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A Sourcebook for Residential Window Market Transformation

Joe Eto and Dariush Arasteh
Environmental Energy Technologies Division
Ernest Orlando Lawrence Berkeley National Laboratory
University of California
1 Cyclotron Road
Berkeley, California 94720

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Abstract

During the late seventies and early eighties, important technical innovations were made to improve the energy efficiency of windows (or, more broadly, fenestration products).[1] Adoption of these advances by the marketplace has been shaped by a variety of factors and circumstances. In view of the increased energy efficiency benefits associated with these innovations, there is national interest in both public and private efforts to accelerate market adoption of these innovations.

The objective of this paper is to assemble information from a variety of sources into a single document that will support and inform the developmentw, implementation, and evaluation of efforts to transform markets for residential windows. Preliminary assessments of selected current efforts are reviewed in order to illustrate how the perspectives and insights identified in this paper can be applied to guide and improve these and other efforts.

Section 1. Introduction and Overview of the Organization of this Report

During the late seventies and early eighties, important technical innovations were made to improve the energy efficiency of windows (or, more broadly, fenestration products). Adoption of these advances by the marketplace has been shaped by a variety of factors and circumstances. In view of the increased energy efficiency benefits associated with these innovations, there is national interest in both public and private efforts to accelerate market adoption of these innovations.

One can refer to this process broadly as one of either the diffusion of innovation or, as we shall discuss, energy-efficiency market transformation. Within this on-going and dynamic process, deliberate, publicly funded efforts to accelerate this process require special considerations because, at bottom, these efforts involve spending other people's money. Hence, while the features of residential window markets discussed in this paper can inform both private and public efforts to accelerate market adoption of energy-efficient windows, this paper emphasizes first the additional considerations appropriate for publicly funded efforts.

The objective of this paper is to assemble information from a variety of sources into a single document that will support and inform the development, implementation, and evaluation of efforts to transform markets for residential windows. Preliminary assessments of selected current efforts are reviewed in order to illustrate how the perspectives and insights identified in this paper can be applied to guide and improve these and other efforts.

We begin, in Section 2, by reviewing recent work that examines the cost-effectiveness of and market potential for more energy-efficient residential windows. This discussion serves to: a) introduce the specific energy-efficient technologies discussed in this paper, b) provide the evidence necessary to justify publicly-funded activities to accelerate the market adoption of these technologies;[2] and c) identify the size of the potential markets for these technologies.

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[1] Innovations that reduce heating costs include: 1) specialized coatings or glass manufacturing processes to reduce heat lost through the glass ("low-e"); 2) inert gas fillings to reduce heat lost through two or more panes of glass; 3) "warm-edge" technologies to reduce heat lost at the interface between the frame and glass; and 4) reliance on better materials and designs to lower the heat lost through the frame of the window; . The primary innovation to reduce cooling costs is specialized coatings on and glass formulations that reduce the admittance of solar energy through the glass ("low solar gain" or "spectrally selective low-e"). [Arasteh 1995]

[2] For the purposes of this paper, a positive finding of cost-effectiveness is a threshold condition for public funding for these activities.

In Section 3, we provide a brief introduction to the concepts involved in what has come to be known as energy-efficiency market transformation. This discussion is intended both to: a) introduce key terms of art, and b) use these terms to describe the formal linkage between the rationale for public funding for energy efficiency programs-in this case, aimed at accelerating the market adoption of energy-efficient residential windows-and the features of the markets for these products, which must be understood in order to increase the likelihood of the success of these efforts.

A key insight from application of energy-efficiency market transformation thinking to the challenges involved in accelerating the adoption of more efficient window technologies is the need to identify and explicitly take into consideration the many factors that influence the decision to purchase and sell energy-efficient windows. We assert that these factors differ for each market event and, within these events, for each market segment. A market event is defined as the circumstance or objective to which the purchase is directed (e.g., renovation/remodeling versus new construction). A market segment is defined as the distribution pathway taken within a market event (e.g., reliance on a window contractor or installation by the homeowner in the case of renovation/remodeling; production versus custom builders in the case new construction). In other words, there is no single market for residential windows; there are many sub-markets. Each sub-market, in turn, is characterized by the roles and incentives of various market participants that collectively explains why certain windows are bought and why others are not. Consciously targeting market participants in ways that address the reasons they behave the way they do (in terms of what windows are purchased) in each sub-market is critical to the success of programs intended to stimulate the sales of more efficient windows.

The next three sections identify and describe key aspects of the primary market events and market segments for energy-efficient residential windows. The first two sections describe the two primary market events that are the initiators for decisions to purchase windows: renovation/remodeling (Section 4) and new construction (Section 5). Section 6 discusses a variety of cross-cutting issues for both events that currently affect the upstream portion of the market (i.e., window manufacturing and window distributors).

The final section integrates the information from the previous sections through illustrations of how this information can be applied through a review of a recent effort to accelerate the market adoption of energy-efficient residential windows. This section illustrates a systematic approach for evaluation and continuous improvement to these efforts. The approach begins by identifying the hypotheses or assumption they make on how they expect to influence the market adoption of (and, in so doing, transform the markets toward) more efficient products. These hypotheses, in turn, should be understood as identifying the information gathering (which may already be in progress) needed to confirm or, when appropriate, improve the chances of success for these and other efforts.

Section 2. The Cost-Effectiveness of and Market Potential for Energy-Efficient Residential Windows

The threshold condition or justification for publicly funded efforts to accelerate the market adoption of energy-efficient residential windows is that the windows are cost effective are cost effective to the consumer. That is, public funding is not warranted for activities that make window purchasers less well off than they would otherwise be. Instead, limited current adoption of what would appear to be in consumer's self-interest is understood to be the result of market barriers that can be reduced by publicly (or privately) funded programs designed to overcome them. Consequently, a first step in developing programs to stimulate the purchase of more efficient windows is an assessment of the cost-effectiveness of energy-efficient residential windows.[3] Examining cost effectiveness, in turn, allows us to briefly introduce energy efficient window technologies and report on current estimates of their ultimate market potential. Discussion of the market barriers that must be overcome follows in Section 3.

Our evaluation of cost effectiveness focuses on the perspective of the ultimate purchaser: the residential homeowner. However, as we will discuss in Sections 4 and 5, cost-effectiveness (perhaps, better thought of as profitability) considered from the perspective of each market participant in the chain of events from sale of raw materials, fabrication, distribution, marketing, and installation is central to understanding why more efficient windows are or are not currently being sold and what might done in the future to increase their sale. Nevertheless, it is important to start with cost effectiveness to the ultimate purchaser because profitability to upstream market participants is, to at least a first approximation, derivative of the ultimate decision to purchase.

Cost effectiveness is determined by, on the one hand, the incremental cost of an energy efficient window and, on the other hand, the incremental value provided (for our discussion, in the form of reduced energy costs[4]). Due to the competitive nature of the window industry, exact costs are notoriously difficult to pin down precisely; at best, we can summarize the limited information currently available. Hence, we start by reviewing past work that estimated the value of more energy-efficient windows and then used this information to determine a break-even cost for energy-efficient windows. Break-even cost refers the cost at which an energy-efficient window becomes cost effective, given an estimate of its value. If extra cost of a more efficient window is less than the break-even cost, then purchase of the window is deemed cost effective.

The value of energy-efficient windows is just the present value of the energy saved by the window. It depends on: 1) the difference in energy use associated with adoption of the energy-efficient window compared to energy use that would result from adoption of a baseline or reference case window, which otherwise would have been purchased; 2) the market price of the energy saved by the more energy-efficient window. Both factors vary depending what region of the U.S. is being considered.

Frost et. al. 1996 calculated the break-even costs for energy-efficient windows separately for ten regions of the U.S. A reference case window was developed for each region based on information regional sales trends.[5] Next, an energy-efficient window was selected for each region by considering whether energy costs were driven primarily by heating or cooling energy use. In heating climates, the energy efficient

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[3] There are other legitimate rationales for publicly funded efforts to influence product markets. We focus on cost-effectiveness and economic efficiency because this focus has been central to public policy discussions regarding energy efficiency.

[4] There are many other factors that affect the cost-effectiveness of energy efficient windows, such as reduced fading of upholstery and carpeting, and sound attenuation. However, these benefits are difficult to quantify and so are rarely included in analysis of cost effectiveness.

[5] These trends are discussed in more detail in sections four and five of this report.

window incorporated low-e glass, low thermal conductivity frames, and warm-edge seals. In cooling climates, the energy efficient window incorporated spectrally selective low-e glass or coatings.

The energy savings from the energy-efficient window were calculated assuming several different heating and cooling systems, and regional energy costs were then used to determine the value of each window with respect to the reference case for each system.

Table 2-1 reproduces the findings from this study. The table illustrates clearly the significant variations that exist in break-even costs. The variations depend both on the region and within regions the type of heating and cooling system used.

Some perspective on these results can be gained by reviewing the limited information available on the incremental price or price premium for energy efficient window products. Table 2-2 summarizes price premiums for efficient windows developed through a survey of northern California window manufacturers. While the applicability of these findings to other regions of the country cannot be known with certainty, a comparison of these prices to the break-even costs in other regions suggests that energy-efficient window are cost effective in many regions of the country.

Given this preliminary finding of cost effectiveness, what is the market potential for these technologies? As noted in the determination of break-even costs, the reference or baseline window being sold in these regions appears to be less energy-efficient than windows that appear to be cost effective. Greater insight is provided by Table 2-3, which summarizes findings from a recent survey of the market share of the energy-efficient technologies described above for each of the ten regions [Ducker 1997]. The table documents the low regional market shares of these technologies.

This finding of low market penetration, coupled with the previous finding that more energy-efficient windows would appear to be cost effective, suggests that there is substantial potential and ample justification for programs to accelerate the market adoption of energy-efficient window technologies. Effective programs to accelerate the market adoption of these technologies will reduce energy use and save consumers money. The current functioning of the market is passing up these opportunities, which are in fact cost-effective to the consumer.

