Getting The Big Picture Of A Small Place

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ABSTRACT

Most commercial and industrial program evaluations do not have sufficient resources to conduct comprehensive market characterization studies. Generally, the population is so large that it is impossible to allocate sufficient resources to capture information about all market participants. In 2000, the Vermont Department of Public Service, recognizing its resources were limited, but so was their market, requested an evaluation that included a characterization of the Vermont commercial and industrial market as part of the evaluation of the Efficiency Vermont commercial and industrial sector programs.

The project that emerged from this request is quite possibly the most comprehensive market assessment of a commercial industrial market to date. Although focused on a very small place – the State of Vermont – it appears to provide valuable lessons for commercial industrial construction markets throughout the nation.

The project includes characterizations of architects, engineers, contractors, suppliers, and real estate developers and managers, as well as end-users in newly constructed and in existing buildings. On-site studies of a nested sample of end-users provide further data on market conditions. The findings reveal the process by which decisions are made to install energy efficient equipment and use energy efficiency solutions from the differing perspectives all market actors.

Introduction

In 2000, the Vermont Department of Public Service requested a characterization of the Vermont commercial and industrial (C&I) building market as part of the evaluation of the Efficiency Vermont commercial and industrial sector programs. The resulting project includes characterizations of architects, engineers, contractors, suppliers, real estate developers and managers, and end-users in newly constructed and in existing buildings. On-site studies of a nested sample of end-users provide further data on market conditions. The findings reveal the process by which decisions are made to install energy efficient equipment and use energy efficiency solutions from the differing perspectives all market actors.

Efficiency Vermont is the only utility in the nation whose sole purpose is to help users of electricity save energy through efficiency. Efficiency Vermont began operating in March 2000, offering programs—including service to C&I firms (end-users)—initially built on prior utility sponsored efforts. Its programs focus on opportunities for energy efficiency in new construction, major renovations, remodeling, and equipment replacements. Efficiency Vermont offers financial incentives and technical assistance to C&I firms and the building and equipment professionals they work with.

This paper presents our findings from the C&I building market characterization. It begins with a description of our approach and then provides a sketch of Vermont—the "small place" delimiting the market. We present our findings as "close-up pictures" of the C&I market. We conclude with our view of the "big picture" of the operation of the C&I building market in Vermont.

Approach

During 2001 and 2002, we conducted telephone surveys among two broad types of market actors, contacting samples of distinct groups within each broad category. First, we surveyed the end users in the building construction market: about 600 C&I firms drawn from the general population and from firms with permits to construct new facilities or renovate, remodel, or add on to existing facilities. Then we surveyed the professionals and equipment suppliers that comprise the supply-side of the construction market. We surveyed samples of architects, engineers, general contractors, electrical contractors, and mechanical contractors, as well as five groups of equipment suppliers—over 130 professionals in all. More detail on the approach can be found in a paper by Albert, Peters & Lloyd (2002) and in the project report by GDS Associates et al. (2003).

The Small Place

Vermont is a small and rural state. The average number of persons per square mile is 66, less than the national average of 80 (which includes large, sparsely populated Western states and Alaska).

Approximately 20,000 C&I firms are located in Vermont. More than half occupy buildings under 5,000 square feet in size, while fewer than 15% (or less than 3,000 firms) occupy buildings of 25,000 square feet or more. Although Vermont does not differ from the New England region in this regard (size distribution of firms), the density in Vermont is much lower. For comparison, one Northeast utility serves an area about half the size of Vermont that has nearly 4,000 large C&I accounts—a density two and one-half times greater than Vermont.

During 1998-1999, the state issued 839 construction permits to C&I establishments. The firms undertaking construction were somewhat larger, on average, than general C&I firms: 19% were over 25,000 square feet.

Among the general C&I population, about 40% had purchased equipment (windows, heating, and/or lighting) in the two years prior to the survey. Of those that had purchased equipment, about 40% had purchased windows, 54% had purchased heating equipment, and 57% had purchased lighting. (Note that 12% had purchased all three systems and 28% had purchased two.)

