumers faced with these unbundled and competitively priced products will be able to choose freely among suppliers. Consumers’ choices, rather than those of vertically integrated utilities, will reveal the appropriate balance between supply- and demand-side resources.

Proponents of government intervention believe that substantial market barriers prevent socially desirable levels of investment in energy efficiency. In particular, they believe that there are substantial market barriers, which prevent socially desirable levels of investment in energy efficiency. They maintain that it is unlikely that any future market structure for the utility industry will ameliorate these “market barriers to energy efficiency.” This belief justifies continued government intervention in energy service markets to correct or overcome the distortions inherent in market-based resource allocations.

Proponents of less (or no) government intervention to promote energy efficiency argue that, given the freedom to operate in a less regulated fashion, the market will achieve efficiencies not previously observed in the utility industry. They argue that any remaining imperfections or failures in the operation of energy service markets are either illusory, too small to be of consequence, or, in any case, best resolved by private individuals acting in their own self-interest, rather than through some form of government intervention.

The issues these discussions raise go far beyond the particular role utilities might play in delivering energy efficiency in the future. They relate, more fundamentally, to the wisdom of having any government intervention in the market. Energy efficiency policies were first proposed in the late 1970s. Since that time, much has changed. Therefore, as a first step toward discussing the appropriateness of future utility policies to promote energy efficiency, we must re-examine whether there is a need for energy-efficiency policies.

This report reviews current perspectives on market barriers to energy efficiency and to relate them to the discussion of utility deregulation. Ratepayer-funded utility energy-

efficiency programs are likely to change in scope, size, and nature as the deregulation process proceeds (Hirst and Eto 1995); our research focuses on understanding to what extent some form of future intervention may be warranted and how we might judge the success of particular interventions, especially those funded by ratepayers.

Let us begin by clearly stating our biases: We believe that government intervention is sometimes appropriate, but must be firmly grounded on detailed examinations of the operation of specific markets. Energy, like labor, capital, and other natural resources, remains a critical underpinning of our nation's economic and social well-being and, therefore, remains a continuing priority for government policies. The generation of electricity, for example, remains a major contributor to environmental problems created by our economy. At the same time, we also recognize that new market institutions are constantly emerging and that they may one day eliminate the need for the government policies we might find appropriate today. Nevertheless, we do not categorically rule out the possibility that government intervention, while not perfect or immune to improvement, may be the best means for accelerating the arrival of this date.

This report is organized in four chapters following this introduction. In Chapter 2, we summarize the history and current status of the debate on market barriers to energy efficiency. We clarify important relationships between market barriers and market failures and introduce concepts from transaction cost economics as a way to better understand certain features of markets. In Chapter 2, we do not take a position on whether the debate has been settled; indeed, we believe that taking any such position diverts attention from the important insights the debate has contributed to our understanding of why consumers do or do not make energy efficiency decisions that would *seem* to be in either their own or society's best interest. We argue that the issue of whether an intervention to change these decisions is warranted is a separate question altogether (which we turn to in Chapter 3). In Chapter 2, we focus only on developing an increased understanding of the "problem(s)" that proposed interventions are intended to correct. These insights, we believe, provide a much needed basis for the criteria by which interventions should be judged.

In Chapter 3, we sketch a normative framework for evaluating interventions. We observe that there is no single market for energy services. We then articulate three broad rationales for government intervention that emerge from the market barriers debate. We also identify overall considerations for determining the appropriateness of interventions in particular markets. We suggest that differences of opinion on the appropriateness of public policies stem not from disputes about the existence of market barriers, but from different perceptions regarding the magnitude of the barriers, and the efficacy and consequences of policies designed to overcome them.

Our discussions lead us to conclude that resolution of debates about the appropriateness of public policies for energy efficiency ultimately hinge on detailed and comprehensive

examinations of end-use markets. In Chapter 4, we initiate preliminary examinations of two large energy end-use markets: new construction and commercial heating, ventilation, and air conditioning (HVAC) and lighting. We introduce descriptions provided by practitioners (rather than academics) on the functioning of these markets using the concepts developed in Chapter 2. Expressed in this fashion, we demonstrate that further examination of these markets along these lines has the potential to settle many important questions regarding the need, design of, and likely efficacy of future public policies to promote energy efficiency.

Market Barriers to Energy Efficiency

2.1 Overview

There is a rich literature concerning what has become known as the “market barriers to energy efficiency” debate. Contributions to our understanding of these “barriers” have come from many disciplines, including economics, engineering, sociology, anthropology, and psychology. Important differences of opinion remain regarding the nature of these barriers and whether they constitute an appropriate justification for government intervention. This Chapter provides an overview of the origins, development, and current status of the debate. Our goal is to introduce key terms and their intellectual development and to trace the evolution of the debate. We have deliberately chosen not to focus on the public policy conclusions of various contributors to the market barriers debate; our opinions about the implications for public policies are taken up separately in Chapter 3.¹

We first describe the origins of the debate on market barriers to energy efficiency by introducing the concept of the “efficiency gap;” perspectives on this gap are central to understanding the primary positions in this debate. We review early explanations offered by those who came to be called “technologists,” which conclude that the efficiency gap is a reflection of important market barriers to energy efficiency. We then describe alternative explanations offered by neo-classical economists, which conclude that the gap is either illusory or overstated. Following these admittedly stylized characterizations of the opposing sides of the debate, we introduce an additional perspective provided by other neo-classical economists. This position holds that there are several well-accepted market failures in energy services markets and many so-called market barriers can be viewed as examples of these market failures, notably the market failure associated with imperfect information. Additional support for this position was also provided by behavioral scientists, although it was not originally framed in the language of economics. We then introduce the field of transaction cost economics, which we believe offers the potential to both enrich the market barriers debate and bridge some of the differences between the various positions (and, in Chapter 3, provides one rationale for the legitimacy of public policies to promote energy efficiency). We conclude with a synopsis of our assessment of the current state of the debate.

¹ We believe that there is an important distinction, usually and often not made clearly in the literature, between the contributions of the various disciplines to the positive analysis of human behavior and the normative implications of each discipline’s analysis. In our opinion, these forms of analysis are distinct and we proceed by treating them as such.

2.2 What is the “Efficiency Gap”?

Prior to the first oil price shock in 1973, there was little public policy discussion of the efficiency of energy use. Oil, the primary fuel in Western industrialized countries, had been cheap and plentiful — discoveries of new fields offered the promise of many years of unhindered supply. However, during the early 1970s, a new intellectual trend, epitomized in *Limits to Growth* (Meadows et al. 1972), combined with the Arab oil embargo to awaken concerns about threats to that supply. This new vision saw business-as-usual leading to steeply rising energy prices. Increasing energy demand along with shortages of fossil fuel supplies would threaten economies built on the promise of cheap energy.

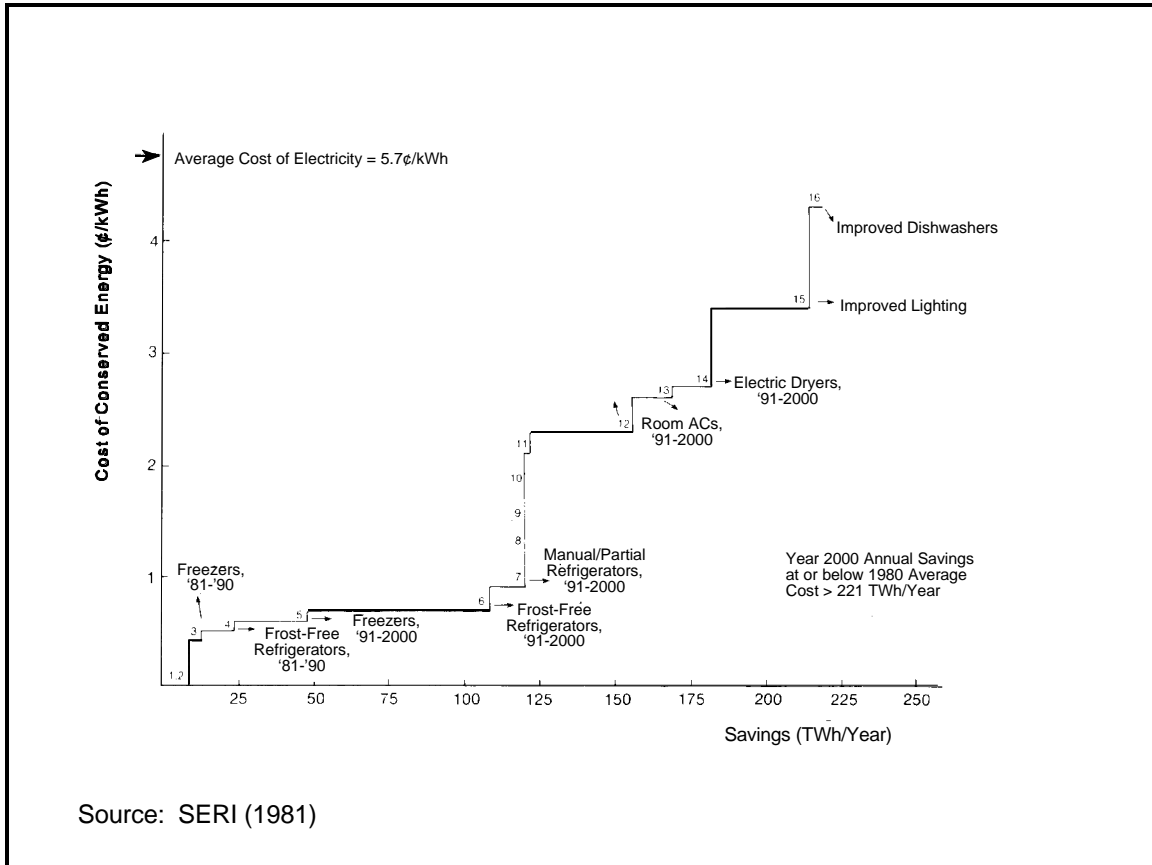
The implication of the new vision for energy policy was articulated in *Energy Strategy: The Road Not Taken* (Lovins 1976). Lovins’ seminal paper described alternative sources of energy that were plentiful, renewable, and more environmentally benign than fossil fuels. The linchpin of Lovins’ argument was the development of the concept of energy efficiency: using less energy to produce more economic output.² This concept, coupled with a review of the apparently highly inefficient use of energy by society at the time led to a conclusion that the market alone was not working to provide the most desirable social outcome. Soon after its publication, ideas about energy efficiency began having a significant effect on public policy.

These ideas were often expressed as questions about the existence and magnitude of an *efficiency gap*. The efficiency gap, a phrase now widely used in the energy-efficiency literature, refers to the difference between levels of investment in energy efficiency that appear to be cost effective based on engineering-economic analysis and the (lower) levels actually occurring (SERI 1981). The gap has frequently been represented graphically using a supply curve of conserved energy or SCCE (see Figure 2-1). A SCCE is generally described as a schedule of the quantity of potential energy savings from various technologies, ordered by the per-unit marginal cost of those savings. SCCE curves have been constructed based on technical potential studies of advanced energy saving technologies and measures (Fickett et al. 1991). In this context, technical potential refers to a hypothesized, instantaneous or “overnight” implementation of an energy-efficient technology, device, or appliance.³ Comparison of the SCCE with the cost of developing

² Others, notably Schipper (1976) further explored the connection between energy efficiency (the rate of consumption for a given level of amenity) and energy conservation (the change in total energy consumption).

³ In this context, we use the term “overnight” to refer to the complete adoption of a technology that is assumed to have no search, implementation, or other non-operating costs (see the hidden cost and transaction cost economics subsections for further development of these ideas). In addition, the term is meant to express the assumption that such diffusion takes place against a baseline consisting of an unchanging or frozen set of technologies. Stoft (1995) refines the basic SCCE framework to allow for inclusion of implementation

Figure 2-1. Supply Curve of Conserved Energy (TWh/year)



new energy supplies suggests that energy services could be delivered through the adoption of these energy-efficient technologies at lower costs than could be achieved through the development of new energy supplies. The currently low market adoption of these energy-efficient technologies, coupled with this unrealized potential, is taken to imply that significant amounts of energy could be saved cost effectively through investments in this equipment because the financing and energy operating costs of such technologies are below the energy costs of currently installed equipment (Meier et al. 1983).

The implicit discount rate suggested by the efficiency gap has frequently been compared to the interest rates offered by other, non-energy-efficiency investments that consumers

costs and more realistic assumptions regarding autonomous technological change. Notably, he also clarifies the need to treat carefully the level of energy service provided in order to draw conclusions regarding the size of the implied efficiency gap (see Section 2.4.5).

are purchasing.⁴ The difference between these rates is offered as *prima facie* evidence of shortcomings in the functioning of the markets for energy efficiency (Ruderman et al. 1987). According to this line of reasoning, the shortcoming rests on consumers' willingness to invest in options offering some particular revenue streams but unwillingness to invest in energy efficiency without receiving substantially higher returns on their investment. In theory, investors should be equally willing to invest in options offering the same expected return for the same levels of risk and liquidity. To explain investors' apparent unwillingness to do so, some commentators point to "market barriers to energy efficiency."

Some argue that the gap is even larger because the relevant discount rate from a societal perspective should be the even lower rate used by large institutions, such as utilities, who because of their obligation to serve, should use their borrowing capacity to underwrite energy-efficiency investments foregone by consumers (Krause and Eto 1988). Still others argue that the relevant discount rate should be an even lower social discount rate because of negative externalities (primarily, environmental ones associated with the discovery, acquisition, refining, transportation, and consumption of energy). This claim implies that, from a social perspective, the efficiency gap is larger than it appears from the perspective of an individual participant in the market, because the social costs of energy use are generally higher than what consumers pay (Holdren 1992)

The gap can be understood, then, as reflecting two distinct phenomena: (1) behavior consistent with use of a discount rate in excess of that used for other, equivalent transactions, and (2) underinvestment in energy efficiency at market prices for energy versus underinvestment in energy efficiency because of the mis-pricing of energy resulting primarily from negative environmental externalities and regulatory failure (see Sections 2.3.4 and 2.5.1 for further discussion). This disaggregation of the efficiency gap can be seen in Figure 2-2.