Table 2-1. Present Value of Energy Cost Savings or "Break-Even Costs" For Energy-Efficient Windows ($/square foot)

Glazing Type	New England	Mid Atlantic	East North Central	West North Central	South Atlantic	Florida
	Super Window	Super Window	Super Window	Super Window	Double SC Low-e	Double SC Low-e
Frame Type	**Wood/Vinyl**	**Wood/Vinyl**	**Wood/Vinyl**	**Wood/Vinyl**	**Wood/Vinyl**	**Wood/Vinyl**
U-Value/SHGC	**0.24 / 0.4**	**0.24 / 0.4**	**0.24 / 0.4**	**0.24 / 0.4**	**0.32 / 0.35**	**0.32 / 0.35**
HVAC System/Fuel Type						
Electric Resistance	6.6	7.9	2.1	2.8	7.9	19.3
Gas Furnace	3.6	3.9	1.2	1.6	4.0	6.0
Oil Furnace	5.0	5.5	1.6	2.4	8.7	21.7
Other Heating	5.5	6.1	1.8	2.6	9.7	24.0
Central Air Conditioning	0.7	0.8	0.0	0.0	1.2	3.2
Electric Resistance+ Central Air Conditioning	7.2	8.7	2.5	3.3	9.1	22.5
Gas Furnace+ Central Air Conditioning	4.3	4.7	1.6	2.1	5.2	9.2
Oil Furnace+ Central Air Conditioning	5.6	6.3	2.0	2.9	9.9	24.9
Other Heating+ Central Air Conditioning	6.1	6.8	2.2	3.1	10.9	27.1
Heat Pump	5.1	6.2	1.8	2.4	6.8	16.9

Source: Frost et al 1996

Table 2-2. Incremental Retail Cost of Energy Efficient Window Products in Northern California[1]

(Source: Opinion Dynamics Corp. 1998)

	Manufacturers		Contractors[2]	
	Number of Responses	Average Cost Increase $	Number of Responses	Average Cost Increase $
New Construction				
DP to DP w/Argon & Low-E	4	1.99		
DP to DP w/Argon & Low-E^2	9	2.04		
DP to DP w/Low-E	4	1.36		
DP to DP w/Low-E^2	2	1.85		
DP to DP w/Argon	8	0.51		
Single to DP	1	1.87		
Replacement/Remodeling				
DP to DP w/Argon & Low-E	4	1.99	12	5.09
DP to DP w/Argon & Low-E^2	8	2.25	9	4.57
DP to DP w/Low-E	2	1.65	14	4.19
DP to DP w/Low- E^2	2	1.97	11	3.71
DP to DP w/Argon	6	0.59	13	1.05
Single to DP	1	3.09		

1. DP refers to Dual Pane, w/ refers to with, "Low- E^2" is used synonymously with the term "Spectrally-Selective Coatings." Manufacturers provided the recommended retail incremental cost.
2. "Contractors" refers to window installation and remodeling contractors.

Table 2-3. Low-E Usage by Technology Segmented by Region (thousands of units)

(Source: Ducker Research Company 1997)

Type	Sputter	Selective Sputter	Pyrolytic	Total Low-E Units
NE	707	150	729	**1,536**
MA	1,150	200	1,131	**2,481**
SA	334	600	471	**1,405**
FL	56	225	220	**501**
ESC	213	300	263	**776**
ENC	1,892	1,025	2,094	**5,011**
WSC	241	300	317	**858**
WNC	669	500	858	**2,027**
MT-N	122	50	79	**251**
MT-S	25	150	118	**293**
NW	439	200	408	**1,047**
CA	333	400	571	**1,304**
TOTAL	**6,132**	**4,100**	**7,259**	**17,491**

Section 3. Energy Efficiency Market Transformation Thinking

Starting in the early nineties, there has been growing recognition of the opportunities for publicly funded interventions to jump-start or otherwise accelerate the market adoption process for new energy-efficient technologies. For some, this process has come to be known as energy efficiency market transformation; for others, it is simply an application of concepts long recognized as the diffusion of innovation [Rogers 1995]. We adopt the principles and vocabulary associated with market transformation because they were formulated with explicit consideration of the economic rationale for public funding for interventions to accelerate the market adoption process described in the previous section.

There are four key concepts in the vocabulary of energy-efficiency market transformation [Eto, Prahl, Schlegel 1996]:

- ***Market Barrier***. Any characteristic of the market for an energy-related product, service, or practice that helps to explain the gap between the actual level of investment in or practice of energy efficiency and an increased level that would appear to be cost beneficial. (See inset for a list of commonly recognized market barriers.)
- ***Market Intervention***. A deliberate effort by government or utilities to reduce market barriers and thereby change the level of investment in (or practice of) energy efficiency.
- ***Market Effect***. A change in the structure of a market or the behavior of participants in a market that is reflective of an increase in the adoption of energy-efficient products, services, or practices and is causally related to market intervention(s).
- ***Market Transformation***. A reduction in market barriers resulting from a market intervention, as evidenced by a set of market effects, that lasts after the intervention has been withdrawn, reduced, or changed.

The application of these concepts to energy efficient windows is as follows. As illustrated in the previous section, adoption of energy-efficient windows would appear to be cost effective for consumers in many regions of the country; moreover, the market potential for these technologies appear to be significant. In view of these opportunities, we postulate the existence of market barriers (or market conditions) that explain why these opportunities are not being picked up as a result of the normal operation of the market. If our understanding of these barriers and their functioning is correct, overcoming them should increase market adoption. Thus, overcoming these barriers should be the target for interventions that seek to increase market adoption of these products.

Summary of Market Barriers

- ***High Information or search costs.*** The costs of identifying energy-efficient products or services or of learning about energy-efficient practices. These can include the value of time spent finding out about or locating an energy-efficient product or service or hiring someone else to do it on the consumer's behalf.
- ***Performance uncertainties.*** The difficulties consumers face in evaluating claims about future benefits, which are made for many energy-efficiency investments and activities. Upstream market participants also face these costs in forecasting the market response to decisions they make to manufacturer, promote, stock, or offer energy-efficient products.
- ***Hassle or transaction costs.*** The indirect costs of acquiring energy efficiency including the time, materials, and labor involved in obtaining or contracting for an energy-efficient product or service.
- ***Access to financing.*** The difficulties associated with the lending industry's historic inability to account for the unique features of loans for energy savings projects (i.e., that future reductions in utility bills increase the borrower's ability repay a loan) as distinct from the other factors affecting the evaluation of a borrower's credit-worthiness.
- ***Bounded rationality, organizational practices, or custom.*** Rules of thumb that serve to limit the focus or scope of considerations for a given decision. It can also include organizational behavior or systems of practice that discourage or inhibit cost-effective energy-efficiency decisions
- ***Misplaced or split incentives.*** Institutional relationships which mean that the incentives of an agent charged with purchasing energy efficiency are not aligned with those of the persons who would benefit from the purchase. The classic example arises in rental property where the landlord has no incentive to install energy saving retrofits in buildings where she does not pay the utility bills. In this case, the tenant, having no financial interest in the building structure or fixtures, is not in a position to authorize retrofits that would benefit her directly in the form of reduced utility bills. Also arises in new construction.
- ***Product or service unavailability.*** Unavailability and high prices may be the result of collusive or anticompetitive practices to hold some products (or producers) off the market in favor of others that offer higher profit or other advantages (e.g., market share). Distributors may face high search and acquisition costs in order to accurately anticipate demand or they may react in a boundedly rational way to expectations for future demand caused, for example, by the newness of a product. As a result, they may limit shelf space for or not stock energy-efficient products.
- ***Externalities.*** Costs that are associated with transactions, but which are not reflected in the price paid in the transaction. For example, environmental costs associated with electricity generation by fossil fuel are not incorporated into prices for electricity or fossil fuel use.
- ***Regulatory mispricing.*** This barrier arises when regulated utility commodity prices are set using ratemaking practices based on average (rather than marginal) costs.

Source: Eto, Prahl, Schlegel 1996; see also Golove and Eto 1996.

In designing programs to overcome market barriers, it is not sufficient simply to overcome any market barrier. Market barriers typically interact and reinforce one another.[6] To be successful, program must overcome the core or key underlying set of market barriers holding up the purchase of more energy-efficient technologies. Otherwise, a program may successfully overcome one market barrier, only to fail in changing a market because another barrier is in fact more important or influential to the purchase decision.

Similarly, to achieve lasting transformation, market barriers must be permanently reduced. Simply circumventing a market barrier may temporarily increase adoption. However, if a market barrier is not lowered or eliminated permanently, then removing the intervention will simply allow the market barrier to reappear and allow the market to revert back to its prior condition.[7]

There are many ways to observe whether interventions have been successful in this regard. An ultimate measure, of course, is changes in sales or market penetration. While central to a final examination of the success or failure of an intervention, information on sales or market penetration is not particularly useful in supporting mid-course adjustments for programs because this information is inherently retrospective (and often difficult to obtain).

There are, however, other, more subtle indicators that can be used to evaluate progress in real-time and initiate mid-course corrections when needed. Table 3-1 lists a number of these indicators, which are referred to as market effects.

The challenge in using market effects is that they cannot be assessed in isolation (unlike sales or market penetration, which are in this sense, the ultimate measure of market effect). Instead, market effects must be combined with a theory or hypothesis of market change in order to determine whether or not market barriers are being overcome. See, for example, Blumstein, Goldstone, and Lutzenhiser 1998.

Market transformation thinking, therefore, requires paying great attention to the actual workings of the markets that programs seek to change. It requires an explicit articulation of the strategies chosen and a description of how the program is expected to modify or change the workings of the market.

While the language of market barriers helps to formalize many of the concepts involved in transforming markets (in ways that can be related directly to the public policy rationales required to justify undertaking these programs), it is often more useful to explain, in lay terms, exactly why the market is not adopting energy-efficient windows that are cost-effective. Moreover, it is essential to explain why proposed program strategies are expected to be successful in moving these markets toward increased adoption of energy efficiency. Linking program strategies to current market conditions makes concrete the interplay among the market barriers that must be addressed if a program is to be successful (recall the discussion above regarding interrelated market barriers and the difference between reducing and simply circumventing market barriers).