The designer and contractor populations are comprised primarily of firms with fewer than five people. Firms with four or fewer employees comprise 80% of the architectural firms, 46% of the engineering firms, and between 65% and 75% of general, electrical, and mechanical contractors. (A study of Vermont's residential construction market similarly found most professional firms to be small [Parlin et al. 2003]).

Some Close-Up Pictures

The Clients Professionals Work With and the Professionals Clients Work With

Most of the designers and contractors work in both the new construction and renovation/ remodeling markets and have both C&I and residential customers. An exception to this pattern was the general contractors; the larger firms tend to work exclusively in the C&I sector. When describing the markets they work in, many respondents said, in essence, that they were fishing in a small pond and took whatever they could reel in.

Architects work on about half of all construction projects. Not surprisingly, larger projects are more likely to involve architects than smaller ones, with the result that architects design about 60% of the floorspace. However, the skew towards big projects is not as great as one might anticipate. While architects worked on two-thirds of the very largest projects, they nonetheless also worked on one-third of the smallest.

Mechanical and electrical engineers each work on about one-third of all construction projects. Engineers are much more likely to be involved in projects in excess of 25,000 square feet; thus, they work on about half of the total constructed floorspace.

Electrical contractors work on nearly every project—85% of all projects and 89% of the total constructed floorspace. (Note that 4% of the construction jobs did not install lighting.) General contractors are involved in almost as many projects—79% of all projects and 81% of floorspace. Mechanical contractors, like architects, have a moderate tendency to work on larger projects; they work on 68% of all projects and 82% of floorspace (13% of projects did not install heating systems).

For half of the projects that did not use an architect, contractors worked directly with the owners in a construction approach termed "design-build." Fifty percent of contractors report at least half of their work is design-build, and all but 25% report they do at least some. Ten percent of architects and 50% of engineers report doing a little design-build work, but none did a lot of it.

Half of the projects involved one, two, or three types of professionals; 20% used four types, 15% used five types, and 13% used six types of professionals. Project size was not a factor in the number of professionals used, except among projects involving six professionals. Half of all projects were less than 5,000 square feet, yet only one-third of the projects using six professionals were that size.

We asked the C&I firms with construction projects and the construction professionals to identify the people that most influence the selection of heating and lighting equipment. On the surface, there appears to be little agreement among the responses of the different groups. However, this can be seen to reflect their differing roles in the market and the variety of organizational structures involved in delivering market services. We present the findings on this point in a subsequent section, interwoven with our interpretation of these data.

Discussion of Energy and Efficiency Between Professionals and Clients

Just over half (55%) of the C&I firms with construction projects discussed energy use with one or more professionals. Sample-wide, firms were most likely to discuss energy use with general contractors (20% did so), but that finding is driven by the fact that most firms use them. When one limits the investigation of each professional to only those firms using the professional, one finds that nearly half of the firms (45%) using electrical engineers discussed energy use with them. One-third of the firms using architects discussed energy use with the architect. About one-quarter of firms using general contractors discussed energy use with that professional, and the same proportion held for mechanical contractors and for mechanical engineers. Only one-fifth of the firms using electrical contractors (and recall that 85% of all projects used one) discussed energy use with them.

We asked C&I firms whether any of the professionals they spoke with had encouraged energy efficiency, and whether any had discouraged it. Very few firms reported being discouraged from pursuing energy efficiency. Firms having conversations about energy with architects were most likely to have been encouraged to pursue energy efficiency (75% of these firms). Two-thirds of the conversations with mechanical engineers included an encouragement for energy efficiency, as did 62% of the conversations with general contractors, 55% of those with lighting contractors, 44% of those with electrical engineers, and 38% of those with mechanical contractors. For the sample as a whole (irrespective of the rates at which professionals were used or energy was discussed), 12% of firms with construction projects received encouragement for energy efficiency from architects and general contractors, 9% received encouragement from lighting contractors, 7% from mechanical contractors, and 6% from mechanical and electrical engineers.

Twenty percent of firms with construction projects reported that they presented their construction professionals with requirements for energy use, such as to make the space more energy-efficient than it was previously or than is typical in similar buildings. About 90% of designers (architects and engineers) reported that their clients express a concern for facility energy costs. However, about two-thirds of designers believe their clients' concern exceeded their clients' willingness to address energy costs, as we show subsequently in Table 2 and its discussion.