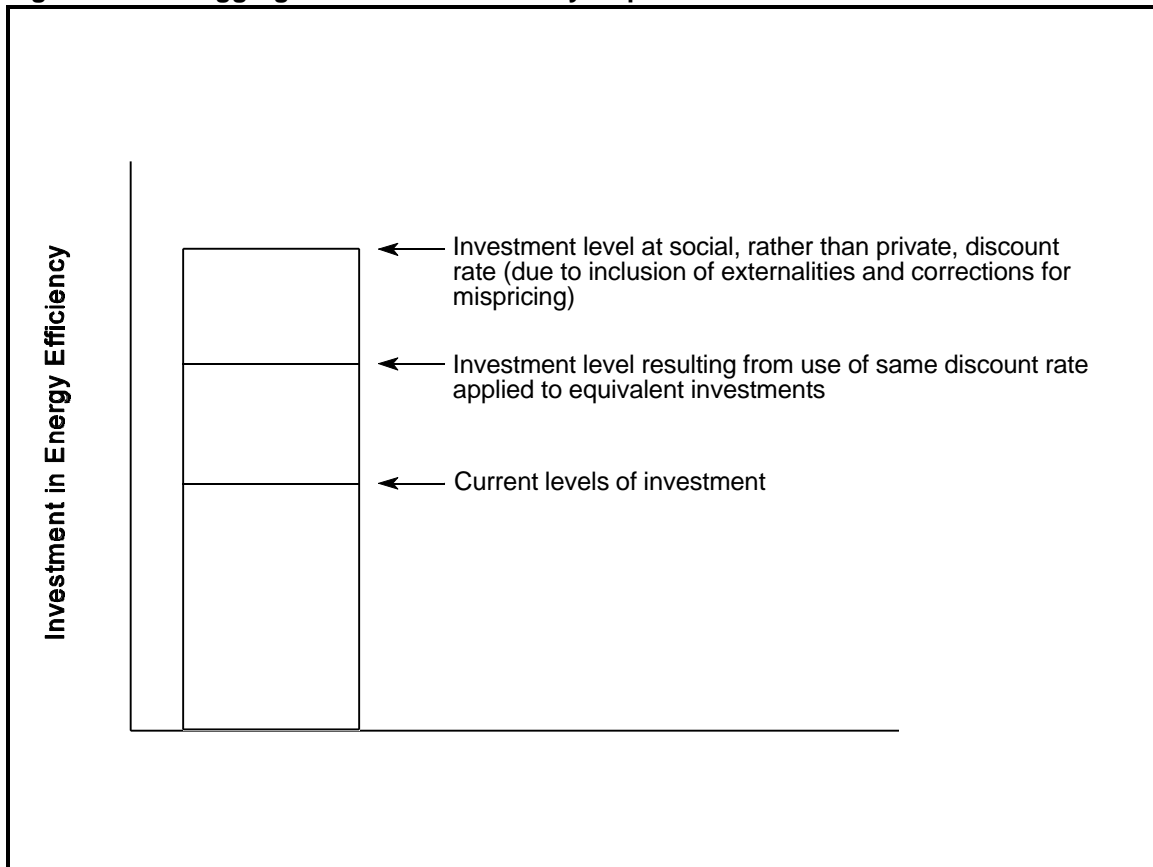
2.3 What are Market Barriers to Energy Efficiency?

As the "technologists," mostly physicists and engineers using discounted cash-flow analysis, pointed out in the early stages of the market barriers debate, significant opportunities existed to use energy more efficiently. Efficiency, in this context, meant providing equivalent energy service at lower total cost (i.e., at lower combined energy operating costs and energy efficiency measure adoption costs). Analysis of the causes for the apparent discrepancies between opportunities and exploitation were first presented systematically by Blumstein, et al. (1980). This paper described features of energy

⁴ An implicit discount rate is the discount rate which equilibrates the incremental cost of an energy efficiency measure with expected changes in future operating costs. See, for example, Train (1985).

services markets that were claimed to inhibit the exploitation of efficiency opportunities, noting, “Although economically rational responses to the energy crises, energy conservation actions may be hindered by social and institutional barriers.” These barriers, as initially presented, were offered as explanations of the difference between actual energy-efficiency choices observed in current energy service markets and markets as predicted/described in economic theory. Each “barrier” was a feature of the energy services market that was believed to inhibit investment in energy efficiency. Six market barriers were initially identified: 1) misplaced incentives, 2) lack of access to financing, 3) flaws in market structure, 4) mis-pricing imposed by regulation, 5) decision influenced by custom, and 6) lack of information or misinformation. Subsequently a seventh barrier, referred to as “gold plating,” was added to the taxonomy.

Figure 2-2. Disaggregation of the “Efficiency Gap”



2.3.1 Misplaced Incentives

Misplaced, or split, incentives are transactions or exchanges where the economic benefits of energy conservation do not accrue to the person who is trying to conserve. The terms have been used to describe certain classes of relationships, primarily in the real estate industry between landlords and tenants with respect to acquisition of energy-efficient

equipment for rental property. When the tenant is responsible for the energy/utility bills, it is in the landlord's interest to provide least-first-cost equipment rather than more efficient equipment for a given level of desired service. There is little or no incentive for the landlord to increase his or her own expense to acquire efficient equipment (e.g., refrigerators, heaters, and light bulbs) because the landlord does not bear the burden of the operating costs and will not reap the benefits of reducing those costs. This misplaced incentive is believed to extend to the commercial sector; however, most of the literature on misplaced incentives focuses on the residential sector.

2.3.2 Financing

The financing barrier, sometimes called the liquidity constraint, refers to significant restrictions on capital availability for potential borrowers. Economic theory tells us that, for a risk-adjusted price, the market should provide capital for all investment needs. In practice, we observe that some potential borrowers, for example low-income individuals and small business owners, are frequently unable to borrow at any price as the result of their economic status or "credit-worthiness." This lack of access to capital inhibits investments in energy efficiency by these classes of consumers.

The capital that may be available through, for example, credit card debt (for those who can obtain them), does not distinguish between purchases or investments and is generally very costly compared to other forms of credit. If a consumer wishes to purchase an energy-efficient piece of equipment, its efficiency should reduce the risk to the lender (by improving the borrower's net cash flow, one component of credit-worthiness⁵) and should, but does not, reduce the interest rate, according to the proponents of the theory of market barriers. Home mortgages are offered as another example of the financing barrier; mortgage qualifications, although purportedly designed to match the ability of the borrower to repay the loan with the loan payback requirements, typically do not consider the operating costs of the home being purchased, despite the impact such costs have on the total cash flow of the homeowner.

2.3.3 Market Structure

The market structure barrier refers to product supply decisions made by equipment manufacturers. This barrier suggests that certain powerful firms may be able to inhibit the introduction by competitors of energy-efficient, cost-effective products. Evidence for

⁵ Credit-worthiness is based on a number of factors including: past debt repayment history, current assets and debts, income, characteristics of the investment/purchase, and net cash-flow.

the contention that market power has led to imperfect competition, while frequently cited informally, has not been developed systematically in the literature.⁶

2.3.4 Regulation

The regulation barrier referred to mis-pricing energy forms (such as electricity and natural gas) whose price was set administratively by regulatory bodies. These procedures and the cost structure of the industries typically result in different prices depending on whether they are set based on average costs (the regulated price) or marginal costs (the market price). Historically, the price of electricity as set by regulators was frequently below the marginal cost to produce the electricity. This mis-pricing was claimed to create an incentive to overconsume electricity relative to conservation or efficiency. More recently, marginal costs of electricity production have frequently dropped below prices as set administratively. This shift has given rise to contentions that the price of electricity now provides an incentive to overinvest in energy efficiency.

2.3.5 Custom and Information

The fifth and sixth barriers, custom and information, have evolved significantly during the market barrier debate from their initial exposition in Blumstein, et al. (1980). Accordingly, we will take them up in subsequent sections of this chapter. The custom barrier will be developed in Section 2.5.4. The information barrier, now seen as central to the debate, will be taken up from a variety of perspectives, starting in Section 2.5.4 and continuing in Section 2.6.

2.3.6 Gold Plating and Inseparability of Features

The notion of “gold plating” emerged from research suggesting that energy efficiency is frequently coupled with other costly features and is not available separately (Ruderman et al. 1987).⁷ Although not generally emphasized in economic theory, one assumption required by the neo-classical paradigm is that all goods are separately available. Close inspection reveals that individual products are, in fact, collections of features, each of

⁶ For a discussion of the significance of imperfect competition in the market for compact fluorescent bulbs, see Haddad (1994).

⁷ Gold plating in this context should not be confused with the unrelated concept of gold plating from regulatory economics, which holds that, under rate-of-return regulation, utilities have powerful incentives to over-invest in capital plant, also known as the Averch-Johnson thesis.

which may be seen as individual goods themselves. Although some features clearly are separable (for example, one may purchase the same refrigerator with or without an ice-maker), many others are not, either because of technological limitations or producer decisions. As a result, buyers may be forced to purchase unnecessary/undesirable features in order to acquire energy efficiency or to settle for less efficient equipment.

Inseparability of features refers specifically to cases where availability is inhibited by technological limitations. There may be direct tradeoffs between energy efficiency and other desirable features of a product; as an example, it is frequently argued that energy efficiency and safety in automobiles must be traded off against each other because it is not possible with current technology to maintain or increase one while simultaneously increasing the other. In contrast to gold plating where the consumer must purchase more features than are desired, the inseparability of features demands purchases of lower levels of features than desired.

2.4 Questioning the Existence of the Efficiency Gap

One of the important criticisms of the market barriers argument points out that the term “market barriers” itself is ambiguous and does not have a consistent conceptual underpinning (Sutherland 1991). Much subsequent debate has revolved around perceived inconsistencies. Neo-classical economists, for example, recognize a variety of economic features, known as market failures that, in principle, inhibit the efficient functioning of the market and provide a justification for government intervention. Many argue, however, that these market failures are simply not pervasive in today’s energy service markets because there are a number of alternative explanations for observed, high implicit discount rates which are consistent with the normal workings of all markets.

This section reviews the most important of the alternative explanations that do not involve market failures. Market failures are taken up separately in Section 2.5. We begin with an important clarification of the distinction between energy efficiency and economic efficiency. We then consider five specific critiques that fall under two broad classes of alternative explanations. The first class of explanations holds that the efficiency gap is over-estimated because it does not consider (1) the heterogeneity of consumers or (2) the natural diffusion rate of any new technology. The second class of explanations holds that the efficiency gap is mis-construed because it does not properly account for important factors influencing the energy-efficiency investment, including (3) risk, (4) hidden costs, and (5) other, non-economic variables. To maintain historical continuity, we also report subsequent responses to some of these critiques.

2.4.1 Energy Efficiency vs. Economic Efficiency

An important clarification for the market barriers debate has come from economists seeking to distinguish between economic efficiency and energy efficiency. Sweeney (1993) has developed a graph characterizing investments along two axes: effect on energy intensity, and effect on economic efficiency (see Table 2-1). Sweeney points out that focusing on energy efficiency (or intensity) as the goal can lead to rejection of investments that *increase* energy intensity, yet *increase* economic efficiency. It is certainly possible, in principle, to conceive of a new technological process that requires, for example, reduced labor intensity yet higher energy intensity, and is more economically efficient than an existing process. By choosing reduced energy efficiency as the objective, this new technology would be rejected, despite the increased economic efficiency offered. This, it is argued, is not consistent with actual (and rational) behavior.

Table 2-1. Energy Efficiency versus Economic Efficiency

	Decreases Energy Intensity	Increases Energy Intensity
Increases Economic Efficiency	“Energy Efficiency”	“Energy Enhanced Progress”
Decreases Economic Efficiency	Not Promoted	Rejected as Undesirable

Source: Sweeney (1993)

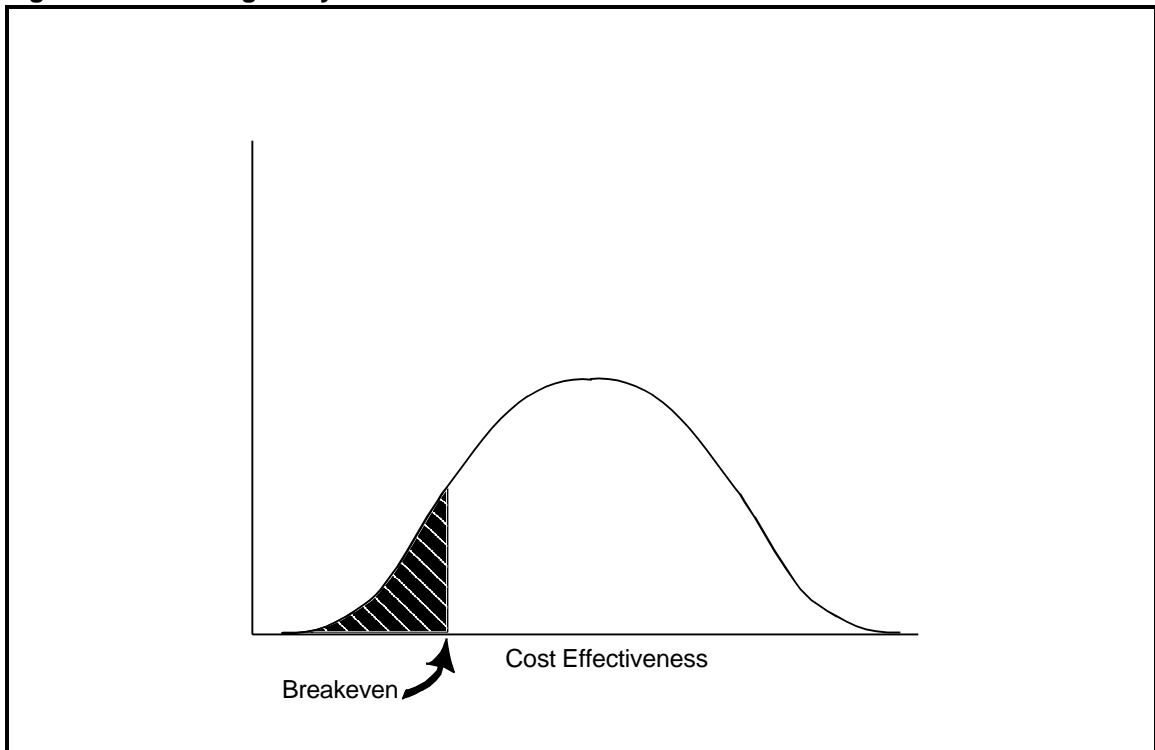
Imprecision in speaking about energy efficiency versus economic efficiency led to regrettable misunderstandings between technologists who sometimes un-critically equated the two and economists who sought to point out the differences between them. Today, there is no serious disagreement over the primacy of economic efficiency as the legitimate social objective for energy-efficiency policies. That is, energy efficiency should be promoted only to the extent that improves economic efficiency (or increases net social welfare). This principle will be central to our discussions of the appropriateness of public policies to promote energy efficiency in Chapter 3.