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[6] In the literature, "chains" of market barriers have been used to describe these linkages [Blumstein et al 1980; Golove and Eto 1996].

[7] In point of fact, interventions will tend to affect several market barriers, whether reversion to the pre-intervention state occurs depends on which market barriers have been permanently lowered with respect to the core or central market barriers originally influencing the market.

Table 3-1. List of Market Effects Potentially Attributable toUtility Energy-Efficiency Programs

Customers
Change in purchasing energy-efficiency behavior due to change in: • awareness • attitudes • knowledge • decision-making processes
Other Businesses includes retail providers (such as equipment vendors, material suppliers, and builders/contractors), wholesale distributors, nonfinancial intermediaries (such as design professionals and auditors), and financial intermediaries (such as banks and other lending institutions)
Changes in promotional practices (all)
Changes in business strategies (all)
Changes in prices offered to customers (all)
Creation of new players (all)
Changes in stocking and distribution practices (retail providers and wholesale distributors)
Changes in design practices (design professionals)
Changes in service offerings (all)
Changes in the nature and type of employee compensation (all)
Changes in contract provisions (all)
Development of new skills (all)
Changes in underwriting practices (financial intermediaries)
Development of new financial instruments (financial intermediaries)
Development of secondary financial markets for energy efficiency (financial intermediaries)
Manufacturers
Changes in product quality
Changes in product attributes
Development of new products
Changes in promotion
Changes in business strategies
Changes in prices offered to retailers
Changes in shipping and distribution practices
Changes in retooling rates
Changes in bundling of features
Changes in production schedule and quantity (*amounts* produced)
Changes in warranties
Building of new plant
Acceleration of response to oncoming standards
Government
Changes in codes, standards, or regulations
Changes in enforcement of codes, standards, and regulations

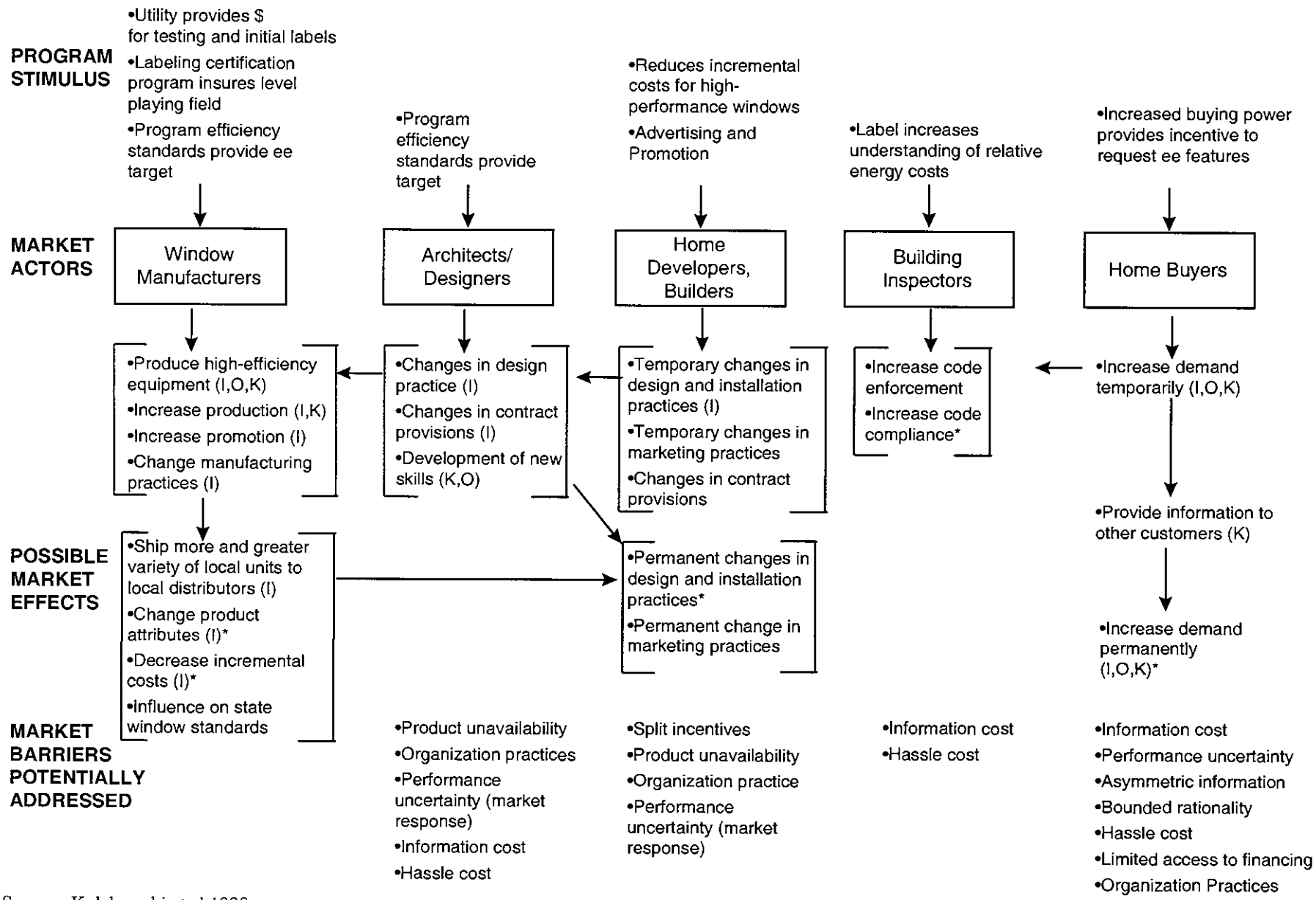
Source: Eto, Prahl, and Schlegel 1996

Market influence diagrams are an especially useful tool for facilitating this process. Market influence diagrams are a graphical tool for illustrating the relationships between market participants, market barriers, program strategies, and market effects. Figures 3-1 and 3-2 reproduce market influence diagrams developed by Pacific Gas and Electric to examine the market transformation impacts of their programs targeted to two distinct market events: remodeling and renovation, and new construction.

Each figure identifies the key market participants involved in decisions to purchase windows in each event. The top of the figure identifies the strategies employed by each program intended to increase the adoption of more energy-efficient windows. These strategies are linked directly to the specific market participants targeted by them. Next, the expected market effects for each market participant are identified. Most important of all, a causal sequence linking the market effects is portrayed. These linkages constitute the "story" or "theory" of how the program expects to influence the market.

The theory in turn identifies the key indicators that need to be tracked in order to monitor the success of the program (or the need for mid-course correction). The key practical importance of articulating this theory is that it provides a systematic basis for program evaluation and refinement. Without a consistent theory (whether or not it is formalized with a market influence diagram – the diagram is simply a heuristic), the likelihood of success is pretty much a hit or miss affair.

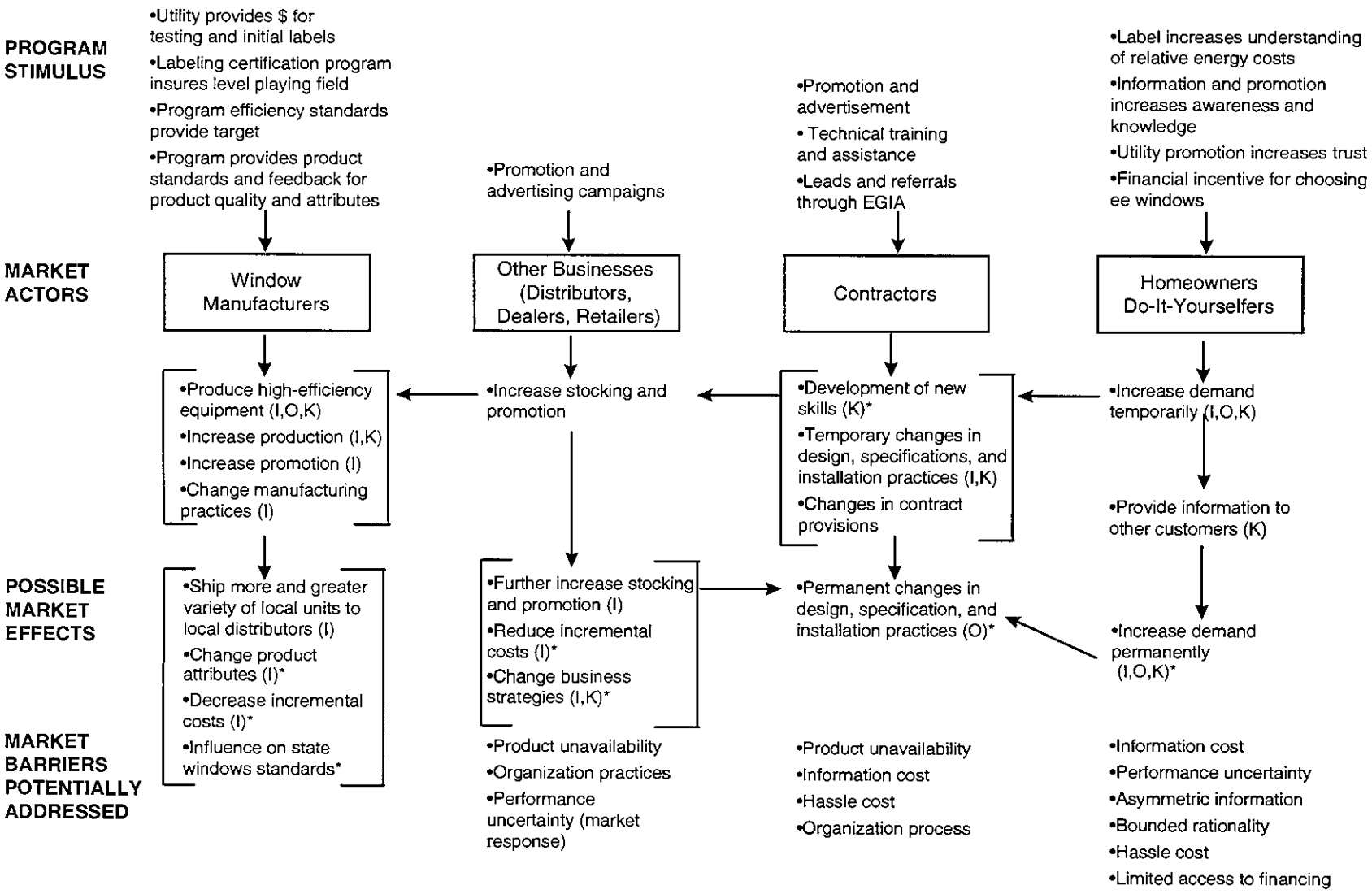
This is not to say that the initial theory will always be the correct one. Indeed, it is far more likely that the initial theory will be in need of refinement. Having a theory, however, provides a systematic basis for testing and improving the theory.