Barriers to Energy Efficiency Identified by Construction Professionals

Across all the groups of designers and contractors, a significant barrier is their difficulty in providing clients with *reliable estimates of the benefits of energy efficiency* (or, similarly, *getting accurate, objective information about options*). This barrier ranked within the top two most problematic for three of the five market actor groups (engineers and general and mechanical contractors), as shown in Table 1.

Table 1. Percent of Market Actors Rating Barrier to Efficiency Options as Substantial

Barriers	Designers		Contractors		
	Architects (n=30)	**Engineer (n=16)**	**General (n=31)**	**Mechanical (n=23)**	**Electrical (n=19)**
Getting Authorization for Research Expenses	63%	63%	Not Asked		
Getting Reliable Cost Estimates for Options	57%	19%			
Assessing Performance of Option in the Project	40%	31%			
Getting Reliable Estimates of Benefits	37%	38%			
Identifying Professional Resources	20%	19%			
Getting Clients to Consider Options	17%	13%	6%	26%	13%
Availability of Efficient Products	17%	31%	6%	21%	13%
Getting Other Professionals to Consider Efficient Options	7%	31%	13%	37%	22%
Cost of Options	Not Asked		35%	37%	22%
Getting Accurate Information on Options			32%	21%	26%

Architects and engineers rated the ability to assess the performance of equipment in a specific application and the willingness of the client to authorize research into performance and benefits as very substantial barriers to energy efficiency in construction projects (see Table 1). No more than one-quarter of designers are paid to conduct computer modeling and life-cycle cost analyses in support of energy efficiency on at least half of their projects (Table 2). These concerns are consistent with the finding by some of the authors on barriers for architects in the Pacific Northwest (Peters & McRae 2001).

Table 2. Percent of Architects and Engineers Reporting Client Commitment to Energy Efficiency

Client Commitment to Energy Efficiency	**Architects (n=30) At Least:**		**Engineers (n=16) At Least:**	
	50% of Projects	**Once in Past Year**	**50% of Projects**	**Once in Past Year**
Client expressed concern for energy costs	87%	93%	81%	88%
Professional expressed more concern for facility energy costs than client expressed	63%	70%	63%	75%
Client willing to invest to have facility be more efficient than similar facilities in the state	53%	60%	31%	50%
Client paid for computer modeling of building or lighting system energy use	27%	33%	19%	50%
Computer modeling resulted in a more energy-efficient design being selected	23%	37%	6%	44%
Client paid for formal life-cycle cost analysis of efficiency options	20%	37%	25%	31%

Contractors see the cost of energy efficiency options as a major barrier. Architects see the ability to provide reliable estimates of the costs as a major barrier, although most engineers do not share this concern.

For equipment suppliers, barriers to increasing the market share of energy-efficient products are evident when the equipment features that are most important to customers are not included among the selling points suppliers emphasize for efficient equipment. Suppliers report customers consider availability, perceived quality/comfort, initial price and durability as important. Of these, only comfort and durability are also on the suppliers' lists of selling features for energy efficient equipment. Not surprisingly, suppliers most frequently emphasize the energy savings of efficient equipment, yet the suppliers themselves do not think energy savings are among customers' primary considerations for window and motor purchases. And suppliers view energy savings as equal in importance, in the customer's view, to other factors for lighting and HVAC purchases.

If changes such as the following were to occur, they would suggest that barriers to energy efficiency are being reduced: (1) suppliers begin to tout features other than energy savings for the energy-efficient equipment they sell; (2) architects and engineers are able to gain assistance and increased capability in assessing performance, benefits and costs; and (3) contractors find system benefits easier to estimate and find each other more willing to discuss and consider energy efficiency options.

Role of Client Awareness in Energy Efficiency and Factors Associated with Measure Installation

As one might expect, C&I firms with construction or equipment projects had a higher awareness (by about ten percentage points) of the efficiency measures we explored than firms without construction or equipment projects. In relative terms, for every four firms with construction or equipment projects that were aware of a measure, only three firms without such projects were aware. Among the former group, for every ten firms engaged in construction that were aware of a measure, just under nine firms with equipment purchases were aware. We conclude from these comparisons that experience in the marketplace is related to awareness of efficiency measures.