2.4.2 Heterogeneity of Consumers

One straightforward technical critique argues that the methods used by conservation advocates in developing SCCEs overstates the size of the efficiency gap. The critique observes that, although a technology may be cost-effective on average for a class of users taken in aggregate, the class, itself, consists of a distribution of consumers: some could economically purchase additional efficiency, while others will find the new level of efficiency not cost effective (Sweeney 1993). This difficulty, also referred to as aggregation bias, is illustrated in Figure 2-3, which demonstrates how a technology that may be cost-effective on average across a population of potential investors, may, in fact, be uneconomic for a subset of that population. Depending upon the distribution of certain characteristics within that population, the size of the subset could be substantial. Thus,

although an analysis based on average users may demonstrate the cost effectiveness of a particular technology, in practice we may observe low rates of adoption stemming from the heterogeneity of the population. To provide a simple example, in evaluating the benefits of replacing an incandescent light bulb with a compact fluorescent lamp (CFL), an assumption is made about the average hours the bulb will be used. There will, however, be users who have a particular light on far more or far less than average. For those whose usage is less, the value of the investment in the CFL is reduced, depending specifically on a variety of other factors.

Figure 2-3. Heterogeneity of Consumers



This observation suggests that the benefits of a particular technology may be overstated for some subset of a total class of users. Clearly, this is an empirical issue and not one that can be settled in the abstract. Koomey et al. (1995), in a rare study that explicitly considers several possible sources of aggregation bias, find little or no impact from them on their findings for the cost effectiveness of recent federal minimum efficiency standards for fluorescent ballasts.

2.4.3 Diffusion Rates

A related critique holds that small market shares of efficient technologies are to be expected because the technologies are generally new to the marketplace. These critics argue that efficiency advocates have incorrectly framed questions about investments in efficiency in terms of an idealized equilibrium level of investment. Many efficiency gap arguments have assumed implicitly that cost-effective technologies are adopted instantaneously (see Section 2.3). However, it has been pointed out that the adoption of new technology is typically gradual (Jaffe and Stavins 1994a). Given the rate of technological innovation for energy-efficient technologies over the last few decades, equilibrium states, i.e., stable levels of the diffusion of a particular technology, are not likely in the near future.

So a more pertinent question, in a nonequilibrium state, may be about the rate of adoption, rather than the level of investment. In fact, little work has been done to compare the rates of the adoption of energy efficient technologies with adoption rates of other important technological advances such as cars, electric typewriters, calculators, microwave ovens, or computers. Examining the rate of adoption of more efficient technologies is another important area for future empirical work.

2.4.4 Risk, Discount Rates, and Modeling the Investment Decision

Two important critiques of market barriers argue that high discount rates are, in fact, warranted given the riskiness of energy efficiency investments. The first is framed in terms of the diversification options available for these investments. The second is framed in terms of the illiquidity of the investments.

The first argument starts with the observation that although engineering/economic analyses assume known and certain future conditions such as energy prices and device lifetimes, in fact such future conditions are uncertain and impose risk on the potential investor (Sutherland 1991). Potential investors, it is argued, will increase their discount rates to account for this uncertainty or risk because they are unable to diversify it away. The capital asset pricing model (CAPM) is invoked to make this point.

The use of CAPM to model energy-efficiency investment decisions has been challenged on several grounds. One criticism points out that CAPM assumes an idealized, frictionless investment environment where all potential investors possess the same information. Although this assumption is reasonable for major financial markets, it does not hold in energy services markets, which means that the diversification strategy

promoted by the model becomes costly or impossible (Johnson and Bowie 1994).⁸ A second criticism questions the appropriate portfolio to consider as the basis for evaluating nondiversifiable risk. Although CAPM relies on a portfolio of all available securities, a portfolio designed to minimize energy price risk may be more appropriate for energy efficiency investments. The general insight of this line of argument is that a price lower than current costs ought to be required by an investor in energy efficiency because of the positive correlation between returns on investments in efficiency and energy prices (Metcalf 1994).

The second argument observes that, unlike an investment in a liquid or saleable good, an investment in efficiency must be held by the initial investor regardless of the performance of the investment or the investor's changing needs (Hassett and Metcalf 1993). Thus, as the rated lifetime of equipment increases, the uncertainty and the value of future benefits will be discounted significantly. The irreversibility of most energy efficiency investments is said to increase the cost of such investments because secondary markets do not exist or are not well-developed for most types of efficient equipment. This argument contends that illiquidity results in an option value to delaying investment in energy efficiency, which multiplies the necessary return from such investments (Metcalf 1994).

Sanstad et al. (1995) challenge the option value approach described by Metcalf. They argue that since the magnitude of the option value declines substantially as the discount rate increases, the option value offers little or no explanatory power for implicit discount rates actually observed for energy efficiency investments. That is, option value can only account for some portion (in fact, very little) of the high implicit discount rates observed in consumer's purchasing behavior.

2.4.5 Hidden Costs

A final criticism of the market barriers position accuses barriers proponents of sloppy accounting. The "hidden cost" argument says that technical potential studies fail to account for either reductions in benefits associated with investments in energy efficient equipment or additional costs not considered in the analysis of cost effectiveness (Nichols 1994, Ruff 1988). On the benefit-side of the equation, the critics argue that the assumption of equivalent levels of service across technological options is incorrect. For example, if the quality of light provided by a CFL is less desirable than that provided by an incandescent bulb, this reduction in benefit (or additional cost) must also be included in the analysis. On the cost-side of the equation, the critics contend that, among other things, information and search costs have typically been ignored or underestimated in

⁸ We observe that although this criticism is technically correct, it actually enhances the method's predictive value. The inability to diversify as required by CAPM means that the price required by the investor (as reflected in the discount rate) must be higher than that suggested by the model, yet consistent with observation.

engineering/economic analyses. Time and/or money may be spent: acquiring new information (search costs), installing new equipment, training operators and maintenance technicians, or supporting increased maintenance that may be associated with the energy-efficient equipment. These costs must be included in the calculations. Taken together, it is argued that the sum of reduced benefits and omitted costs fully explains any remaining efficiency gap.

The challenge involved in responding to the hidden cost argument requires distinguishing carefully between treating the argument as simply a matter of faith and treating it as a matter subject to empirical examination. In the first case, if one simply assumes that hidden costs, by definition, fully account for the difference between observed behavior and what would appear to be in the consumer's economic self-interest, then the introduction of new information can never change the outcome; the postulation of hidden costs is not a testable hypothesis.

In response to the possibility of changes in the energy service amenity delivered, analysts have begun to identify products with characteristics that are fully equivalent except for energy efficiency (Kooimey and Sanstad 1994). They have attempted to demonstrate that, for certain appliances, in the absence of hidden costs, investment in energy-efficient equipment is still less than economically efficient. In other words, buyers fail to choose equipment options that provide equivalent levels of service at lower life-cycle cost. Herman and Hicks (1994) also find minimal or no changes in energy service amenity in their examination of two utility DSM programs. Others have begun to quantify the search costs associated with energy-efficiency decisions. Hein and Blok (1994) found search and information costs of energy efficiency improvement measures to be between 3 and 8% of the total investment costs.⁹ Unfortunately, but of necessity, both studies are anecdotal. Nevertheless, they suggest that there are at least some cases in which hidden costs do not adequately account for the efficiency gap.

2.4.6 The Importance of "Noneconomic" Variables

Discounted cash-flow, cost-benefit, and social welfare analyses use price as the complete measure of value although in very different ways; behavioral scientists, on the other hand, have argued that a number of "noneconomic" variables contribute significantly to consumer decision making. Stern (1986) argues, for example, that psychological considerations such as commitment and motivation play a key role in consumer decisions about energy efficiency investments. Stern and Aronson (1984) had argued earlier that other factors, such as membership in social groups, status considerations, and expressions of personal values play key roles in consumer decision making.

This position has found empirical support in research focusing on consumer use of air conditioning (McGarity and Kempton 1988); this work revealed that both economists and technologists have oversimplified descriptions of the services provided by certain appliances. For example, rather than viewing the sole service provided by air

⁹ We will return to aspects of hidden costs in discussing transaction cost economics in Section 2.6.

conditioning equipment, cooling of the air, consumers have a variety of concerns and objectives, such as air flow or noise, for which they are willing to trade off precise air temperature concerns. Likewise, consumers may use air conditioners in part as home security devices, running them when not at home to create the impression of occupancy. This research suggests air conditioning units provide a variety of services and are associated with a variety of costs, rather than providing a single service that can be precisely represented by assuming an average desirable indoor temperature and calculating actual temperature differentials and a single cost that can be represented by the price of the service.

This observation is another way of expressing the point made earlier regarding economic versus energy efficiency (see Section 2.4.1). In the language of (economic) utility theory, the profitability of energy efficiency investments is but one attribute consumers evaluate in making the investment. The value placed on these other attributes may, in some cases, outweigh the importance of the economic return on investment.

2.5 Market Failures and the Efficiency Gap

The previous arguments questioning the existence of the efficiency gap have attempted to dispute the existence of the market barriers discussed earlier and to minimize the magnitude of inefficiencies resulting from existing market imperfections. At the same time, economists have long recognized a variety of types of what they call market failures (Fisher and Rothkopf 1989). There is agreement among economists that market failures provide a necessary justification for government intervention. Without commenting on the magnitude of these failures or the additional conditions required to support government intervention,¹⁰ the following discussion describes market failures relevant to energy efficiency. In contrast to the challenges to the market barriers arguments just discussed, our discussion focuses on identifying those neo-classical market failures that are present in the energy services market. We use this reasoning to show how many market barriers can be understood as examples of market failures, notably those associated with the absence and cost of information.

2.5.1 Externalities

Externalities refer to costs or benefits associated with a particular economic activity or transaction that do not accrue to the participants in the activity. For example, air pollution emissions associated with fossil fuel combustion are a negative externality because they reduce the quality and value of the air, adversely affect human and ecosystem health, and damage property well beyond that of the suppliers and consumers of the energy. Externalities are typically understood in economic terms as resulting in a mis-pricing of the relevant good or service (underpricing in the case of negative externalities), and a consequent incentive to over- or under-consume the good. Although there is general agreement on the concept of negative environmental externalities, their magnitude is in

¹⁰ This topic is the subject of Chapter 3.

dispute. Some argue that the magnitude of the damages is enormous and represents a serious threat to future economic well-being (Ottinger et al. 1990). Others argue that existing environmental regulation has internalized a significant proportion of these costs (Joskow 1992).

2.5.2 Imperfect Competition

In order for a market to function effectively, all parties to an exchange or transaction must have equal bargaining power. In the event of unequal bargaining positions, we would expect that self-interest would lead to the exploitation of bargaining advantages. Although, in theory, we should be able to identify or measure such positions directly, we can more easily infer this information from observing the structure of the market. A variety of market structures have been identified as likely to reflect unstable or unequal bargaining positions. These structures include monopoly, monopsony, oligopoly, and oligoposony and refer to markets in which there are either one or small numbers of either sellers or buyers and large numbers of the other. It is generally argued that those parties on the side of the market with limited participants have power in the market. In addition, certain types of conduct, such as collusion, while not necessarily reflective of unstable market structures, are considered anti-competitive. Collusion refers to agreements between economic agents to act in concert for the purpose of gaining bargaining advantages. Investigation of the prevalence and importance of this market failure in the market for energy services has been limited and represents a significant research opportunity.

2.5.3 Public Goods

Public goods are defined in economics by two characteristics: 1) consumption of such goods by one party does not diminish the benefits to other consumers of the same goods and 2) once such goods have been provided to one consumer, it is not possible to restrict their consumption by others. Because these characteristics violate the assumptions necessary for economic efficiency, public goods are said to represent a market failure. It has been generally acknowledged by economists and efficiency advocates that public-good market failures affect the energy services market. Investment in basic research is believed to be subject to this shortcoming; because the information created as a result of such research may not be protected by patent or other property right, the producer of the information may be unable to capture the value of his/her creation. This provides a disincentive to produce such information and is widely believed to result in an underinvestment in basic research. This market failure applies to all forms of basic research, including energy efficiency (Howarth and Andersson 1993).

The information created by the adoption of a new technology by a given firm also has the characteristics of a public good. To the extent that this information is known by competitors, the risk associated with the subsequent adoption of this same technology may be reduced, yet the value inherent in this reduced risk cannot be captured by its creator.