Source: Kulakowski et al 1998

Notes: * =Possible Lasting Mkt. Effects, I=Incentives, K=Knowledge, O=Options

Figure 3.1. Market Influence Diagram for PG&E New Construction Window Program.



Source: Kulakowski et al 1998
Notes: * =Possible Lasting Mkt. Effects, I=Incentives, K=Knowledge, O=Options

Figure 3.2. Market Influence Diagram for PG&E Window Replacement Program.

Section 4. Residential Replacement Markets for Windows

Replacement refers to the remodeling activities that typically involve replacing existing windows with new ones. However, it can also involve adding new windows as part of an addition to or renovation of an existing residence. According to the most recent industry survey, slightly more than 50% of new window sales were made to the replacement window market [Ducker 1997]. In this section, we describe: a) the types of remodeling and renovation market events that take place in which new windows are purchased, b) the factors affecting the homeowner's decisions to initiate these events; and c) the decision-making environments that influence which windows are selected and installed. Findings from recent market research are provided to illustrate aspects of these discussions.

Within the remodeling and renovation market, two distinct market events can be identified: a) retrofit and b) replacement at time-of-sale. Retrofit spans both remodeling and renovation. It is generally characterized by a conscious decision by the homeowner to upgrade the residence primarily to satisfy his/her needs associated with continuing to live in the residence. Replacement at time-of-sale refers to upgrades intended primarily to improve the salability of the residence to a new owner, which in turn affects the value the homeowner may place on the various amenities offered by available window choices. For example, a retrofit decision may be motivated by a desire to increase comfort, durability of the windows, and possibly energy costs. A replacement at time-of-sale decision may be motivated primarily by "curb" appeal with little or no regard for comfort, durability, or energy costs. Hence, the incentives faced by a selling homeowner are likely to differ somewhat from the incentives faced by the purchasing homeowner (which, in this sense, are similar to the incentives faced by the builder, discussed in the next section, who will not pay the energy bills for the home for which the windows are being purchased). Both events are characterized by the discretionary nature of the decision to purchase new windows. However, replacement at time-of-sale tends to take place within a more compressed time scale. This may, in turn, reduce the product options available, constrain the ability of the homeowner to seek information to assist in the decision-making process.

For both market events, the homeowner is the primary decision-maker (although as noted the decision-maker may be either the selling or purchasing homeowner for time-of-sale replacement). For both market events, the homeowner's decision will depend, in part, on whether the homeowner pays the energy bills of the residence. That is, the incentives of a landlord that does not pay the energy bills of the tenant can differ substantially from the incentives of a homeowner that does pay the bills (and again is similar to that faced by the builder).

For both market events, there are broad range of factors that influence the decision to replace existing windows. It is useful to discuss these factors separately first from the demand (homeowner's perspective) and second from the supply (window sellers/installers) side of the equation.

The buyer's or homeowner's decision in each of these market events is influenced by: a) the incentives or factors motivating the homeowner to select one versus another window product; b) the information available (as well as by the credence placed on the veracity of the information or its applicability to the decision at hand); and c) customer awareness or knowledge of energy efficiency.

Table 4-1 reports results from a recent survey that examined homeowner's responses when asked to identify the single most important reason for replacing or installing new windows. Energy considerations rank high among these reasons, which suggests that the incentives motivating homeowners bodes well for purchase of energy efficient windows. This finding is consistent with another study in which window contractors report that over half of their customers ask about energy efficiency without prompting [Wirtshafter 2000].

Table 4-1. Single Most Important Reason for Replacing or Installing New Windows

(Source: Opinion Dynamics Corp. 1998)

Reason	Number of Respondents (n = 150)	Percent of Respondents
Reduce energy costs	35	.23
Old windows were leaky/drafty	35	.23
Old windows were broken/didn't operate properly	20	.14
Improve home appearance	19	.13
Old windows were rotten	14	.09
Decided to remodel home	12	.08
Old windows let too much heat/sunlight in	5	.04
Old windows got condensation/water on them	2	.01
Old windows let in too much outside noise	2	.01
Don't know/not sure	2	.01
Other	4	.03

Table 4-2 reports findings on the sources of information relied on by homeowners on what type of window to install. Word of mouth, not surprisingly, ranks highest on this list. Next in importance, however, are those selling and installing windows, which highlights the importance of examining the supply side of the window sales equation, which will be discussed later in this section.

Table 4-2. Source of Information on Type of Window to Install*

(Source: Opinion Dynamics Corp. 1998)

Source	Percent of Respondents (n = 150)
Friend/Relative/Neighbor	.28
Window Contractor	.14
General/Remodeling Contractor	.14
Manufacturer Literature/Advertising	.07
Retail Home Improvement Center	.06
Retair Window Store	.05
PG&E Literature/Advertising	.03
Architect/Designer	.03

*Only those sources mentioned by 3% or more of the respondents are listed. Respondents were permitted to provide more than one source.

Table 4-3 reports findings on the importance placed by homeowners on various window characteristics. These findings clarify that heating energy considerations are an important driving force in the window selection process. However, the implication for higher energy efficiency windows for cooling is that packaging efficiency as an inherent attribute of these other selection considerations will be superior to packaging cooling efficiency as a separate commodity.

Table 4-3. Importance of Window Characteristic

(Source: Opinion Dynamics Corp. 1998)

Characteristic	Mean Score* (n = 150)
Ability to Reduce Cost of Heating	4.2
Look or Appearance	4.1
Ability to Increase Comfort/Reduce Drafts	4.0
Store or Contractor's Reputation	3.9
Ability to Eliminate Condensation on Surface	3.7
Price	3.7
Ability to Let in Light	3.6
Ability to Reduce Cost of Air Conditioning	3.5
Ability to Reduce Noise	3.3
Ability to Reduce Furniture and Carpet Fading	2.9
Manufacturer	2.8

*1 = "not at all important" and 5 = "very important"

Table 4-4 reports on homeowner's awareness of the properties of windows that make them energy efficient. These results indicate that beyond the visually obvious feature of double panes, there is low understanding of the other techniques available to improve window energy efficiency. This suggests that there is a role either for strategies that increase awareness of these techniques or for other strategies that "signal" the presence of these features (e.g., Energy Star, see Ward et al 2000).

Table 4-4. What Makes a Window Energy Efficient*

(Source: Opinion Dynamics Corp. 1998)

Feature	Percent of Respondents (n = 150)
Double Pane	.75
Special Seal/Perfect Seal	.06
Argon Gas	.06
Quality of Installation	.05
Low-E	.05
Quality of Window	.04

*Responses given by 4% or more respondents are listed. Respondents were permitted to provide more than one choice

As noted previously, it is especially important to understand the influence of the supply side of the sales equation on a homeowner's final choice of window (including its energy efficiency qualities). There are at least four pathways by which windows for remodeling and replacement are purchased and installed: a) builders/general contractors; b) glass shops/window contractors; c) home center, mass merchandiser/window stores; and homeowner, friend, family member. Figure 4-1 reproduces a visual summary of these pathways, the interrelationships among them, and sales volumes estimated for each pathway from a recent study of the Northern California residential remodeling and renovation window market.