The most likely relationship is that C&I customers learn about efficiency measures in the process of constructing a building or purchasing equipment. We developed support for this hypothesis by analyzing and, based on the findings, rejecting the opposite relationship: that customers' awareness of measures typically predates their marketplace experience. To explore the opposite relationship, we made the intermediate assumption that customer awareness only pre-dates market experience in firms with staff who keep abreast of equipment options—typically, larger firms. A correlation of the number of measures the firm was aware of and firm size, controlling for whether the firm had purchased equipment, found no correlation between awareness and firm size. Thus, we conclude that it is mainly through the firms' marketplace interactions that they become aware of energy efficiency measures.

Next, we sought to draw inferences about whether one the side of the market (end-users versus professionals) is more likely to drive measure installation rates than the other side. It is certainly safe to say that in some cases the C&I firms drive measure installation and in other cases the professionals are the drivers. But which group exerts a greater influence on measure installation rates? The answer identifies which group should receive more program intervention efforts—end-users or the professionals that serve them?

We found that about three-quarters of all reported discussions between C&I firms and professionals about energy-efficiency measures culminated in measure installation. The rate of discussion of a measure taken as a proportion of those who were aware of it ranges from 82% to 31%, with the lower proportions associated with those measures having the lowest installation rates.

We conducted a multivariate regression analysis to determine the factors leading to the installation of efficiency measures. For firms with construction projects, we found the following: more efficiency measures were installed by larger firms or projects, by firms that had used the services of Efficiency Vermont, by firms using more types of professionals, and by firms that discussed energy use with a mechanical engineer or alternatively, discussed energy use with an architect or general contractor. (The alternative variables yielded equations of almost equal explanatory power.) Recall that the number of types of professionals used is independent of firm size for all but use of six professionals.

These findings do not negate the role of the end-user, but they emphasize the importance of the professional in the installation of efficiency measures. To recap the findings: three-quarters of reported discussions of measures with professionals culminated in measure installation; firms using more types of professionals and firms discussing energy use with particular types of professionals were more likely than other firms to install efficiency measures. These findings are consistent with findings for Vermont's residential new construction market obtained by a different research team (Parlin et al. 2003).

Firms with equipment purchases, but not construction projects, were not asked about the involvement of professionals, under the assumption that they had dealt primarily with suppliers. Although we later questioned this assumption for various reasons, we were consequently unable to include variables relating to professionals used. The regression equation for firms purchasing equipment showed that size of firm and use of Efficiency Vermont services were positively associated with measure installation.

The Big Picture

Social Networks

Social networks are the connections each of us have to others, including our patterns of communication and whom we receive resources from and give resources to. We may have different networks for our different spheres of activity: professional, community, familial, etc. (See Reed & Oh 2003 for an overview of network theory and an application of the theory to the commercial building market.)

In large groups, we need a search strategy or filter to facilitate establishing effective networks. For example, among national and international companies, one often finds that the largest and most profitable firms deliver services to and seek services from other large, profitable firms.

Vermont is small, both in terms of land size and population density. Based on our research, we believe the small size of the construction market in Vermont makes it possible and indeed, highly likely, that most commercial construction professionals in good standing are qualified to work on most commercial construction projects done in the state. For instance, we find limited use of design firms located outside of Vermont. It is the exceptional project that would require more expertise than is available from the typical, competent local professional. Vermont's building and construction designers, contractors, and suppliers seize the opportunities that present themselves: large or small projects; commercial and industrial or residential clients; nearby or farther away; or new construction, renovation or remodeling.

In Vermont's C&I construction market, firms do not need to use a search strategy that stratifies service providers based on size or other predetermined characteristics. Word-of-mouth communication is particularly effective. People tend to work with the people they know or are familiar with, and this familiarity promotes a feeling of trust prior to the establishment of the working relationship.

We do *not* find evidence that larger professional firms are more likely than smaller professional firms to have expertise in energy efficiency or to encourage its use. We do *not* see evidence in Vermont to support a theory that large professional firms working with large customers should be credited with the most efficiency measure installation. Furthermore, in Vermont, one's social network can extend through most of the state. Consistent with this, we did not find a relationship between location within the state and the number of energy efficiency measures installed in permitted construction projects.