2.5.4 Imperfect Information

In order for markets to work well, participants in a potential exchange must be fully informed about the objects of exchange and about conditions and objects in other markets. Ideally, information is perfect and costless (Harris and Carmen 1991), including knowledge of current and future prices, technological options and developments, and all other factors that might influence the economics of a particular investment. Economists acknowledge that these conditions are frequently not and in some cases can never be met. A series of information market failures have been identified as inhibiting investments in energy efficiency: (1) the lack of information, (2) the cost of information, (3) the accuracy of information, and (4) the ability to use or act upon information.

Perfect information includes knowledge of the future, including, for example, future energy prices. Because the future is unknowable, uncertainty and risk are imposed on many transactions. The extent to which these unresolvable uncertainties affect the value of energy efficiency is one of the central questions in the market barriers debate. Of course, inability to predict the future is not unique to energy service markets. What is unique is the inability to diversify the risks associated with future uncertainty to the same extent as that available in other markets (see Sections 2.3.2 and 2.4.4).

Even when information is potentially available, it frequently is expensive to acquire, requiring time, money or both. Because of the costs of information, participants in an exchange often act without full information. Hence, the limitations on information resulting from the acquisition or search costs is a prominent failure in the energy services market (see Section 2.6, below).

Accurate information may be difficult to obtain; those who have information have strategic reasons to manipulate it in order to inflate its value. Sellers advertise and promote their goods by providing information about their own goods. Self-interest is an incentive for the provision of misinformation by sellers, and the costs of acquiring additional information may be high enough to inhibit acquisition of sufficient unbiased information to overcome well-distributed misinformation. One reason why consumers may choose not to buy more efficient appliances, even when provided with information (via labeling) establishing the cost effectiveness of such purchases, is that consumers are wary and mistrustful because of past experience with advertised misinformation (Stern and Aronson 1984). In addition, as mentioned earlier, the creation of information is limited because information has public good qualities. That is, there may be limits to the creator's ability to capture the full benefits of the sale or transfer of information, in part because of the low cost of subsequent reproduction and distribution of the information, thus reducing the incentive to create information that might otherwise have significant value.

Finally, individuals and firms are limited in their ability to use — store, retrieve, and analyze — information. Given the quantity and complexity of information pertinent to energy efficiency investment decisions, this condition has received much consideration in the market barriers debate. Kempton and Montgomery (1982) examined the methods by which residential consumers computed energy savings from investments in efficiency. They find that prevailing methods systematically underestimate energy savings.

This work is consistent with the notion of bounded rationality in economic theory. In contrast to the standard economic assumption that all decision makers are perfectly informed and have the absolute intention and ability to make decisions that maximize their own welfare, bounded rationality emphasizes limitations to rational decision making that are imposed by constraints on a decision maker's attention, resources, and ability to process information. It assumes that economic actors intend to be rational, but are only able to exercise their rationality to a limited extent (Simon 1957). Important theoretical refinements to this concept, known as prospect theory, have been developed by Tversky and Kahneman (1981, 1986). This theory contends that individuals do not make decisions by maximizing prospective utility, but rather in terms of difference from an initial reference point. In addition, it is argued that individuals value equal gains and losses from this reference point differently, weighing losses more heavily than gains. Recent work by Kempton and Layne (1994) established that the conclusions consumers are able to draw from their analytical effort are restricted by the form in which they receive price and consumption data and by their limited analytic capabilities.¹¹

The concept of bounded rationality has been extended to decision making by firms as well as by individuals (Decanio 1993). In addition to the individual limitations to rationality presented because firms are collections of individuals, firms, themselves, do not behave like individuals in the sense of acting with a single mind. Decanio cites the work of Mancur Olson (1971) who argued that, "the logic of collective action is such that, in general, 'rational, self-interested individuals will not act to achieve their common or group interests'" (p. 907). This finding is tempered by the efforts of managers to create the appropriate incentive schemes necessary to align the individual's interest with the firm's interest, but Decanio argues, "Failures of complete maximization are to be expected" (p. 907).

Both the misplaced incentives and the financing or liquidity constraint market barriers discussed earlier can be understood as examples of information market failures.¹² As noted, property rental rates do not reflect the value of energy efficiency investments. Although not yet established empirically, it is likely that this shortcoming represents a failure of the market to adequately transmit the information regarding the value of energy efficiency to the potential renter of these investments. Renters are also inhibited in their ability to exercise rational decision making because of a lack of information about the value of the investments as well as future prices and conditions. Likewise, the purchase market appears similarly hindered in transmitting information about the value of energy efficiency investments in property for sale.

¹¹ Kempton and Layne (1994) liken today's energy bills to receiving a single monthly bill for all groceries purchased with no identification of the items.

¹² While we argue that many market imperfections or barriers can be understood as information market failures in order to provide a sense of legitimacy for these market barriers, we recognize that this categorization is distinct from the normative issue of whether or not it suggests practicable improvements to the problem under investigation. For example, without judging specific DSM program designs, we object strongly to the notion that problems of imperfect information are likely to be addressed wholly by the activities offered through current utility DSM information programs.

With respect to the liquidity constraint barrier, one explanation for the lack of available capital for low-income individuals and small businesses is that the costs of investigating the credit worthiness of such individuals or firms (acquiring the necessary information to establish an acceptable level of risk) may be sufficiently high to significantly diminish the economic viability of such loans. In other words, if the probability of a loan default rises as the income of the borrower decreases, the percentage of creditworthy investors out of the total pool of low-income individuals and small firms declines and the cost of acquiring adequate the relevant information increases because a larger number of potential clients will need to be investigated per loan.

2.6 Transaction Cost Economics: A New Contribution to the Middle Ground

Market failures are well-accepted among economists as providing a legitimate basis for government intervention. In several places, we referred to information-related market failures that are characterized by the cost of acquiring or using information. In this section, we briefly expand on a formal approach for studying this phenomena, called transaction cost economics. We believe it offers both a powerful approach for improving our understanding of this class of market failures and, in Chapter 3, a means by which to assess the appropriateness of government policies to reduce these costs.¹³

Neo-classical economics generally relies on the assumption of frictionless transactions in which no costs are associated with the transaction itself. In other words, the costs of such activities as collecting and analyzing information; negotiating with potential suppliers, partners, and customers; and assuming risk are assumed to be nonexistent or insignificant. This assumption has been increasingly challenged in recent years.¹⁴ The insights developed through these challenges represent an important new way to evaluate aspects of various market failures (especially those associated with imperfect information).

Arrow (1969) provided an explanation for the general failure of markets to develop; this explanation is only now being applied to questions about the functioning of the energy services market. Arrow noted “market failure is not absolute, it is better to consider a

¹³ We are grateful for discussions with S. Goldstone for stimulating our thinking on this topic. See, Goldstone (1995).

¹⁴ The earliest challenge to the neo-classical assumption appears to have been recognized by Coase in the 1930s:

I was to realize that there are costs of using the pricing mechanism. What the prices are have to be discovered. There are negotiations to be undertaken, contracts have to be drawn up, inspections have to be made, arrangements have to be made to settle disputes, and so on. These costs have come to be known as transaction costs. Their existence implies that the methods of coordination alternative to the market, which are themselves costly and in various ways imperfect, may nonetheless be preferable to relying on the pricing mechanism, the only method of co-ordination normally analyzed by economists (Coase 1991, p. 7).

broader category, that of transaction costs, which in general impede and in particular cases completely block the formation of markets” (p. 48). One of the implications of this remark for the energy services market may be that the slow diffusion rates of efficient technologies may be better understood in terms of the transaction costs associated with the development of such markets than by the types of neo-classical market failures discussed earlier. The remark also suggests the difficulty in establishing the range of magnitudes of transaction costs, since evaluation of those costs in transactions that fail to materialize may be impossible, despite their apparent magnitude.

Transaction cost economics examines the implications of evidence suggesting that transaction costs are not insignificant but, in fact, constitute a primary explanation for the particular form taken by many economic institutions and contractual relations (Williamson 1985). Transaction cost economics is well-defined conceptually, as illustrated by the description, “Transaction cost analysis entails an examination of the comparative costs of planning, adapting, and monitoring task completion under alternative governance structures” (Williamson 1989, p. 142).

Despite their conceptual elegance, transaction costs have proven difficult to measure. Two studies have made preliminary steps toward quantifying aspects of a few, but by no means all, of these costs in energy service markets. The findings of Hein and Blok (1994), cited earlier in Section 2.4.5, were largely confined to what are generally referred to as search costs. That they discovered, in Williamson’s terminology, relatively high *ex ante* transaction costs, but relatively low *ex post* costs, despite the likelihood that *ex post* costs will be much higher, points to the limitations of their analysis. Wolcott and Goldman (1992) concluded that the risk premium demanded by energy service companies investing in the first DSM bidding programs ranged between 0.5 and 2.5 ¢/kWh.

Transaction costs economics also offers support for claims that the illiquidity of certain investments leads to higher interest rates being required by investors in those investments. Williamson (1985) argues that “durable, firm specific assets,” creating what he terms “high assets specificity,” provide poorer collateral and create higher risk “in that specialized assets cannot be redeployed without sacrifice of productive value” (p. 54), thereby increasing the costs associated with investments in such assets and creating the need for higher corresponding returns from such investments. There are a number of implications to this point, including a partial explanation of observed rates and a suggestion of the possible importance of the development of secondary markets for energy efficiency investments.

Finally, Williamson (1985) argues that the key issue surrounding information is not its public goods character, but rather its asymmetric distribution combined with the tendency of those who have it to use it opportunistically. This claim is consistent with findings presented earlier about consumer skepticism surrounding energy efficiency claims in that consumers recognize the possibility of the opportunistic use of information. Thus, reducing transaction costs becomes a problem of both economizing on bounded rationality along with safeguarding against opportunism.

As a simple illustration of the concept, many utility demand-side management (DSM) programs can be analyzed as attempts to reduce the magnitudes of various transaction

costs. Here is a simple example of such a program: A private business establishes a maximum three-year payback rule on investments in energy efficiency as its investment criterion, despite access to capital at a lower cost than this criterion implies. Some portion of the difference between the cost of capital and the payback represents the costs to the firm of the information necessary to evaluate energy efficiency investment opportunities or the risks; however, a second firm (a utility or energy service company), may be in position to acquire the same information for less or diversify its risk and effectively arbitrage the two transactions such that it can profitably underwrite some portion of the efficiency investment for the first firm. In simple terms, the second firm could share the costs of making the investment and still profit by retaining only returns over and above those required by the first firm to meet its payback requirements. Transaction costs are reduced utilizing alternative institutional forms of organization, and the original firm, the facilitating firm, and society benefit in ways that would not be possible for the original firm on its own.

In summary, as Johnson and Bowie note (1994), “[W]e find considerable merit in a public policy perspective that regards energy efficiency as a coordination problem rather than viewing energy efficiency with reference to an optimized system. Recognition of the important role of institutions in structuring transactions brings a change in emphasis from competition and utility maximization to coordination and incentive structures” (p. 12). The approach offers much promise of enhancing our understanding and improving the functioning of the market for energy services. As we will argue in the next chapter, we strongly believe that development and application of viable methodologies for calculating transaction costs will be an important next step for assessing changes in social welfare via investments in energy efficiency.

2.7 Synopsis: The Contributions of Positive Analysis

As they were originally described, “market barriers to energy efficiency” referred to a broad set of market features that appeared to explain why observed levels of investment in energy efficiency were suboptimal from either a private or social perspective. Subsequent discussions have clarified, modified, and increased the precision of these descriptions. While only a subset of the original list of market barriers represent what neo-classical economists accept as market failures, others represent a transaction cost economics-based sense of market failure. We would argue that both neo-classical market failures and transaction cost-based failures represent legitimate possible objects of government policies.

We observe that powerful insights into the nature of many market failures have emerged from the discipline of transaction cost economics. Transaction cost economics, contrary to neoclassical economics, starts with the assumption that transactions are rarely costless, and that much of the current structure and organization of today’s economic institutions can be explained by efforts to minimize transaction costs. High transaction costs are central, for example, to explaining the difficulty consumers face in acquiring and acting

on information on the value of energy efficiency investments. In addition, the issues of asymmetric information and opportunism pervade the relationships prevalent in the energy services market and can now be seen as central to efforts to reduce transaction costs.

We have been careful in our discussions to avoid the normative implications of the market barriers debate for energy-efficiency policies. That is, we have made a conscious decision to focus only on the analysis of consumer and institutional behavior provided by the market barriers debate. In the next chapter, we take up the policy issues directly. For example, we will argue that it is useful to utilize the framework of transaction cost economics for assessing energy-efficiency policies: A rough threshold condition for such policies might be that they must reduce the net transaction costs associated with energy efficiency investments. Whether governments or private institutions are best suited or uniquely responsible for seeking these reductions, however, remains an open question.

The market barriers debate has been important for energy-efficiency policy discussions for two reasons. First, evidence of market failure provides a necessary condition for government intervention to improve total social welfare, although this justification is not necessary for intervention aimed at the separable objective of improving social equity. Second, the analysis of particular market failures provides us with a much deeper understanding of how energy-efficiency investment decisions are actually made in certain market sectors. We believe this understanding is critical to a more comprehensive assessment of the efficacy of any particular public policy, which we believe should be treated with specific reference to the particular market failures they seek to reduce or remove.

Rationale and Considerations for Public Policies to Promote Energy Efficiency

3.1 Overview

In discussing the debate on market barriers to energy efficiency, we stopped short of drawing conclusions as to whether alleged market barriers, viewed as market failures (in some cases, as activities fraught with high transaction costs) justified intervention. In this section, we turn directly to this issue. Our goal is to better understand the positions drawn from the debate, what assumptions they rely on, and what might be done to resolve the questions they raise regarding the appropriateness of intervention.