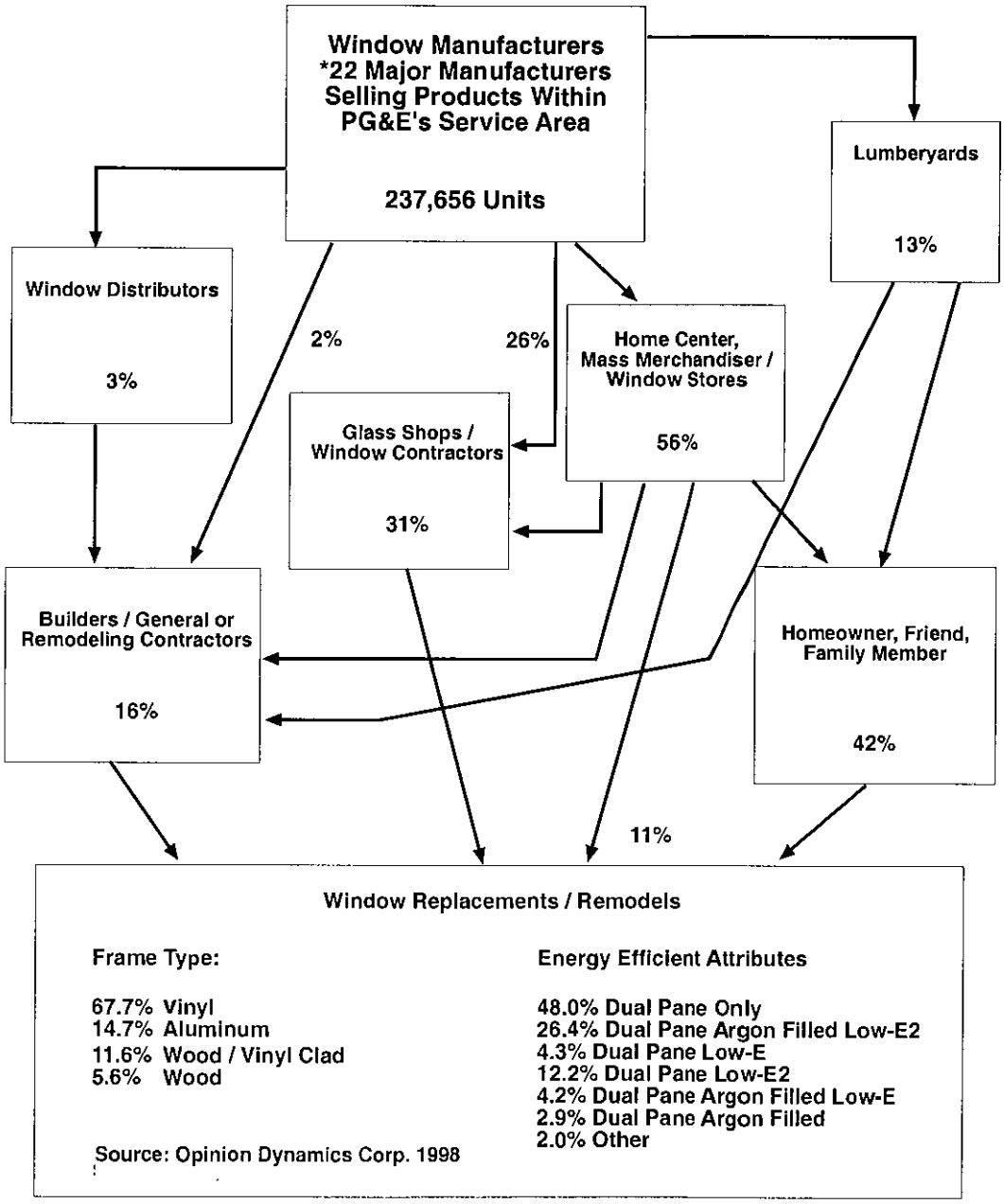


Figure 4-1. 1997 Northern California window replacement and remodeling market window distribution and installation process.

Each market setting involves different market participants, each of which has unique characteristics and incentives that influence how they interact with and affect the homeowner's decisions. Understanding these differences and how they influence the purchase of energy efficient windows is the starting point for evaluating the likely success of programs designed to stimulate these purchases. From the standpoint of evaluating the commercial transactions associated with window purchases, it is especially useful to focus on how commercial market participants profits are affected by transactions involving energy-efficient windows. Other things being equal, commercial market participant's interests in selling more efficient windows depends on their perception of the relative profitability of selling efficient windows compared to selling less efficient windows (or other products).

A homeowner typically works with a builder or general contractor when the window purchase and installation decision is part of a larger remodeling project or home addition. Many aspects of the decision-making process closely resemble those associated with the construction of a custom-built new home–hence, we reserve discussion of this pathway for the next section.

A homeowner tends to work directly with a glass shop/window contractor, and home center, mass merchandiser/window stores in projects that involve only the replacement of existing windows (rather than as part of a larger, more comprehensive remodeling project). As a result, more of the homeowner's attention and interest (compared to a general remodeling project or addition) is often devoted to the window selection process. In working with these market participants, the homeowner usually contracts for both the purchase and installation of the new windows. Pricing strategies (and hence profit) of the seller/installer reflect a combination of the window product purchase price and the fees charged for installation.

The choices available to the homeowner in the can vary greatly depending on the pathway chosen. Some seller/installers may offer only certain brands of windows. Stocking practices will dictate the variety of windows available and the cost premium associated with special orders for non-standard products (such as higher efficiency windows).

As will be discussed in Section 6, price competition at the lower end of market for replacement windows is fierce. This market is characterized by many smaller players seeking to differentiate themselves primarily on window brand, features, and price. Marketing and advertising plays a larger role in influencing homeowner's decisions in this market. There is in fact great variability in pricing and installation practices. Advertising is important because homeowner's at this end of the market many times do not have access to (or interest in pursuing) a broad scope of information on products and their attributes. A more subtle reason is that windows purchased in this market are a combination of two products, the window, itself, and its installation.

It is particularly difficult to "brand" or differentiate the second of these "products:" the quality of installation. And, in fact, quality of installation has been an on-going concern for many consumers. In the recent rise of construction liability claims, poor window installation is frequently targeted. The ease of entry and exit into the industry has no doubt contributed to negative image consumers sometimes have of the industry. Part of this is the folklore of fly-by-night window replacement, akin to that of the "tin men" selling aluminum siding door-to-door in the 1950's.

However, while window and general contractors are looked to for advice, the opinions of persons more familiar to the buyer rank higher due, in part, to the greater trust placed in these opinions. This is in part a reflection of the lower credibility consumers place in the opinions of those who ought to have comparatively greater knowledge and information about windows and window performance. Another study echoes this observation in finding that 48% of customers mention past services as the reason for firm selection (Wirtshafter 2000).

In the final market setting, the homeowner, friend, or family member purchases the window from a mass merchandiser/window store and then installs or oversees the installation of the windows. Profit to the mass merchandiser/window store derives solely from the sale (and possibly delivery) of the window product. Profit from sales of window products in turn is affected by price competition among competing sellers, inventory costs, and the cost of the product. The cost of the product to the mass merchandiser/window store is affected by product selection and purchase volume. Again, a window that must be specially ordered costs more than a window that is routinely stocked.

As part of profit motivation of window sellers and installers, their ability to market energy efficient windows effectively is a function of their perceptions of what customers want. Table 4-5 reports retailer's perceptions of the relative importance of factors considered by customers when purchasing new windows.

Table 4.5. Retailer's Perceptions of Customer Considerations in Window Purchases-Average Rankings (1 = highest; 4 = lowest)

Price	1.8
Quality	2.2
Appearance	3.3
Energy Efficiency	3.4

Source: Macro International 1999

This brief review of the residential markets for energy-efficient windows in remodeling and renovation has sought to identify the various submarkets through which decisions to purchase and install windows are made and to describe some of the considerations taken into account by consumers and the various market participants in each market in making these decisions.

Section 5. Residential New Construction Markets for Windows

According to the most recent industry survey, slightly less than 50% of new window sales were made to the new construction window market [Ducker 1997]. In this section, we describe: a) the different types of new construction; and b) the factors affecting the builder's decision to install energy efficient windows. Findings from recent market research are provided to illustrate aspects of these discussions.

Residential new construction markets can be divided into submarkets first by considering building type and second by considering builder type. Single-family, multi-family, and manufactured (i.e., mobile) homes are the three primary types of residential new construction. Single-family homes are by far the dominant form of residential new construction and are the sole focus of the discussion in this section. According to the U.S. Census, single-family new construction starts have ranged between 70% and 90% of annual residential new construction starts in the U.S. in the 1990s.

New home builders build both speculative and custom (or "to-order") single-family homes. Speculative homes are built prior to identification of a buyer. Custom homes are built following a sales contract between the builder and the buyer.

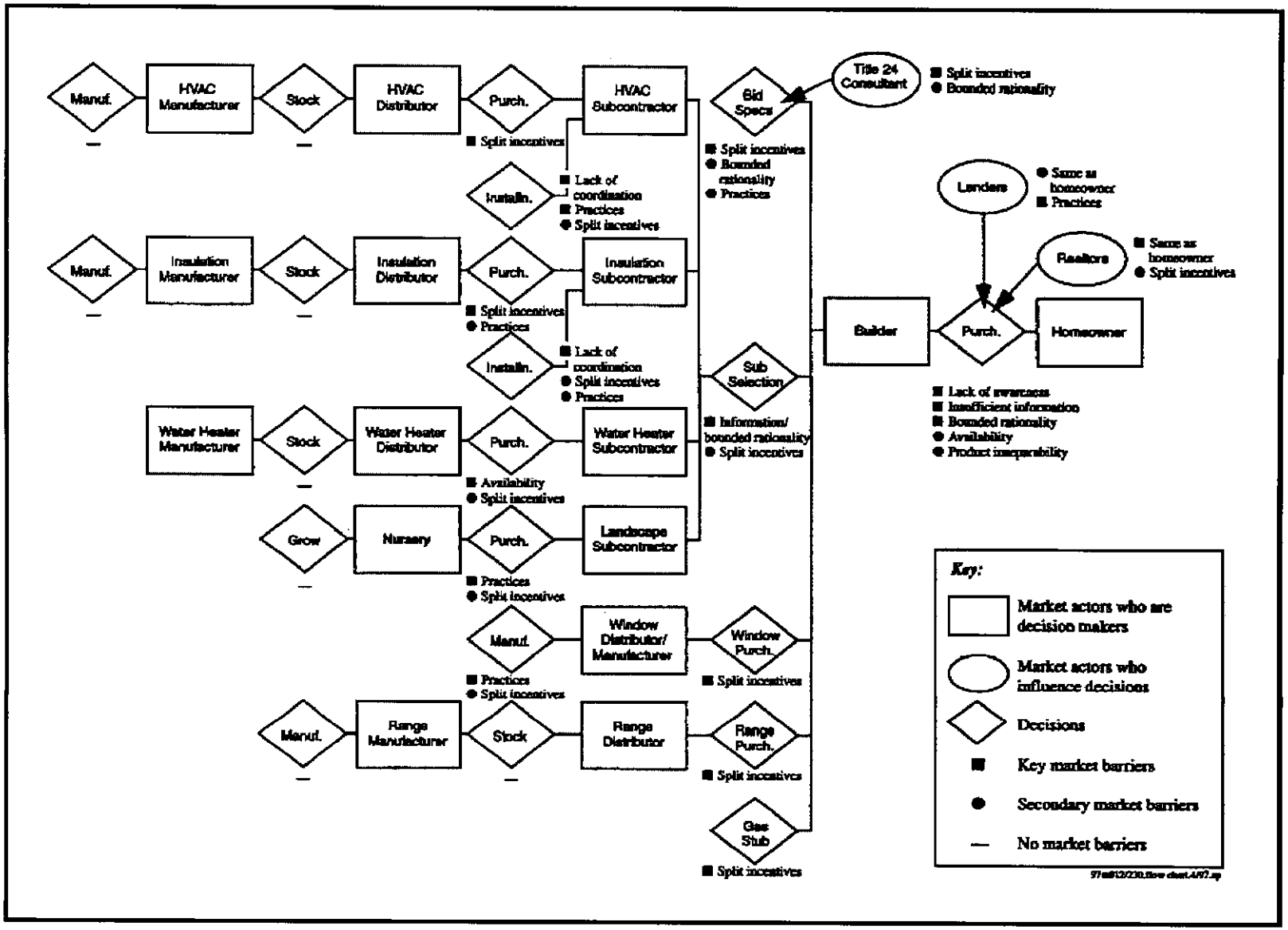
The degree of customization available is an important determinant of the new home buyer's opportunities to influence the selection of windows for the home. For a speculatively built home, the buyer's decision is between one home versus another and is unlikely to be one that is determined by the choice of windows alone. The buyer must trade off the entire package of features for a speculatively built home against the alternatives.