The Role of Professionals in Efficiency Measure Installation

Interactions with construction professionals contributes, on average, at least as much as, if not more than, firm size to the determination of the number of efficiency measures installed. C&I firms installed more efficiency measures, on average, when they discussed energy use with mechanical engineers, or with architects or general contractors, than when such conversations did not take place. Firms installed more measures when they had been in contact with more professionals, contact that increases the likelihood they are exposed to energy efficiency ideas. Finally, using statistical regression analysis, we found use of Efficiency Vermont services makes a positive contribution to the number of energy efficiency measures installed in projects.

So, Who Really Makes the Decisions about Efficiency?

Every market group was identified by at least one group as being among the top two decision-makers for HVAC and lighting equipment decisions. How do we understand this? Who is it that programs need to reach?

To answer this question, we need to consider the construction process.

In a traditional, architect-designed project, the owner hires an architect to produce the design and equipment specifications (specs). See Figure 1. The architect hires an engineer (as a consultant) to assist. When the specs are finished, the owner hires, through a bid process, a general contractor to construct a building according to the specs. The general contractor hires mechanical and electrical contractors (subcontractors) to assist in the construction. The general contractor purchases equipment from the supplier, from whom the owner can purchase directly as well.

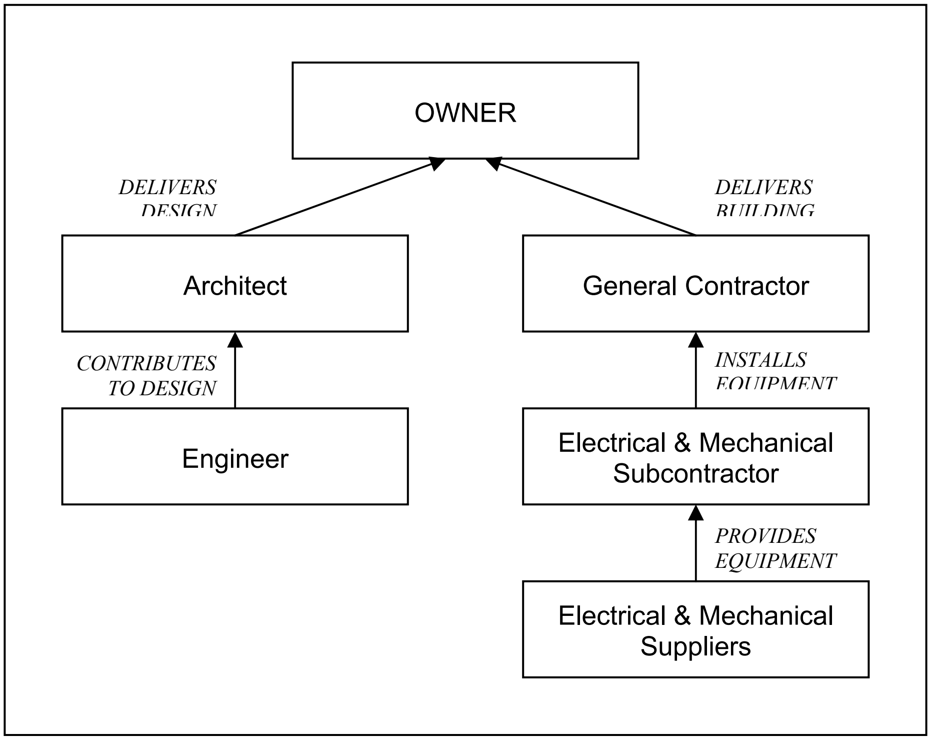

Figure 1. Traditional, Architect-Designed Projects (Idealized)

Design-build projects are more difficult to define since they occur in multiple ways (see Figure 2). The owner does not usually hire an architect to generate the design specs, although architects and, more frequently, engineers may be called in as consultants on the design. (In some places, there is a legal requirement for architect or engineer approval of the design and specs.) The owner hires a design-build firm, often a general contractor, although perhaps a construction manager, engineering firm, or even mechanical or electrical contractor, if appropriate to the project. The design-build firm may hire the designers (or include designers in-house) and subcontractors, or the owner may hire them directly. The owner may come to the process with a design and set of specs (such as when the owner has already constructed a similar facility—the source of the specs). Alternatively, the design-build firm may already have a design (perhaps from similar projects) or include in-house design capability sufficient to the task (such as needed for tilt-up construction or "big box" buildings). The design-build firm and/or the owner design the project and make purchases from suppliers.