Those who argue that market barriers are real are proponents of intervention — pro-active energy-efficiency policy. They argue that barriers have led to substantial misallocation of resources (an underinvestment in energy-efficient technology) and that public policies are necessary to reduce the economic distortion caused by the market’s shortcomings. Another group grants the existence of well-defined market failures (as a subset of less well-defined market barriers) and acknowledges that these failures, while they provide necessary conditions for intervention, they do not, in and of themselves, provide sufficient conditions for intervention. This group argues that a cost/benefit or net social welfare analysis is necessary to determine whether any proposed policy intervention is appropriate. A third group argues that the market as currently structured is functioning efficiently and any intervention will necessarily reduce overall social welfare.

Understanding the assumptions underlying each of the three positions in the debate is very important. We would argue, for example, that the first and third positions are largely rooted in ideological assumptions about the role of government; future investigations are unlikely to change these assumptions. The second and we believe more appropriate position, however, rests on empirical facts about the way in which energy service markets currently do or could operate in the future. These assumptions can, in principle, be tested, revealing the size, cost, and secondary impacts of problems in particular energy service markets. In Chapter 4, we outline some of the questions that such examinations might consider.

In this chapter, we start by defining features of energy service markets and the role of energy efficiency in these markets. Historic imprecision in defining “energy services” has added confusion to public policy discussions about improving the function of this “market.” We then ask: What are rationales for intervening in the market? We identify three distinct rationales that emerge directly from the discussion in Chapter 2. Next, we describe considerations that we believe must be satisfied in order for these public policies to achieve their objectives satisfactorily and the need for more information on how

markets actually operate in order to make these judgements. We close by outlining a framework for interpreting this information.

3.2 What is the “Market” for Energy Services?

One of the most vexing issues for energy-efficiency policies is the extremely heterogenous nature of energy use, the many and constantly changing opportunities for using energy more efficiently, and the variety of institutions and firms that influence energy use. Confusion about just what is meant by the “market for energy services” obscures important differences in the debate of these policies. We propose a handful of clarifying distinctions toward an improved understanding of what we mean by the market for energy services; from a clearer definition, we can formulate a standard from which to judge interventions that seek to “improve” the operation of the market.

Porter (1980) offers powerful insights about market structure and the competitive forces acting on market players. However, application of formal models such as these to energy services is complicated.¹⁵ First, there is no single industry called “energy services”; instead, there are many energy services and many different markets for them. Second, among these markets, many overlapping distinctions can be made.

At one end of the spectrum of market participants, firms supply energy in the form of electricity, natural gas, fuel oil, propane, wood, etc. Some firms are rate-regulated, such as investor-owned utilities; others set prices more or less in direct response to the competitive pressures of the market, such as sellers of fuel oil or wood. At the other end of the spectrum, residential, commercial, and industrial customers, building renters and owners, and private firms and public institutions make decisions that result in the consumption of one or more forms of energy. As described in the previous section, these end users pay prices for energy that may or may not reflect the full costs associated with its use from a societal perspective. These consumers make energy-use decisions without satisfying many of the information requirements assumed in analyses of perfectly competitive markets, and they incur modest to significant transaction costs for all decisions. The decisions they make are essentially voluntary and presumed to be

¹⁵ Porter’s model distinguishes five competitive forces to describe generic industry structure and identify competitive strategies for firms operating in particular industries. For any given industry, there are (1) current competitors within the industry; (2) potential new entrants; (3) suppliers to firms within the industry; (4) buyers for the products and services produced; and (5) substitute products and services. The model is based on well-defined notions of the line of business that the industry is engaged in (e.g., tires, paper, cosmetics, etc.).

relatively unconstrained (with the exception of building codes and product energy-efficiency standards).

In between these two ends of the spectrum lie a host of firms that directly or indirectly influence these transactions. Manufacturers produce products that either use energy directly (e.g., equipment or appliances) or will ultimately affect the use of energy (e.g., building materials). Vendors and retailers sell these products to consumers directly or to intermediaries whose activities lead indirectly to the use of energy by these products (e.g., builders). These intermediaries, in turn, consist of a large network that profits from the specification, purchasing, installation, operation, repair, and maintenance of energy-using products. With the exception of certain equipment manufacturers whose behavior is somewhat oligopolistic, most intermediaries operate in what are accepted as reasonably competitive markets.

Energy efficiency can be thought of as a feature or attribute of the products and services offered in these markets. It is not a stand-alone product (with the exception of certain products, such as insulation). Most manufacturers offer both standard and high-efficiency versions of their products. Some firms, such as energy service companies, profit specifically from adoption by consumers of energy efficiency products and services. For most firms however, energy efficiency is not a primary consideration or the dominant feature of the product or service they sell: architects design buildings, contractors build them, and building managers operate them.

Thus, the market for energy services is not a single market but a collection of overlapping markets that form a continuum between the production and ultimate use of energy. Some parts of this market appear more competitive than others: some are highly regulated; still others, notably the end use of energy, are fraught with a number of shortcomings described by the neoclassical model of perfectly competitive markets, prominent among them, the high transaction costs for energy efficiency investments (discussed in Chapter 2). As a result, policies that influence only selected aspects of this market should not be expected to remedy all shortcomings.

For example, it has been argued that mis-pricing of electricity results from the historic practice of setting rates at average rather than marginal costs as discussed earlier. However, it is not obvious nor likely that increased competition in the generation and sales of electricity and across-the-board regulatory changes will address all the information failures observed in end-use markets. It does appear likely that these changes (e.g. incorporating grid congestion externalities into transmission pricing) will improve regulatory pricing by internalizing some significant externalities and by moving closer to marginal cost pricing.

Hence, some humility is appropriate. There is not a single “energy problem,” nor is there a single market for energy services. It is, therefore, unlikely that there will ever be a

single public policy resolution. A far more pragmatic approach is to strive for clarity on the objective(s) of a particular policy, as well as a candid assessment of its likely limitations. We lay the groundwork for such an approach in the next three subsections.

3.3 Three Rationales for Public Policies Promoting Energy Efficiency

We believe three distinct rationales can be offered by advocates for government intervention in the energy service markets:

1. The market is not achieving the socially optimal distribution of wealth, income, or property rights. Individuals and firms are seeking to maximize their personal and economic welfare, but are inhibited from doing so by imperfections in the market (i.e., market failures). Government can intervene to reduce market failures, assisting individuals and firms in achieving their rational economic objectives and improving net social welfare. One example of these market failures are the negative environmental externalities associated with energy supply. As result of these externalities, the market underprices energy. Government intervention is required to insure an economically efficient level of energy supply given this mis-pricing. If energy prices reflected the full costs of supply and consumption as discussed in Section 2.5.1, consumers would have the appropriate incentive to improve the energy efficiency of their appliances and equipment. However, because society bears the burden of these costs, society has a right to minimize them.

2. The transaction costs associated with investments in energy efficiency, such as the acquisition of information or the risks associated with investments in new technologies, are high in the market as currently structured and substantially inhibit such investments. Alternative institutional arrangements, including government regulation of (through efficiency standards, for example) and participation in the market (through DSM programs, for example) can reduce transaction costs, facilitate the development of markets that are currently hindered by high costs, and increase net social welfare.

3. Government can help individuals and firms help themselves. The behavior of individuals and firms is not consistently economically rational. Firms make energy-related investments that do not always maximize net present value; individuals make energy-use decisions that appear not to maximize their own welfare. However, government can do for firms and individuals what they are unwilling to do for themselves. This rationale rests on an interventionist conception of the role of government. Such intervention is not, however, without precedent. Social security is a good example; it is a program of mandatory personal savings implemented by the federal government to

compensate for the perception that, left on their own, individuals will underinvest in their own retirement.¹⁶

3.4 When are Public Policies for Energy Efficiency Appropriate?

Most would agree that no market is perfect and that government intervention is sometimes appropriate. Most would also agree that, in principle, the three rationales listed above provide legitimate justifications for public policies to promote energy efficiency (although the third may be somewhat controversial). If disagreements about energy-efficiency policies do not lie with these principles, then what is their source?

In our opinion, the disagreements arise from differences of opinions about (1) the size of the problem(s) addressed by the policies, (2) the effectiveness of the proposed policies, and (3) the consequences, possibly unintended, associated with particular policies. If our assessment is correct, then better information should help to resolve these differences. In Chapter 4, we describe examples of this type of research for two important classes of building energy efficiency opportunities. In the remainder of this subsection, we elaborate on the underlying disagreements on which these assessments might shed light.

The first area of disagreement is about the magnitude of the so-called market barriers (now better understood as examples of certain market failures). Our earlier discussion of this debate clarified that market failures were only necessary, but not sufficient conditions for public policies to remedy them. Assessing the magnitude of market failure can help us determine when the failure is sufficient to warrant resolution through public policy.

This question of magnitude lies at the heart of the debate over the efficiency gap: Is the gap so large that it accounts for significant misallocations of society's resources? or is the gap so small that the misallocations are insignificant? If the gap turns out to be quite small, then the need for public policies to correct it is not great. Many of arguments against the existence of market barriers presented in Chapter 2 (e.g., heterogeneity of users, natural diffusion rate for new technologies, sloppy accounting of direct and hidden costs, etc.) have the effect of diminishing the size of the efficiency gap. As noted, studies of supply curves of conserved energy have only recently attempted to address issues of heterogeneity of users, changing baseline efficiencies, constancy of amenity provided, and implementation costs (see, for example, Koomey et al. 1991). Similarly, much of the

¹⁶ One could also argue that this example is based partially on elements of the first two rationales. First, because society bears at least some costs that result from underinvestment in retirement income, society has a right and an obligation to minimize those costs. Second, government, by virtue of its size and ability to marshal cash flows, can reduce the transaction costs associated with assuring post-retirement income compared to each individual making such arrangements privately.

discussion about environmental externalities centers not on their existence but rather on their magnitude.

An intriguing illustration of the magnitude question examined from the point of view of transaction costs suggests that market barriers can sometimes accumulate and reinforce one another. Originally presented in Blumstein et al. (1980), but left essentially undeveloped since, the idea of chains of market barriers refers to small imperfections, any of which individually represents an insignificant distortion to efficiency, but which in combination are of a magnitude sufficient to be considered a market failure.¹⁷ This phenomenon acknowledges both that the magnitude of the distortion to economic efficiency (the costs imposed) by any individual imperfection is small (and, which by itself, probably does not justify public policy intervention), but that the imperfections taken together do justify intervention. The chain of market barriers phenomenon explicitly recognizes that there are series of decisions, actions, and transactions between the production of goods and their ultimate sale to the end user. This idea of chains of barriers may represent fertile ground for explaining why analyses focusing on very specific market features might identify only small inefficiencies while the market overall may be substantially more inefficient and provide the potential for obtaining significant leverage through the identification of those links that are most amenable to productive intervention.

The second underlying disagreement about energy efficiency policies concerns the efficacy of the policies proposed to address the identified market barrier/failure(s). Two variants of this concern are often expressed: Will the policy work at all? Or, will it work, but only at a cost greater than that caused by the market barrier/failure? We argue that both variants in fact reduce to a more general consideration: Does the policy increase net social welfare?

Whether a policy will work at all is usually determined through an accounting of direct costs and benefits. Joskow and Marron's review of utility DSM program costs (1992) is a leading example of an analysis questioning the cost effectiveness of these programs based on a straightforward accounting of costs and benefits. The response of Eto et al. (1996) to the contrary is also framed in these terms.

However, some argue that the definition of cost effectiveness embodied in these approaches is overly restrictive. Measuring direct costs and benefits alone may not capture some or even the bulk of the social welfare impacts of a policy. An energy-efficiency policy that appears cost effective based on a direct accounting of dollars spent and energy saved may be incomplete, if, for example, there are changes in the energy

¹⁷ Jaffe and Stavins (1994b), for example, define market failure as market barriers that might justify a public policy intervention to overcome them.

service amenity provided, important benefits not counted, or other indirect costs and benefits. For example, in the previously cited study by Eto et al. (1996), cost effectiveness was established without including any environmental benefits associated with reduced electricity generation. Similarly, there is emerging evidence that some DSM programs induce non-participants and participants to undertake additional energy-efficiency actions outside of the program, leading to additional benefits, but no additional program administrative costs (Violette, Rosenberg, and Stone 1995, Levine and Sonnenblich 1994).

Examining policies from the broad perspective of their net impact on social welfare raises a final concern expressed in debates about the merits of public policies for energy efficiency: Will the success (or even the existence) of a proposed public policy designed to ameliorate these market barrier/failure(s) compromise other important public policy or social values that also contribute the general welfare?

A tangible example of this concern also emerges from debates over the wisdom of utility DSM programs. Ratepayer-funded DSM programs benefit some ratepayers more than others. Ideally, the actual participants in a DSM program reduce their energy bills or increase productivity. Nonparticipants, too, will see reductions in bills with the right combination of marginal and average utility costs, program costs, and sales base. Under different circumstances, however, their bills may increase, leading to the concern that nonparticipants are inappropriately subsidizing participants. Much controversy over DSM programs centers over allegations about the perceived inequities and inefficiencies associated with the latter situation; see, for example, Cichetti and Hogan (1989).

In principle, the magnitude of the cross-subsidy, if it exists, is in principle quantifiable (see, for example, Hirst and Hadley (1994)). Furthermore, regulatory accounting procedures and DSM program design features can mitigate some cross-subsidies (Centolella et al. 1993). However, cross-subsidies combine issues of both the equity effect (just described) and an efficiency effect. Analysts have begun to quantify the efficiency effect in terms of a price impact on nonparticipants (see, for example, Hobbs 1991, Braithwait and Caves 1994, and Herman 1994). However, at bottom, trading off equity and efficiency is a problem to which economic analysis can contribute little. How social welfare is maximized in these situations is essentially a political decision. However, we submit that a better understanding of the magnitudes involved should improve these decisions.