At the same time, the degree of "customization" available varies widely. It ranges from a limited set of upgrade options (which may or may not include energy-efficient windows) within a small set of plans that are largely fixed (more common for large volume builders) to complete freedom-in-plan selection, site orientation, and specification of all finishing details (more common for small volume builders).

In summary, the direct demand for windows in new construction is largely determined, or at least moderated, through decisions made by the builder. Accordingly, we first consider influences on builder's decisions to install energy-efficient windows and second influences on customer's decisions to purchase or specify new homes that feature energy-efficient windows.

Construction of new single-family homes is dominated by large volume builders/developers. In 1999, the top 15 builders each had gross revenues in excess of $1 billion; the top 94 builders each had gross revenues in excess of $100 million.

Organizationally, builders are best thought of as construction management firms that coordinate the activities of many separate firms, each of which provides specialized services under subcontract to the builder. [Herman et al 1997b] Figure 5-1 is a stylized representation of this organizational form.



Source: Herman et al 1997a

Figure 5-1. Residential New Construction Market Structure

For windows, Figure 5-1 suppresses several of the important pathways through which windows are installed. Figure 5-2 provides a more detailed representation of these pathways. Essentially there are four pathways: a) builder purchases windows from a manufacturer or distributor and installs them with his/her own crew; b) builder selects windows from a manufacturer or distributor and subcontracts installation to a third party, which may be affiliated with or part of the manufacturer or distributor; and c) builder subcontracts window selection and installation entirely to a third party.

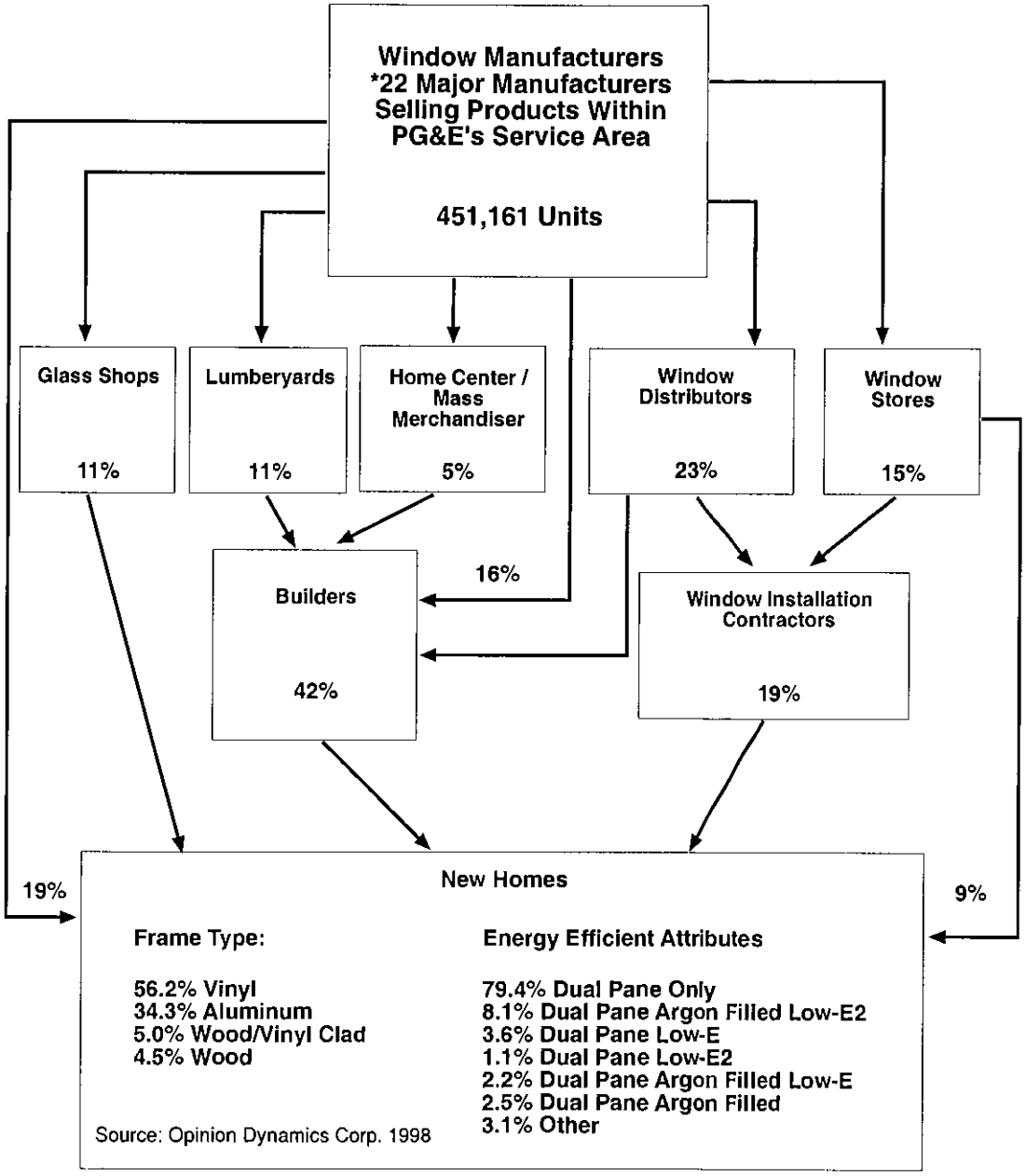


Figure 5-2. 1997 Northern California new construction market window distribution and installation process..

These pathways each influence the window selection process. Leading up to and through this process, the builder is also influenced by other market participants, including architects and, in California, title-24 consultants.[8] A recent survey asked builders to assess both decision-making for window selection and factors influencing builders decisions on window selection. See Figures 5-1 and 5-2. These findings confirm the dominant role played by the builder in the window selection decision for new construction. It is clear from these findings that strategies that effectively target builders will have significantly leverage in markets for new homes, compared to those that target new home buyers.

So what do builders want and how can these desires be met, at least in part, by more energy efficient windows? Arguably, profit, to a first approximation, is the appropriate bottom line from which to evaluate this question. Leaving aside for the moment builder's perceptions of the extent to which energy-efficient windows increase the salability of new homes—roughly, will buyers pay more for new homes with energy-efficient windows or equivalently will higher priced homes take longer to sell (to be taken up next), the other side of the profit equation is cost.

One dimension of cost is the cost of materials; since energy-efficient windows cost more than standard windows, this factor weighs against them. Another dimension is availability and coordination with the construction process; if energy-efficient windows take longer to produce or deliver (perhaps because they are not routinely stocked), then adjustments to construction schedules represent a cost. Yet another dimension of cost is ease of installation and product reliability; if energy-efficient windows are more difficult to install or more prone to failure than standard windows, the risk of call-backs is a significant cost premium that would dissuade builders from specifying them.

Of course, builders must respond ultimately to customer's demands and preferences for new homes. The tables cited above confirm the direct role played by homeowners in the choice of windows for new construction. These figures, however, do not reveal the extent of the indirect role played by windows in buyer's preferences.

Table 5-1 indicates that new home buyers generally do not know whether or not their new home has energy efficient windows (or what features make windows energy efficient). A partial explanation is provided by another finding from this study: Less 30% of these new home buyers *whose homes were not completed at the time of purchase* were even offered a choice of windows.

Table 5-1. New Home Buyer Awareness of Energy-Efficient Window Glass Features*

(Source: Opinion Dynamics Corp. 1998)

Feature	Percent of Respondents (n = 401)
Gas Fill	.20
Low-E Coating	.20
Tinted Glass	.13
Other	.06
Don't Know/Not Sure	.52

*Some respondents mentioned more than one feature.

[8] Title-24 consultants advise California builders on the cost effectiveness of various options for meeting California's building energy code. The specialized expertise provided by these consultants typically included computer simulations of the energy performance of the home.

This study also reports that 90% of new home buyers claim that their windows are energy efficient. Yet, as illustrated in Table 5-2, these claims are based primarily on the perception that double pane windows are energy efficient. In fact, new home buyer's awareness of specific energy-efficient window technologies is low. See Table 5-3.

Table 5-2. New Home Buyer Awareness of What Makes a Window Energy Efficient*

(Source: Opinion Dynamics Corp. 1998)

Feature	Percent of Respondents (n = 401)
Double Pane	.74
Vinyl	.11
Low-E	.09
Argon Gas	.07
Don't Know/Not Sure	.05

*Respondents were permitted to provide more than one choice.

Table 5-3. Window Terminology Awareness (New Home Purchasers)

(Source: Opinion Dynamics Corp. 1998)

Terminology	Percent of Respondents (n = 401)
Argon, Krypton, or Gas-Filled	.51
U-Factor	.34
Low-E	.33
Solar Heat Gain Coefficient	.27
Visible Transmittance	.11
Spectrally Selective	.05

Table 5-4 puts these findings in perspective by summarizing the factors that buyers report influence their decision to purchase a new home. Energy costs are not mentioned in this list and so must be judged a lower priority in buyer's decision-making. In other words, lack of consumer awareness and knowledge, while important, may not be the dominant factor influencing customer's ability to specify energy efficient windows. Instead, new home buyer's overall interest in energy cost issues is low. This finding suggests that strategies to increase new home buyer's interest in energy-efficient windows must tie these interests to other higher priority interests they express in selecting new homes. Greater awareness or understanding of window energy efficiency, at least from the standpoint of the technologies involved, may not even be necessary.