In equipment replacement projects, the owner usually directly hires the electrical or mechanical contractor. The contractor and/or the owner purchases from suppliers.

Each of these scenarios is idealized. As we saw from the data on professionals involved in the projects, most construction efforts used three or four of the six professionals we asked about.

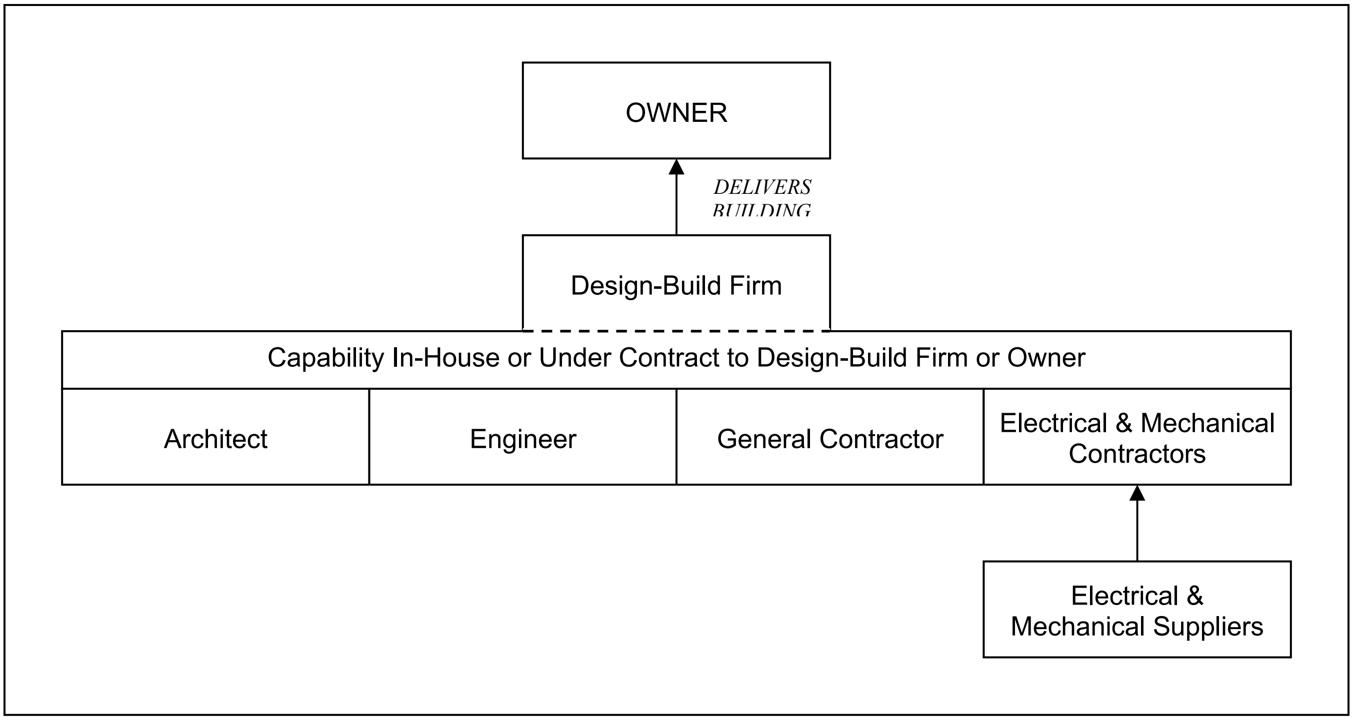

Figure 2. Design-Build Projects (Idealized)

There are three junctures in the process where key decisions are made that affect the building and equipment efficiency: (1) the extent to which the design itself minimizes building energy use; (2) the extent to which contractors modify the design in a way that increases energy use (often, to reduce first costs); and (3) the extent to which suppliers provide the most efficient equipment meeting the specs (or provide less efficient equipment, often to reduce first costs).