Finally, the concern that energy efficiency policies could compromise the general welfare is complicated by the fact that we cannot know the future with certainty. Sometimes energy-efficiency policies are opposed not because they not might work but because their working may preclude the development of private institutions and firms that could overcome market failures or reduce transaction costs at a lower cost than the public policy or could offer a way of overcoming market failures that is more appropriate (e.g., market-

oriented) than that offered by public policies. The first opposition to energy policies above is based on a perception that public policies are costly compared to private solutions. The second derives from a political view of the role of government as being subordinate to the workings of the market. Nevertheless, both can be reduced to a more general question regarding whether or not net social welfare is improved. We note in closing that we have seen little evidence presented to support the latter contention that public policies are foreclosing private sector market options. Instead, we take the proliferation of energy service providers pursuant to utility DSM programs as evidence that these programs have overcome market barriers previously inhibiting these markets from developing.

3.5 A Framework for Assessing Future Public Policies

Our discussions rely on the following starting assumptions:

1. There is no single market for energy services; instead, the “market” consists of hundreds of end uses, thousands of intermediaries, and millions of consumers.
2. Markets are not perfect, but neither are the institutions which seek to correct market imperfections.
3. Technological and institutional change is an enduring feature of energy service markets.

We do not believe the market barriers debate can be settled by ideological fiat; instead, it must be addressed in a highly disaggregate fashion, considering particular markets and a realistic assessment of the limitations of particular institutions and policies. It is unlikely that, even when public policies are appropriate, there will ever be a single best policy solution (e.g., government minimum efficiency standards); instead, multiple approaches to overcoming market failures or reducing high transaction costs tailored to particular circumstances are more likely to be appropriate. In the next section, we explore the types of information currently available for developing these approaches.

Two Energy Service Markets: From Theory to Empiricism and Back

4.1 Overview

In Chapter 3, we argued that the desirability of energy efficiency policies hinged on the magnitude of the problem(s) they seek to address, their efficacy in redressing these problems, and their interaction with other public policy and social objectives. We also suggested that in order to determine the appropriateness of public policies these issues needed to be examined by looking in detail at particular markets. In this chapter, we begin the task of characterizing the issues for energy efficiency policies in two important end-use markets: new construction, and commercial HVAC and lighting retrofits.

As we will demonstrate, reaching conclusive answers is not easy and we do not pretend to offer them in this paper. Examining particular end-use markets makes clear that the problems are complex and highly interrelated. Our goal is to offer initial observations regarding the types of investigations that have been made or appear necessary in order to make assessments regarding the market's current operation. In doing so, we hope to clarify what may or may not constitute evidence of the need for, efficacy of, and interactions among energy-efficiency (and other) public policies.

As discussed in Chapter 2, the nature of externalities and public goods is such that further analysis of specific institutions, market settings, and individual transactions in particular markets is not required. Accordingly, we focus most of our discussions on those unique market features that involve the lack of, cost of, asymmetric access to, and/or ability to use information.¹⁸ In this regard, we wish to be absolutely clear that it is wholly inappropriate to conclude from an assessment of a situation as being one fraught with information "problems" that the appropriate policy response should consist solely or even mainly of activities that are traditionally associated with DSM information programs. While such programs may turn out to be appropriate, we believe many information problems can only be addressed by more involved analyses of the factors influencing behavior. Hence, we sometimes describe situations based on the transaction costs they appear to involve because we believe that to do so is more suggestive of practical policies that might improve them.

We proceed by reviewing a small but growing body of more and less well-circulated "gray" literature represented by the writings of energy-efficiency advocates and analysts,

¹⁸ We also believe examination of issues associated with imperfect competition (see Section 2.5.2) is appropriate but, as described in Section 2.3.3, we have not found much in the literature, "gray" or otherwise, to support further development of this topic.

and contained in utility DSM program evaluations. This literature is oriented to practitioners, many times anecdotal, and generally not consciously grounded in the formal approaches of the academic literature on market failures, transaction cost economics, etc. The gray literature is nevertheless an extremely rich and heretofore largely unexamined source of important empirical insights into the workings of particular markets. Accordingly, much of our review is devoted to expressing the insights offered from the more formal perspectives described in Chapter 2. In doing so, we sometimes identify promising avenues for future investigations to quantify these insights more rigorously and, thus, provide a stronger foundation for public policies. In other cases, we are content simply to indicate the linkages between the observations and the more formal literature.

We sometimes refer to existing policies to raise issues, however, we do not speculate on appropriate future policies in this paper. This topic is taken up separately in a forthcoming paper examining the particular roles that utilities and others might play.

4.2 New Construction

New building construction is one end-use market that has been identified as having significant potential for energy-efficiency improvements. Although not an end use *per se*, new construction can appropriately be thought of as a package of technologies or end uses for which a single, complex market exists. A recent and comprehensive examination of the market for new construction is provided by Lovins (1992). This work, which presents a relatively thorough consideration of the steps in the new building construction process, contends that the magnitude of the distortions of this market are such that the unnecessary expenditures during the past several decades only for space conditioning and the electricity supply infrastructure to run it total hundreds of billions of dollars.

Much of Lovins' argument relies on the concept of chains of market barriers described in Chapter 3. Here, we review individual elements in this chain to assess how they might be examined in more detail. For convenience, we adopt Lovins' multi-step, temporal characterization of the new construction process. We first describe the developers' objectives; then we discuss project financing, building design, and, lastly, building construction.

4.2.1 Objectives of Developers

Developers of new construction projects can be divided into a several classes whose relationships to energy costs differ. Projects are developed for (1) the developer's own use, in which case the developer is responsible for future energy costs; (2) building owners that have well-articulated energy management practices and principles; (3) clients without such practices; (4) speculation (the ultimate owners or tenants and their interests

in future energy costs are unknown); and (5) turnkey sale or tenants who will be responsible for their own energy costs.

According to conventional wisdom of energy-efficiency advocates, for (1) and (2), the developer will be comparatively more interested in both construction and operating costs. For (3), energy efficiency will neither be a priority nor ignored; it will simply take a place with (some would say behind) other priorities of the developer. For (4) and (5), first cost considerations will dominate the development process and typically more capital-intensive energy-efficiency options will be ignored.

It should, in principle, be possible to examine the energy-efficiency choices made (and not made) by representatives of each of these classes of developers. To date, only anecdotal information has been presented. More systematic evaluation could clarify both the degree of under-investment (if any) for each class of developer, as well as the fraction of new construction accounted for by each class. Doing so will provide much needed information to address the magnitude of the efficiency gap and related issues associated with the heterogeneity of consumers.

4.2.2 Time Constraints in New Construction

Lovins identifies several aspects of the new construction financing that are purported to inhibit investment in energy efficiency. All stem from time constraints on the loan process that hinder innovative design ideas because increased review is required for evaluation of novel or unusual designs.

One time constraint on the loan process is pressure created by the threat of interest rate fluctuations. If a project is designed to be economic at a certain interest rate, and a delay in the approval of loan financing may result in an increase in interest rates, the whole project may be jeopardized. Costs imposed by risk are a form of transaction costs. It is equally likely that a decline in interest rates could improve the economics of a project; however, there are three reasons why an investor would choose to act quickly rather than face the risk of rate changes: (1) although a decrease might marginally improve the profitability of a project, an increase might kill the project entirely; (2) as the magnitude (positive or negative) of possible changes in rates increases, a typical risk-averse investor will prefer the possibility of a small change (assuming an equal probability of an increase or decrease) in rates to the equal possibility of a large change; and (3) a loss-averse investor (from prospect theory) will prefer to avoid the possibility of a loss rather than accept the equal possibility of a gain.

A second time constraint on the financing process for new construction is that delay can kill a project, if permits or other funding commitments expire. Although it would certainly be rational to trade-off the potential benefits of increased energy efficiency for

the security of economic project financing, economic analyses typically do not consider these trade offs because all goods are assumed to be independent of one another — a case of inseparability of goods, as discussed in Chapter 2.

A third time constraint in new construction financing is what Lovins calls the “checker” mentality of project reviewers, which discourages innovative energy-efficiency designs. Under time pressure with rewards for minimizing mistakes, reviewers will be inclined to prefer familiar designs. This attitude can also be understood in terms of transaction costs: The expense to the reviewer of acquiring information and studying plans sufficiently to understand (and approve) unfamiliar designs appears to be significantly higher than that of understanding (and approving) familiar designs. It is likely that the magnitude of these transaction costs differentials could be reduced over time as more and more project reviewers are informed about more recent and energy-efficient design strategies. However, it could also be argued that, because of the ongoing development of new technologies, a transaction cost differential will always exist between familiar and cutting-edge designs.

We are unaware of formal studies on the impact that project financing for new construction has on the choice of energy-efficient technologies. Whether the additional time involved in incorporating comparatively less familiar energy efficiency designs might hold up the project financing process (as opposed to other aspects of the building design process) has not been examined in isolation. Even if this delay were documented, energy-efficiency policies by themselves are unlikely to reduce interest rate fluctuations or the timing of funding commitments. Instead, policies would more likely focus on accelerating the internal review period for energy-efficient designs. This topic, then, is more appropriately taken up in investigations of the design process described next.

4.2.3 Agency Problems and Lack of Information in the Design of Buildings

The building design process is said by Lovins to contain many examples of the misplaced incentives barrier discussed in Chapter 2. Analyzing misplaced incentives requires separating them into two types: those that spring from the differing objectives of developers, as discussed in the Section 4.2.2, and those that derive exclusively from the institutional relationships and sequence of professional practice in the building design process, which we focus on in this sub-section.

Lack of information is identified as a major barrier throughout the new construction design process. An architect, William McDonough, has been quoted by Lovins as saying that most of the U.S. buildings built in the past few decades are “monuments to the designer’s ignorance of where the sun is” (p. 11).

It is alleged that the lack of adequate information on the part of any single design contributor is aggravated by a design process, which does not provide adequate communication among participants such as project architects, landscape designers, site planners, and building architects. Lovins notes that “The delegation of assignments to specialists weakens the essential linkages between different tasks. Some parts of the system are optimized or sized at the expense of others and of the overall result, but the trade-offs are seldom made explicit” (p. 14). The architect, often delegated the ostensible responsibility for design coordination, is faced with a task that “exceed(s) the ability of any one person or firm” (Segrist 1991).

For example, the difficulty of designing for energy efficiency is compounded in many commercial buildings because critical elements of the building load may not be known when the building is designed. The combination of lack of coordinated design and load uncertainty is said to result in (wildly) excessive equipment-sizing safety margins. Each successive designer, uncertain about load size, adds a safety margin to the equipment sizing. As these margins multiply, the overall margin can become far larger than necessary from the perspective of the overall building demand. This multiplication of safety margins may represent a particularly egregious example of the chain of barriers and amplification of inefficiency problem described in Chapter 3. Another information failure is a lack of understanding about what makes people comfortable, which results in indoor space designs that do not meet human comfort needs efficiently.

The use of rule-of-thumb estimates in response to the lack of information is proposed as one cause of underinvestment in efficiency in new construction. Although a similar contention has been investigated and substantiated in residential energy consumption (Kempton and Montgomery 1982), no systematic evaluation has been done for commercial new construction. In neo-classical economic terms, a failure to acquire and fully and accurately utilize all relevant information is a market failure. This failure also fits well with the notion of bounded rationality in that practitioners do not make robust calculations but instead rely on approximations and is consistent with the insight from transaction costs economics suggesting that the perceived additional cost of acquiring and fully utilizing additional information outweighs the perceived benefit. From a policy perspective, the key question is whether such information can be provided in a cost-beneficial way.

Finally, the design sequence itself is considered a barrier to energy-efficient design. Mechanical designers are generally among the last to do design work on a building; they are generally expected to fit the building mechanics into the structure as previously developed. According to Lovins, this often yields the worst possible layout, with long and circuitous runs of ducts and pipes that maximize friction and fan and pump energy, and with poor or no access for cleaning and maintenance. As mentioned above, this phenomenon may be understood in terms of the increased transaction costs associated with possible design options resulting from the current design sequence.

Lovins goes on to argue that the process by which design services fees are arranged is “*at the root of today’s appallingly low mechanical-system efficiencies*” (emphasis Lovins’) (p. 22). Price competition for jobs largely eliminates innovation and forces engineers to resort to rule-of-thumb selections from major manufacturers’ equipment catalogs. A popular engineering textbook notes that:

When a consultant is selected at a bargain-rate-fee, corner cutting is inevitable unless a loss on the engagement is accepted.... [This] takes the form of using less staff time or assigning less qualified professionals and technicians whose compensation levels are lower. When this occurs, performance suffers. The degree of care and creativity drops. Fewer alternatives or solutions are examined. Plans and specifications are less complete and thorough. Quality suffers because less time is given to checking and reviewing engineering work.... [C]onstruction cost may be excessive because of ... inefficient design. Life-cycle costs may be excessive because of inadequate attention to design factors affecting operating costs.... The result inevitably is second-rate engineering. (Stanley 1982, pp. 44-45, 51)

At the same time, it must be recognized that there is an inevitable scarcity of, and competition for, top engineering and design talent. Assigning such talent on a preferential basis to building design will likely lead to declines in performance on other classes of projects. For policy purposes, we must ask whether there are institutions or arrangements that would allow us to more effectively utilize talent in building design without incurring excessive costs in other areas.

Collectively, building design practice can be seen as a case of misplaced incentives. In addition, one apparent source of suboptimal designs appears to be lack of information regarding better energy efficiency designs. Hence, simply providing better information appears unlikely, by itself, to result automatically in better designs. Instead, the problems seem to be entrenched in the very institutional relationships that make up the design process. These relationships appear to work jointly to preclude or make difficult the introduction of better information into the design process.