Table 5-4. Single Most Important Reason for Purchasing Home Now Lived In*

(Source: Opinion Dynamics Corp. 1998)

Home Feature	Number of Respondents (n = 401)	Percent of Respondents
Location	141	.35
Overall price	54	.14
Floor plan	39	.10
Wanted new home	17	.04
Larger size	13	.03
Establish equity	12	.03
Cost per square foot	11	.03
Outside looks	11	.03
Rented previously	10	.02
Personally designed & built	10	.02
Other/not sure	83	.21

*Reasons provided by ten or more respondents are listed. Respondents were permitted to give only one reason.

To summarize, programs that allow builders to increase profits (through increased margin or volume) will facilitate builder specification of energy efficient windows. New home buyer preferences currently do not place significance on energy cost (or window energy efficiency), hence programs that stress the ability to energy-efficient windows to enhance other features buyers desire will be more successful

This brief review of the residential markets for energy-efficient windows in new construction has sought to identify the various submarkets through which builder's and new home buyer's decisions to purchase and install windows are made, and to describe some of the considerations taken into account by the various market participants in each market in making these decisions.

Section 6. The "Upstream" Window Manufacturing and Distribution Process

Sections 4 and 5 focus largely on homeowner's and builder/remodeler's decisions to select windows and the influences of the market immediately upstream of these decision-makers. In this section, we consider the window manufacturing industry as a whole. We identify several key aspects and recent trends within the industry and identify some of the implications they may have for efforts to improve market adoption of energy efficiency in the future.

Historically, windows have been a custom product.

The earliest windows were fabricated from raw materials (glass and wood) on-site by the carpenters and craftsmen building new homes. Gradually, lumber mills began prefabricating window frames and shipping them to construction sites. Today, windows are fabricated or fully assembled from raw materials in advance at dedicated window manufacturing facilities. The scale of these facilities ranges widely from small glass shops producing hundreds of windows annually for local markets to large national firms producing thousands of windows annually (see Figure 6.1).

However, while some standardization has taken place, windows are usually built to order; this is almost always true in remodeling and renovation. Manufacturing cost savings have been driven by the introduction of ever greater levels of automation and methods to minimize waste. Yet, these advances must always be able to accommodate highly flexible product specifications.

The customized nature of window fabrication has several important implications for the production of energy-efficient window products.

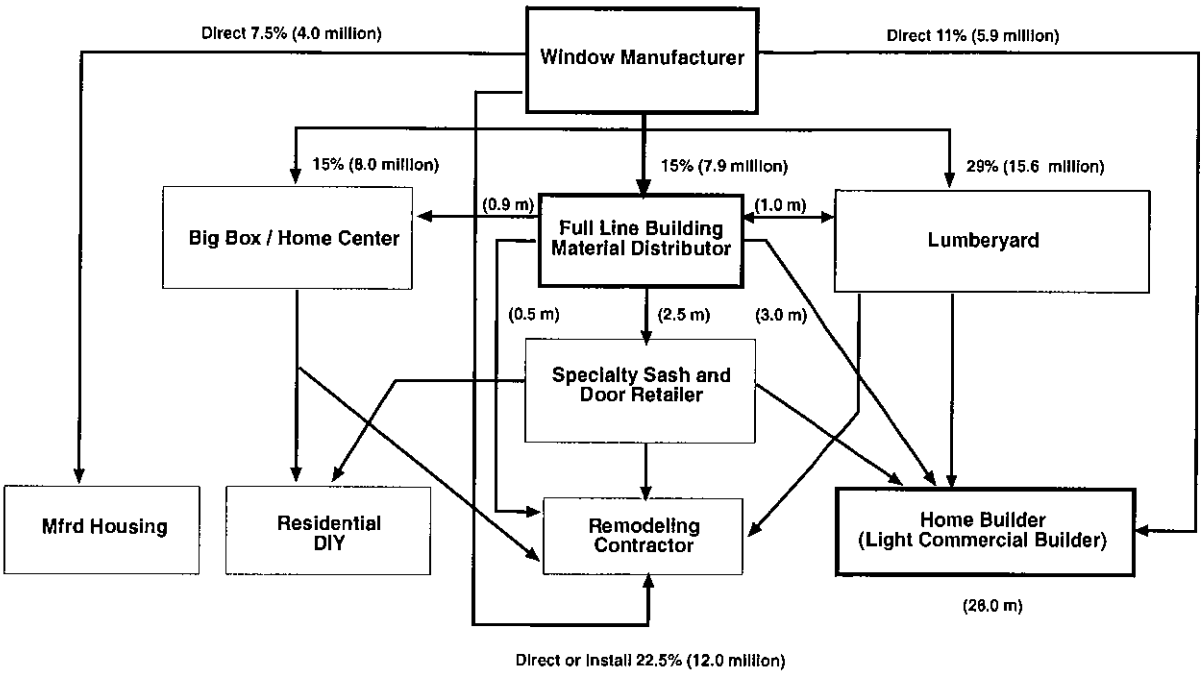
Quality control (particularly in producing sealed or insulated glass), inventory management, and waste minimization are constant challenges for window manufacturers. For example minimizing the variation in window product offerings (to facilitate quality control, reduce inventory stocks, and minimize waste through greater standardization) is in direct conflict with the need to be able to make windows to order.

Until energy-efficient window product features become "standard" practice, there will always be a manufacturing price premium for energy-efficient windows that extends beyond the increased cost of energy-efficient raw materials, such as low-emissivity glass. This manufacturing price premium will, of course, be translated directly into higher consumer prices for finished windows.

An interesting exception to this observation is industry experience with warm-edge technologies. Because the manufacturing costs for application of this technology to the creation of insulating glass is actually lower than the cost of traditional sealing technologies, industry adoption of this technology has been swift and largely independent of the energy-efficiency benefits offered by this technology.

Upstream suppliers of raw materials to window manufacturers are few and influential.

The custom nature of window manufacturing and comparatively high cost of shipping finished windows has resulted in an industry that is made up predominantly of smaller manufacturers serving local or regional markets (we discuss trends toward consolidation below). While there are several national manufacturers, the market share of the five largest firms is estimated to be 20% and the market shares of the 15 largest firms is estimated to be 35% [Ducker 1997]. See Figure 6-2.



Source: Ducker, 1997

Figure 6-1. National window distribution and installation pathways.

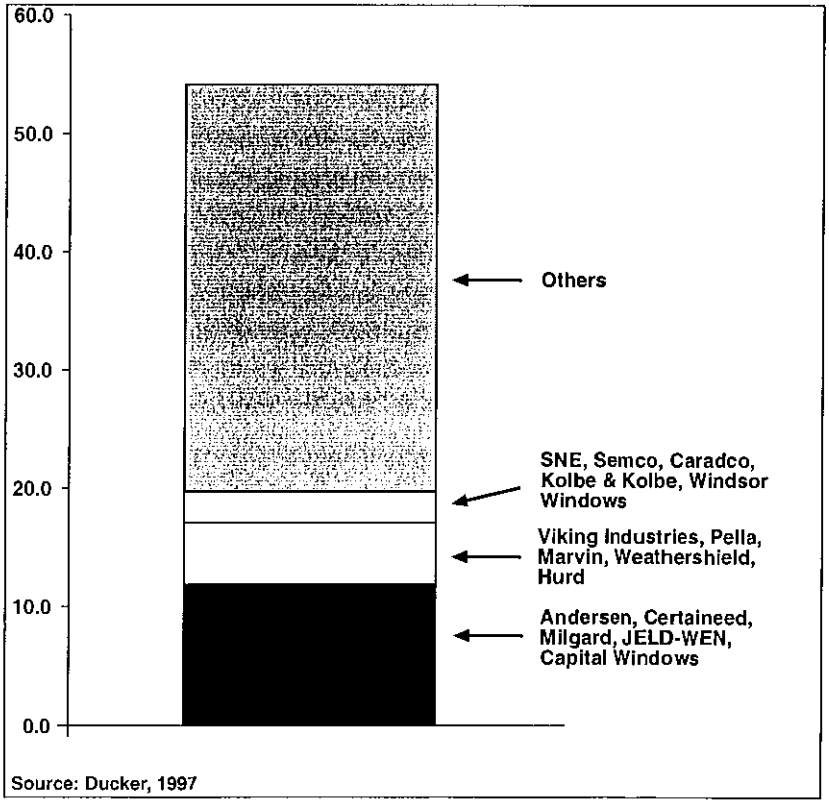


Figure 6-2. Leading window manufacturers segmented by relative production volume.

In comparison, the suppliers of raw materials are far fewer in number. There are only five glass manufacturers active in the U.S. For vinyl windows, there are fifteen major U.S. suppliers. The small number of upstream suppliers has important implications for the diffusion of energy efficient window material selection and manufacturing practices.

Competition among suppliers has led them to offer significant technical and, in some cases, financial support to downstream purchases of their raw materials. For example, raw material suppliers are a primary source of technical information (e.g., on energy efficiency) and marketing support for window manufacturers. Vinyl suppliers, in addition, often have interlocking business relationships with manufacturers in the form of equipment rental and lease agreements tied to purchase of raw vinyl. These suppliers accordingly offer a strategic point of leverage for affecting the product offerings and manufacturing practices of the multitude of individual window manufacturers. However, tapping these suppliers requires assessing the extent to which their business interests are aligned with the adoption of more energy-efficient windows.

Glass manufacturers focus naturally on the type glass selected by window manufacturers. Currently, all manufacturers make some form of low-e glass appropriate for applications in heating climates. However, for cooling applications, only two or three manufacturers produce spectrally selective low-e glass. Accordingly, enlisting the support of glass manufacturers to promote energy-efficient windows for cooling climates involves a delicate balancing act to simultaneously promote energy-efficient windows for heating climates in order to avoid unduly favoring one set of manufacturer's products over those of the others (which do not offer glass products that are as well-suited to saving cooling energy). Basic R&D to assist all manufacturers in producing spectrally-selective low-e glass may be complementary strategy.