4.2.4 Time and Monetary Constraints in the Building Construction Process

With respect to the construction and building commissioning process, time pressures seem to be a key factor affecting investment in energy efficiency. As the interest expense of maintaining an uncompleted and/or unoccupied building mounts, contractors and operating engineers are under great pressure to prepare the building for occupancy. This transaction-cost-based pressure may lead to substitution of readily available, likely cheaper, but less efficient equipment, and to inadequate system commissioning. As

energy-efficient equipment becomes as common in the market as standard equipment, this substitution problem will diminish. However, as discussed earlier, because newer technologies are likely to always be more efficient than their predecessors, there may always be a gap between best available technology and best readily available technology. With many technologies, the significance of this gap is mitigated because of the equipment's short lifetime. In new building construction, however, long lifetimes exacerbate the impacts of this effect. Lack of specific expertise, another form of information failure, on the part of contractors and building operators, also reduces attention to and achievement of energy-efficient construction and operation.

Anecdotal evidence on energy-inefficient substitutions made during the construction process is plentiful (Harris et al. 1990). The opportunities for increased energy efficiency through better building commissioning practices are also widely acknowledged (Dodds et al. 1994). This problem, too, appears to stem from the incentives inherent in the contractual relationships among general contractors, their subcontractors, value engineers, and the building developer. Investigating the language and current practice in enforcing these contracts would be an appropriate start for improving our understanding of how widespread these practices are and clarifying whether additional actions might be appropriate.

4.3 Commercial HVAC and Lighting

The retrofit of commercial HVAC and lighting systems has been a prime target of utility DSM programs (Eto et al. 1996). The program design and evaluation literature is rich with insights and anecdotes about this market. In this section, we review four important concepts: (1) the propensity to act; (2) risk and the economic lifetime of measures; (3) economic windows of opportunity; and (4) landlord/tenant incentives and behavior.

4.3.1 The Propensity to Act

Although somewhat outside the focus of this chapter, in this section we present a brief discussion of some customer segmentation work that has been done primarily for the purpose of marketing DSM programs. We include this work because we believe it relates to another conception of market failure, not fully developed in Chapter 2, but that nonetheless provides insight into the nature of market shortcomings. DeJanvry et al. (1991) have argued that:

Strictly speaking, a market fails when the cost of a transaction through the market exchange creates a 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 fail selectively for particular households (or firms), making the corresponding commodity a nontradeable for that household (or firm). [Parentheticals added.] (p. 1405)

Customer segmentation has also been used to understand potential investors' limited interest in energy-efficiency investments and is consistent with the notion of market failure described above. Limitations result primarily from an investor's ability to raise capital, willingness to invest, and ability to acquire and utilize the necessary information. Temple, Barker, and Sloane/Xenergy (1985) utilize a segmentation scheme that identifies four classes of consumers: 1) Active, 2) Centralized, 3) Disengaged, and 4) Middle. Each of these categories can be evaluated with respect to their investment limitations as mentioned above for both commercial HVAC and lighting end-uses; however, little evaluation has actually been undertaken.

“Active” consumers are differentiated by their awareness of the potential economic value of energy efficiency, the possession of some expertise in energy conservation technologies, and having established procedures for the approval of energy efficiency investments. As such, Active consumers are the among the best candidates to make investments in energy efficiency on their own. The transaction costs of acquiring information may be seen as the key variable in determining which classes of consumers are likely to make such investments. Almost all Active consumers are owner-occupants or long-term lessors, but not all owner-occupants and long-term lessors are active.

Even within specific classes of consumers, however, important differences may exist in interest and ability to invest in energy efficiency. A study of two universities concluded that one was more capable of acquiring decentralized energy-efficient lighting while the other was more capable of acquiring centrally controlled equipment, for reasons relating to organizational structure and institutional culture (Cebon 1990).

“Centralized” firms meet the criteria for active consumers but have a significant degree of centralized control over investments as well, so centralized consumers may be the most likely group to invest in energy efficiency. Not only are the transaction costs of information acquisition smaller than for other groups, but the intra-firm costs of information distribution are less as well. Many large grocery and fast food chains and some hotel and large retail chains fall in the centralized category.

“Disengaged” consumers are businesses that do not focus on energy efficiency for one or more reasons such as 1) the party who controls investment in equipment doesn't pay the energy bill, and 2) no individual within the firm has time to focus on energy issues.

Both of these reasons were discussed in Chapter 2. The former is the classic misplaced incentives barrier, and the latter is an excellent example of bounded rationality in a firm. “Middle” firms, the largest segment of consumers, who often have a moderate degree of interest but limited capabilities to manage or fund conservation projects, do not cross the threshold for inclusion in the more well-defined categories. Therefore, generalization about Middle firms is difficult.

4.3.2 Risk and the Economic Lifetimes of Energy Efficiency Measures

A critical issue in the market barriers debate has been confusion surrounding the use of implicit discount rates. As discussed in Chapter 2, some argue that high rates are a rational response to the uncertainties associated with capital investments in energy efficiency.¹⁹ DSM program evaluation literature has begun to document the nature and extent of these uncertainties. At the same time, there is increasing appreciation of the potential for institutions to price and permit the transfer of these risks.

An important issue for understanding consumer investment decisions is the economic lifetime of savings. Laboratory analyses of technological performance rely on assumptions of maximum lifetimes for devices. It is generally accepted that physical lifetime in the field will differ from performance in the laboratory. Recently, these studies of the physical lifetime of devices have been complemented by a growing awareness of the difference between the economic and physical lifetime of devices. In an analysis of their own DSM programs, the Bonneville Power Administration noted that:

The total energy savings achieved from these programs is a function of both the efficiency of the energy conservation measure (ECM) and of its estimated lifetime. The importance of the latter cannot be overemphasized. Unfortunately, lifetime estimates based on laboratory results or optimum field conditions do not take into account real-life variables such as the installation, operation, and maintenance practices employed at the site in which the ECM is located. Similarly, estimates which consider a less than ideal operating environment, but do not factor in the effects which remodeling, renovation, and business turnover can have on an ECM's life expectancy, may also prove to be inaccurate. (Skumatz et al. 1991) (p. I-1)

With respect to both HVAC and lighting, “... it is clear that business turnover and physical modifications occur very frequently among commercial energy users. These changes could have a significant impact on the effective life of energy conservation measures...” (Skumatz and Hickman 1992, p. 3.282). Findings about occupancy turnover rates have

¹⁹ Chapter 2 also presented some of the responses, which suggest that the extremely high implicit discount rates observed for some energy-efficiency investments are simply not explicable using this rational model.

varied significantly. Velcenbach and Parker (1993) found a range of turnover rates from 17% for supermarkets to 3% for large office buildings and retail stores, and with an average of 5% for all business types. Skumatz et al. (1991) found, in contrast, turnover rates of 25% or more for small offices, small retail, and fast food sites; they also found that malls, hospitals, grocery stores, and schools are businesses that tend not to turn over.

In a subsequent study, Skumatz and Hickman (1992) found that 40% of buildings retrofitted with energy conservation measures remodeled, renovated, or turned over within two years of installing the measure. The study found that renovations and remodels in commercial buildings virtually always affect lighting systems. Together, these findings suggest that technical potential studies of lighting will overstate the benefits of the commercial application of efficient technologies if the lifetimes of benefit streams are not carefully aligned with actual field lifetimes — renovation/remodel lifetimes as well as device lifetimes.

While the basic insight that business turnover or remodeling can truncate the physical lifetime of conservation measures, generalizations about specific rates must account for region-specific effects. Renovation and remodeling are strongly influenced by overall economic conditions; during the time of the Skumatz studies, the Pacific Northwest economy was particularly robust. In contrast, Galawish et al. (1995) found recently that business turnover is lower among participants in its DSM programs than among the general population.

Investments in energy-efficient equipment differ from textbook investments in at least two key ways. First, while investments in financial instruments, such as stocks, bonds or CDs, are typically highly liquid and can be easily bought and sold, investments in efficient equipment are generally highly illiquid and generally cannot be resold. This lack of resale potential contributes to the riskiness of efficiency investments and may have a significant effect on decision makers. Recent efforts by Fannie Mae to develop a secondary market for energy efficiency loans are an explicit effort to address this illiquidity (IRT 1995).

Second, even when a secondary market for equipment exists, the costs associated with removal of existing and installation of new equipment may prohibit such transactions. These costs are dependent in part on the physical “depth” of installation; they represent transaction costs with potentially significant implications for the investment decision. For example, HVAC equipment, particularly air ducts, is typically installed in the core of a building and in the plenums of individual floors and suites. Replacement of these ducts is extremely costly because of their relative inaccessibility and the resulting disruption of business. On the other hand, lighting equipment is generally installed in ceilings or interior walls, which is cheaper and less disruptive.

4.3.3 Economic Windows of Opportunity

The insights developed by studies of the economic lifetime of conservation measures have also been used to develop the concept of economically favorable “windows of opportunity” for equipment purchase decisions. The basic idea is that the economic viability of investments in efficient equipment varies with the type and timing of the associated construction activity, from construction of new buildings to no construction activity. In other words, the transaction costs are low at certain times in the life of a building or construction project and rise significantly outside those specific times. The term “events-based marketing” refers to attempts to influence investment decisions that are highly sensitive to the timing of a series of events (Skumatz, et al. 1991). The size of economic windows varies depending on the specific equipment in question and on the timing of the possible purchase and installation.

One way to apply this insight is to classify various types of building construction activity according to windows of opportunity. Construction activities in existing buildings can generally be classified according to the following list: (1) expansion or renovation, which are essentially forms of new construction; (2) remodeling, which consists of major alterations to an existing space;²⁰ (3) retrofit, which here refers to equipment replacement specifically for the purpose of energy efficiency; (4) planned equipment replacement; and (5) emergency equipment replacement.

The key facet of the timing issue is the relationship between transaction costs and calculation of investment returns. During new construction, renovation, or remodeling, for example, when basic equipment is being installed for the first time or is already being removed as part of the construction process, the incremental cost of installing new efficient equipment is simply the difference between the initial costs (purchase, transportation, and installation) of standard and of efficient equipment. During a retrofit, on the other hand, or when the basic equipment is not otherwise being removed, the incremental cost is the full cost of removal and installation. Thus, the economics of the investment decision clearly depend on the timing of the investment.

Commercial HVAC and lighting differ in their economic windows. Based on the work of Skumatz and others, Pacific Energy Associates (PEA), one of the prime proponents of the construction activity-based method of identifying windows of opportunity, distinguishes among varieties of HVAC and lighting equipment in evaluating these windows (Gordon 1992). PEA suggests that efficient HVAC is most feasible during new construction, expansion, and renovation. Certain pieces of HVAC equipment, such as package/zone systems can be replaced with efficient equipment at the time of remodeling and equipment retirements. Controls for any system can be added during any of the five activities. The economic window for lighting is wide in that transaction costs for lighting replacement are low. Virtually all types of efficient lighting equipment are economically feasible during construction, expansion, and renovation, remodeling, or equipment

²⁰ Some practitioners distinguish between hard and soft remodeling. Hard remodeling is defined as alterations associated with changes in tenant needs. Soft remodeling is defined as appearance upgrades and may or may not include lighting changes.

replacement. Lighting system improvements may be feasible during retrofits but are more often economic during other windows of opportunity.

Transaction cost differentials are also evident between planned and emergency replacements. In an emergency situation, prompt replacement will likely take precedence over energy efficiency considerations. In addition, stocking practices of local equipment suppliers may limit the availability of efficient replacement equipment.

4.3.4 Landlord/Tenant Incentives and Behavior

Both the commercial lighting and HVAC markets are potentially subject to the landlord/tenant incentive mismatches described earlier in Chapter 2. We believe, however, that the complexity and variety of commercial lease agreements, including cost-pass-through and cost-escalation clauses may mitigate this barrier in the commercial sector (although, to an unknown extent), in contrast to the residential sector, where it is thought to be significant.

To the extent that lighting and HVAC equipment is present in commercial rental property, landlord/tenant mismatches are alleged to be obstacles to investment in energy efficiency. This finding is challenged, however, by Sutherland (1990), who used a regression analysis of Energy Information Administration (EIA) data to conclude that the number of conservation features in a building is not statistically related to the type of occupancy (owners versus renters), implying that conservation strategies are not impeded by the renting or leasing of buildings. Though not formally published, some believe that this finding is based on a misinterpretation of the EIA data, whose survey questions they point out do not ask questions in form that would allow one to test the conclusions drawn by Sutherland (Koomey 1996). Sutherland's finding, moreover, is directly at odds with numerous reports by utility program evaluators and consultants in the field who indicate that leased buildings tend not to participate in DSM programs (Applied Energy Group 1994, Xenergy 1993, Quantum Consulting 1994).

4.4 Conclusion

The gray literature is rich with observations on the workings of current energy services markets. Little of this information has been expressed formally using the conceptual framework of market failures or transaction costs. We believe further investigation and clarification of existing findings in relation to these concepts is critical for grounding future public policies for energy efficiency in these markets. We have made a modest attempt to synthesize some of the gray literature in these terms. Much has been learned, but in many areas much speculation remains. In some cases, we have been able to identify areas where these speculation can, in principle, be put to rest by future investigations.