Vinyl manufacturer interests are two-fold. On the one hand, vinyl manufacturers are united in seeking to increase market share for vinyl versus wood or aluminum windows. Since its introduction, the market share of vinyl windows has grown steadily, from less than 20% in 1988 to more than 35% in 1996 [Ducker 1997]. By and large, they have been very successful in taking market share primarily from aluminum windows with attendant benefits for energy efficiency. Most expect this trend to continue, due both to lower production costs and resulting consumer demand. The industry has accommodated this shift in framing materials rather smoothly with many of the same manufacturers that historically produced aluminum windows simply switching to produce vinyl windows.

On the other hand, competition among vinyl manufacturers is fierce due to the homogeneity of raw material. To the extent energy-efficiency initiatives do not unintentionally favor certain vinyl suppliers over others, this issue is largely avoided.

Window markets are further segmented by product differentiation strategies.

As noted there are a few large, national window manufacturers. These manufacturers tend to produce more expensive wood windows, which in turn are marketed as premium products. Competition in these markets focuses on quality, reputation, and deliverability.

In these markets, energy-efficiency as a valued-added feature is an important strategy for product differentiation. In fact, the largest U.S. window manufacturer has adopted a corporate strategy to feature energy-efficiency as a key product selling point.

Vinyl window manufacturers (and before them aluminum window manufacturers), in contrast, have traditionally focused on the low end of the market. Competition in this market focuses on price. In these markets, energy-efficiency that comes with a price premium is a much more difficult proposition. The lower manufacturing cost of vinyl windows and warm-edge technologies have been the primary drivers for energy-efficiency in these markets.

In point of fact, the energy-efficiency of windows in these markets (as well as in the high-end market) has also been influenced by the adoption of double-pane windows as the industry standard. The lesson here is that changing standard practice through either or both codes/standards and promotional activities is central to improving the energy-efficiency of windows sold at the lower end of market.

The organization of the window industry is changing due to consolidation.

Currently, rapid consolidation is taking place in the window manufacturing industry. News in industry periodicals is dominated by acquisitions or mergers among firms.

The historic structure for the industry is changing for two reasons. First, the modern window manufacturing industry is comparatively young. Aluminum windows were first produced in quantity in response to the availability of aluminum as a low-cost material and the increased demand for housing following World War II. Vinyl windows were first produced in quantity in the 1980s, often by the same firms that also manufactured aluminum windows. The comparatively low initial capital investment required by the production process for both types of windows facilitated ease of entry into this end of the window manufacturing business. Coupled with the comparatively high cost of transportation, the structure of the window manufacturing business for aluminum and later vinyl windows evolved as one characterized by a large number of small manufacturers serving local markets. Typically, these have been family-owned businesses. Today, the owners of small window manufacturing firms as a whole represent an aging population that is now beginning to retire and their heirs appear to have little interest in continuing the family business.

Second, and perhaps more importantly, price competition among these manufacturers at the low end of the price spectrum is fierce. Consolidation represents one of the few opportunities for realizing manufacturing cost savings given a falling real price for window products. These cost savings result from capturing economies of scale in marketing, distribution, manufacturing, and inventory management.

The implications of consolidation are both positive and negative from the standpoint of energy-efficient windows. On the positive side, greater consolidation typically comes with increased technical sophistication and greater ability to incorporate energy-efficient products into the production process. On the negative side, consolidation is a manifestation of intense pressures within the industry to reduce manufacturing costs, which are increased by the use of energy-efficient raw materials, such as low-e glass or gas-filled insulated products.

Section 7. The California Window Initiative

In this final section, we apply the theoretical concepts involved in market transformation (identified in Section 3) and the reviews of the markets for replacement windows (described in Section 4) to a recent market transformation program. The program is the California Window Initiative (CWI), which is a third-party program initiative supported by California's Public Goods Charge and administered by the Pacific Gas and Electric Company and by the Southern California Edison Company. The perspective taken in this review is to: 1) identify specific hypotheses or reasons to believe that Initiative will succeed in transforming the market; 2) use these hypotheses to identify the kinds of questions that an evaluation to assess the program's performance must address; and 3) propose methods that might be used to gather the information necessary to answer the questions. In selecting this example, no effort has been made to be judgemental; there are many more worthy efforts for transforming markets for energy-efficient windows worth reviewing. Instead, our objective is to illustrate how what we call energy-efficiency market transformation thinking should be used in an "on-line" manner to continuously review and, as appropriate, modify this and other market transformation efforts.

The CWI program targets four distinct groups within California's markets for residential windows: 1) glass manufacturers, component suppliers, window manufacturers and distributors; 2) production builders; 3) Title 24 energy consultants[9]; and 4) home centers, other retail outlets, replacement contractors, and remodelers. Customers are not a direct target of CWI's activities. The goal is to increase these upstream market actors' knowledge and understanding of energy-efficient residential windows. The service provided by the program consists of a large number of tailored presentations (with extensive Q/A) that are being delivered at the business sites and professional meetings of a significant fraction of the California population of these market actors.

CWI's underlying market transformation hypothesis is that increasing the knowledge of these market actors will improve their ability and increase their incentive to sell, specify, and install more energy-efficient windows. Generally, this transformation is to expected to result from the increase in profit realized from the sale of more expensive, energy-efficient windows. For builders, and by implication Title-24 consultants, the transformation is expected to result from increasing these market actor's understanding that low-e, especially spectrally-selective low-e, low-SHGC windows represent a particularly attractive compliance path in the latest revisions to Title-24, which went into effect in 1999.

CWI's hypothesizes the following market effects (which do not necessarily line-up neatly with the groupings of market actors listed above). Following each of the market effects identified by CWI in their proposal, we discuss our categorization of them for our later discussions.

1. For "Product Sources" (manufacturers, distributors, large retail outlets): a) increase product promotion efforts; b) increased manufacture and distribution of energy-efficient products; and c) increased inventory/stocking of energy-efficient products. For purposes of discussion, we categorize all of these as changes in business practices; the third may also be categorized as a market share indicator.

2. For "Upstream Sales Agents" (builders, realtors, and other sales professionals): a) improved attitude exhibited in discussions with buyers and buyer's agents; and b) increased promotion efforts for energy-efficient windows. We categorize the first as both a change in knowledge and incentives. We also categorize both as changes in business practices.

[9] Title-24 refers to California's building energy code, which specifies minimum levels of energy efficiency for new construction. Title-24 consultants assist builders in complying with the code by providing technical support for building energy use calculations, energy-efficiency options, and completion of compliance forms.

3. For "Buyers/Agents" (architects/specifiers, builders/remodelers, and end-use customers): a) increased demand due to understanding of benefits of energy-efficient windows; and b) improved attitude and word of mouth referrals. The first reflects a change in market share. Both reflect changes in business practices or individual behavior.

In evaluating the market effects that might emerge from the CWI's activities, it is useful to bear in mind the challenges facing the CWI hypothesis for market transformation. Our purpose in summarizing these challenges is not to suggest that we have any reasons to believe that they are or will take place, but simply to provide logical counterpoints to market transformation hypothesis presented earlier.

I. Better information may not be understood or retained by those receiving it;

2. better information may be misconstrued by those receiving it, possibly leading to business practices that are further at odds with increasing sales of energy-efficient windows;

3. despite now possessing "better" information, customers will not perceive that the credibility of these actors has been improved;

4. other factors, possibly unrelated to the energy-efficiency of windows or the information being delivered, may lead these market actors to believe or act upon the belief that there are greater profits to be had from promoting less energy-efficient products;

5. builders may not believe it is in their interest to comply with the new revisions to Title-24;

6. builders (and their Title-24 consultants) may find that there are cheaper (or more profitable) alternatives to specifying energy-efficient windows in complying with the new revisions.

What follows is a listing of possible market effects indicators identifying the methods, availability, and issues that must be addressed in collecting and analyzing information to support the existence of various market effects. In the following descriptions, participants refers to those exposed to the information provided by CWI staff.

Indicator: Attendance records w/affiliations
Market Effect: Increase in participant knowledge
Method/Data: Normal auditing procedures; random sample of attendees
Availability: Any time after program has begun
Issues: Exposure to information not necessarily equal to retention and provides no guarantee of application

Indicator: Pre/post-treatment questionnaires or interviews, repeated after 6 months, and/or 1 year, and/or 2 years, etc.
Market Effect: Increase in participant knowledge; changes in business practices; possibly, changes in market penetration
Method/Data: Could be a statistical sample; may want to create/sample from a comparison group
Availability: Depends on frequeucy selected
Issues: Controlling for other influences; tracking participants over time; reliability of participant recall

Indicator: Interviews with customers/home buyers following interactions with program participants
Market Effect: Changes in participant business practices
Method/Data: Use open-ended questions; also interview customers/home buyers following interactions with non-participants as comparison group
Availability: Likely not to be repeated very frequently (maybe once sometime after the program)
Issues: identifying customers/home buyers (treatment and comparison group); reliability of customer recall; controlling for other influences.

Indicator: Self-reports of sales by technology by market event/segment
Market Effect: Changes in market penetration
Method/Data: Survey (pay?) manufacturers, distributors, retailers, builders to disclose sales
Availability: This is a lagging indicator; some frequency (perhaps annual) should be established on an on-going basis
Issues: Need to address confidentiality and secure data; control for other influences on sales (identify comparison service territories; e.g., SDG&E)

Up to this point, discussion of evidentiary standards has been intentionally omitted. To our mind, evidentiary standards cannot be discussed in a vacuum, but should instead be dictated by the value that the information provides. For example, if compensation to CWI hinged on any one of these market effect indicators, the evidentiary standard is likely to be higher than if compensation is not tied to these indicators. In other words, if the value of information is low, then the accuracy and precision associated with gathering the information (which will have a direct implication for the amount that should be spent collecting it) should also be low.

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