References

- Applied Energy Group 1994. "Impact Evaluation of Niagara Mohawk Power Corporation's 1993 Commercial and Industrial Lighting Rebate Program." Prepared for Niagara Mohawk Power Corporation.
- Arrow, K. 1969. "The Organization of Economic Activity: Issues Pertinent to the Choice of Market Versus Non-Market Allocation." *The Analysis and Evaluation of Public Expenditure: The PPB System, Vol 1*. U.S. Joint Economic Committee, 91st Congress, 1st Session. Washington, D.C.: U.S. Government Printing Office. pp. 59-73.
- Blumstein, C., B. Kreig, L. Schipper, and C. York 1980. "Overcoming Social and Institutional Barriers to Energy Efficiency." *Energy* 5(4):355-72.
- Braithwait, S. and D. Caves 1994. "Three Biases in Cost-Efficiency Tests of Utility Energy Efficiency Programs." *The Energy Journal* 15(1):95-120.
- Cebon, P. 1990. "Organizational Behavior and Energy Conservation Decision Making." *Proceedings for the ACEEE Summer Study on Energy Efficiency in Buildings*. Vol 2:2.17-2.26. Washington, D.C.: American Council for An Energy-Efficient Economy.
- Centolella, P., S. Mitnick, B. Barkovich, K. Yap, and D. Boonin 1993. *Cost Allocation for Electric Utility Conservation and Load Management Programs*. ORNL Report No. Sub/95X-SH985C. Washington, DC: National Association of Regulatory Utility Commissioners.
- Cicchetti, C. and W. Hogan 1989. "Including Unbundled Demand-side Options in Electric Utility Bidding Programs." *Public Utilities Fortnightly*, June 8.
- Coase, R. 1991. *The Institutional Structure of Production*. Nobel Prize Lecture. Stockholm. December 9.
- 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.
- Dodds, D., T. Haasl, C. Chappell, and C. Kjellman 1994. "How Much Does Commissioning Cost and How Much Does it Save?" *ACEEE Summer Study on Energy Efficiency in Buildings*. Vol. 5:5.89-5.96. Washington, DC: American Council for An Energy-Efficient Economy.
- Eto, J., E. Vine, L. Shown, R. Sonnenblick, and C. Payne 1996. "The Total Cost and Measured Performance of Utility-Sponsored Energy Efficiency Programs." *The Energy Journal* 17(1):31-51.
- Fickett, A., C. Gellings, and A. Lovins 1991. "Efficient Use of Electricity." *Energy for Planet Earth*, pp. 11-23. W.H. Freeman and Company, New York, NY.
- Fisher, A. and M. Rothkopf 1989. "Market Failure and Energy Policy: A Rationale for Selective Conservation." *Energy Policy*, 17(4):397-406.

REFERENCES

- Galawish, E., R. Flood, L. Owashi, M. Rufo 1995. "PG&E's Non-Residential Program: Are the Measures Still There?" *Proceedings International Energy Program Evaluation Conference* . Chicago, IL.
- Goldstone, S. 1995. "Restructuring: A Stimulus to Improving Utility DSM, How Economists Might Help." Western Economic Association, 70th Annual Conference.
- Gordon, F. 1992. *Bonneville Power Administration's Commercial Sector Conservation Market* . Portland, OR: Pacific Energy Associates, Inc.
- Haddad, B. 1994. "Why Compact Fluorescent Lamps Are Not Ubiquitous: Industrial Organization, Incentives, and Social Convention." *ACEEE Summer Study on Energy Efficiency in Buildings* . Vol. 10:10.77-10.84. Washington, DC: American Council for an Energy Efficient Economy.
- Harris, J., R. Diamond, O. DeBuen, A. Hatcher, B. Nordman, and M. Piette. 1990. *Energy Edge Impact Evaluation: Findings and Recommendations from the Phase One Evaluation*. Lawrence Berkeley Laboratory Report. Berkeley, C.A.: Lawrence Berkeley Laboratory
- Harris, R. and J. Carmen 1991. "The Political Economy of Regulation: An Analysis of Market Failures." In *Scaling the Corporate Wall* . Sethi, S. Prakash, Paul Steidlmeier, and Cecilia M. Falbe, ed. Englewood Cliffs, NJ: Prentice Hall.
- Hassett, K. and G. Metcalf 1993. "Energy Conservation Investment: Do Consumers Discount the Future Correctly." *Energy Policy*, 21(6):710-716.
- Hein, L. and K. Blok 1994. "Transaction Costs of Energy Efficiency Improvement." *Proceedings*. European Council for an Energy-Efficient Economy.
- Herman, P. 1994. *The Value Test: Its Context, Description, Calculation, and Implications* . Sacramento, CA: California Energy Commission.
- Herman, P. and E. Hicks. 1994. "From Theory into Practice: One Utility's Experience with Applying the Value Test." *ACEEE Summer Study on Energy Efficiency in Buildings* . Vol. 8:8.71-8.88. Washington, DC: American Council for an Energy Efficient Economy.
- Hirst, E., and J. Eto. 1995. *The Justification for Electric-Utility Energy-Efficiency Programs*. Oak Ridge National Laboratory. Oak Ridge National Laboratory Report No. ORNL/CON-419 and Lawrence Berkeley Laboratory Report No. LBL-37593. Oak Ridge, TN: Oak Ridge National Laboratory.
- Hirst, E., and S. Hadley. 1994. *Price Impacts of Electric-Utility DSM Programs*. Oak Ridge National Laboratory Report No. ORNL/CON-402. Oak Ridge, TN: Oak Ridge National Laboratory.
- Hobbs, B. 1991. "The 'Most Value' Test: Economic Evaluation of Electricity Demand Management Considering Customer Value." *The Energy Journal* 12(2):67-91.
- Holdren, J. 1992. "Prologue: The Transition to Costlier Energy." in *Energy Efficiency and Human Activity* . Schipper, Lee and Stephen Meyers. Cambridge, UK: Cambridge University Press. pp. 1-51.
- Howarth, R. and B. Andersson 1993. "Market Barriers to Energy Efficiency." *Energy Economics*. 15(4). October
- IRT. 1995. "Energy-Efficient Mortgages." *IRT Newsletter* .

- Jaffe, A. and R. Stavins 1994a. "The Energy Paradox and the Diffusion of Conservation Technology." *Resource and Energy Economics*. 16(2): 91-122.
- Jaffe, A. and R. Stavins 1994b. "The Energy-Efficiency Gap: What Does it Mean?" *Energy Policy*. 22(10): 804-810.
- Johnson, F. and R. Bowie 1994. "Transaction Costs, Energy Efficiency and Institutional Design." *17th Annual International Energy Conference: Conference Proceedings*. Cleveland, OH: International Association for Energy Economics.
- Joskow, P. 1992. "Weighing Environmental Externalities: Let's Do It Right." *The Electricity Journal* 5 (4): 53-67.
- Joskow, P. and D. Marron. 1992. "What Does a Negawatt Really Cost? Evidence from Utility Conservation Programs." *The Energy Journal* 13(4):41-74.
- Kempton, W. and L. Montgomery 1982. "Folk Quantification of Energy." *Energy* 7(10):817-827.
- Kempton, W. and L. Layne 1994 "The Consumer's Energy Analysis Environment." *Energy Policy* 22(10):857-866.
- Koomey, J. 1996. personal communication.
- Koomey, J., C. Atkinson, A. Meier, J. McMahon, S. Boghosian, B. Atkinson, I. Turiel, M. Levine, B. Nordman, and P. Chan 1991. *The Potential for Electricity Efficiency Improvements in the U.S. Residential Sector*. Lawrence Berkeley Laboratory Report No. LBL-30477. Berkeley, C.A.: Lawrence Berkeley Laboratory.
- Koomey, J., and A. Sanstad 1994. "Technical Evidence for Assessing the Performance of Markets Affecting Energy Efficiency." *Energy Policy*. 22(10): 826-832.
- Koomey, J., A. Sanstad, and L. Shown 1995. *Magnetic Fluorescent Ballasts: Market Data, Market Imperfections, and Policy Success*. Lawrence Berkeley Laboratory Report No. LBL-37702. Berkeley, C.A.: Lawrence Berkeley Laboratory.
- Krause, F. and J. Eto 1988. *Least-Cost Utility Planning, The Demand-Side: Conceptual and Methodological Issues*. Washington, D.C.: National Association of Regulatory Utility Commissioners.
- Levine, M. and R. Sonnenblick 1994. "On the Assessment of Utility Demand-Side Management Programs." *Energy Policy* 22(10):848-856.
- Lovins, A. 1992. *Energy-Efficient Buildings: Institutional Barriers and Opportunities*. Boulder, CO:E-Source, Inc
- Lovins, A. 1976. "Energy Strategy: The Road Not Taken?" *Foreign Affairs* 55(1): 65-96.
- McGarity, A. and W. Kempton 1988. "Redesign of Air Conditioner Controls Based on a Field Study of User Behavior. *ACEEE Summer Study on Energy Efficiency in Buildings*. Vol. 11:11.85-11.99. Washington, DC: American Council for an Energy Efficient Economy.
- Meadows, D. et al. 1972. *Limits to Growth*. New York: Universe Books.

REFERENCES

- Meier, A., J. Wright, and A. Rosenfeld 1983. *Supplying Energy Through Greater Efficiency: The Potential for Conservation in California's Residential Sector* . Berkeley: University of California Press.
- Metcalf, G.E. 1994. "Economics and Rational Conservation Policy." *Energy Policy* 22(10):819-825
- Nichols, A. 1994. "Demand-Side Management. Overcoming Market Barriers or Obscuring Real Costs?" *Energy Policy* 22(10):840-847.
- Olson, M. 1971. *The Logic of Collective Action: Public Goods and the Theory of Groups* . Cambridge, MA: Harvard University Press.
- Ottinger, R., D. Wooley, N. Robinson, D. Hodas, S. Babb, S. Buchanan, P. Chernick, E. Caverhill, A. Krupnick, W. Harrington, S. Radin, and U. Fritsche 1990. *Environmental Costs of Electricity* . Pace University Center for Environmental Legal Studies. New York, N.Y.: Oceana Publications.
- Porter, M. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors* . New York, N.Y.: The Free Press.
- Quantum Consulting 1994. "Consumers Power Company's Reduce the Use Program Nonresidential Evaluation Report." Prepared for Consumers Power Company.
- Ruderman, H., M. Levine, and J. McMahon 1987. "The Behavior of the Market for Energy Efficiency in Residential Appliances including Heating and Cooling Equipment." *The Energy Journal* 8(1):101-124.
- Ruff, L. 1988. "Least-Cost Planning and Demand-Side Management: Six Common Fallacies and One Simple Truth." *Public Utilities Fortnightly* , 121: 19-26.
- Sanstad, A. and R. Howarth 1994. "'Normal' Markets, Market Imperfections, and Energy Efficiency." *Energy Policy* 22(10):811-818.
- Sanstad, A., C. Blumstein and S. Stoft 1995. "How High are Option Values in Energy-Efficiency Investments?" *Energy Policy* 23(9):739-744.
- Schipper, L. 1976. "Raising the Productivity of Energy Utilization." In *Annual Review of Energy* , eds. Hollander, Jack M. and Melvin K. Simmons. Vol 1, pp. 455-518.
- Segrist, P. 1991. "New Technology Advances Depend on Bldg. Owners." *Energy Users News* 16(6):13-17.
- Solar Energy Research Institute (SERI) 1981. *A New Prosperity: Building a Sustainable Energy Future* . Andover, MA: Brick House Publishing.
- Simon, H. 1957. *Models of Man* . New York: Wiley and Sons.
- Skumatz, L. and C. Hickman 1992. "Measure Life Study: The Effect of Commercial Building Changes on Energy Using Equipment." *ACEEE Summer Study on Energy Efficiency in Buildings* . Vol. 3:3.281-3.292. Washington, DC: American Council for an Energy Efficient Economy.
- Skumatz, L., K. Lorberau, R. Moe, R. Bordner and R. Chandler 1991. *Bonneville Measure Life Study: Effect of Commercial Building Changes on Energy Using Equipment* . Synergic Resources Corporation.
- Stanley, C. 1982. *The Consulting Engineer* . Wiley. NY.

- Stern, P. 1986. "Blind Spots in Policy Analysis: What Economics Doesn't Say About Energy Use." *Journal of Policy Analysis and Management* 5:200-227.
- Stern, P. and E. Aronson 1984. *Energy Use: The Human Dimension* . New York: W.H. Freeman.
- Stoft, S. 1995. *The Economics of Conserved-Energy "Supply" Curves* . Berkeley, CA: University of California Energy Institute.
- Sutherland, R. 1991. "Market Barriers to Energy-Efficiency Investments." *The Energy Journal* 12(3):15-34.
- Sutherland, R. 1990. "An Analysis of Conservation Features in Commercial Buildings." *Energy Systems and Policy* 13:153-166.
- Sweeney, J. 1993. "Comments on 'Energy Efficiency and Human Activity: Lessons from the Past, Importance for the Future.'" Unpublished draft.
- Temple, Barker, and Sloane/Xenergy 1985. *Market Research on Program Preferences among Commercial Customers* .
- Train, K. 1985. "Discount Rates in Consumers' Energy-Related Decisions: A Review of the Literature." *Energy* 10(12):1243-1253.
- Tversky, A. and D. Kahneman. 1986. "Rational Choice and the Framing of Decisions." *Journal of Business* 59(4-2):S251-S278.
- Tversky, A. and D. Kahneman. 1981. "The Framing of Decisions and the Psychology of Choice." *Science* 211:452-458.
- Velcenbach, P. and L. Parker. 1993. "Can DSM Survive Persistence?" *Proceedings International Energy Program Evaluation Conference* . Chicago, IL. pp. 506-517.
- Violette, D., M. Rosenberg, and C. Stone. 1995. "Setting a Research Agenda for Assessing Market Transformation and Spillover." *Proceedings International Energy Program Evaluation Conference* . Chicago, IL.
- Williamson, O. 1985. *The Economic Institutions of Capitalism* . New York: Free Press.
- Williamson, O. 1989. "Transaction Cost Economics." in *Handbook of Industrial Organization, Vol. 1* . Schmalensee and Willig, eds. New York: Elsevier Science Publishers B.V.
- Wolcott, D. and C. Goldman 1992. "Moving Beyond Demand-Side Bidding: A More Constructive Role for Energy Service Companies." *ACEEE Summer Study on Energy Efficiency in Buildings* . Vol. 8:8.177-8.196. Washington, DC: American Council for an Energy Efficient Economy.
- Xenergy 1993. "CIA Retrofit Rebate Program Billing Analysis Final Report." Prepared for Pacific Gas and Electric Co.