Thus, we see that all the market players—including the owner, who approves the specs, modifications to the specs, and the supplied equipment, either in a thoughtful or cursory way—have a direct effect on the efficiency of the building, and can act as a barrier to that efficiency. In particular, those market players that have the most interaction with the owners—architects, mechanical engineers, and general contractors—have the greatest influence on efficiency. This conclusion is supported by our regression findings on the positive influence that discussing energy use with any of these three professionals has on total measures implemented.

Figure 3 shows the market players identified as having the greatest influence on equipment decisions, as reported by the interviewed groups. Owners and engineers are most frequently identified, with each of the other market players identified by only one group. Figure 4 shows the market players identified as most frequently posing a barrier to energy efficiency, as reported by the interviewed groups. The differences in the responses of the market players to key decision makers and barriers reflect each group's typical role in the construction process and their participation in traditionally designed or design-build projects.

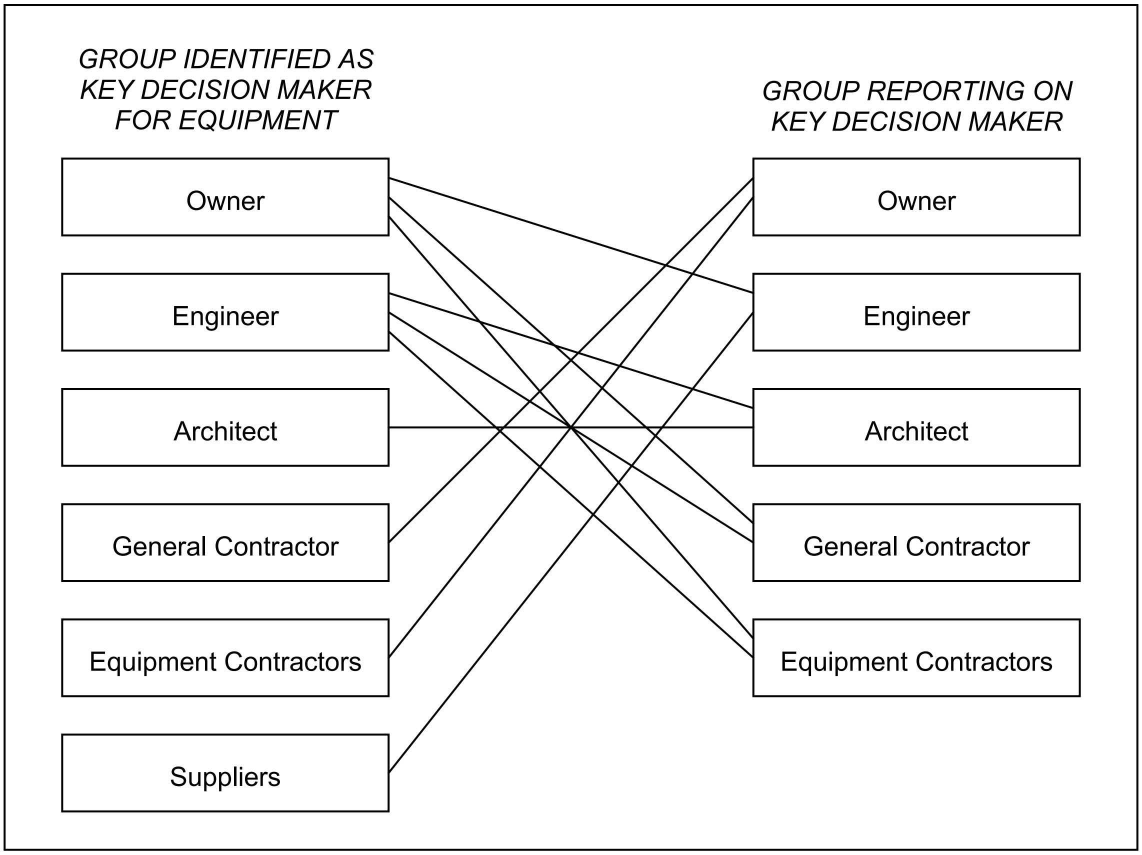

Figure 3. Market Actors Identified as Key Decision Makers

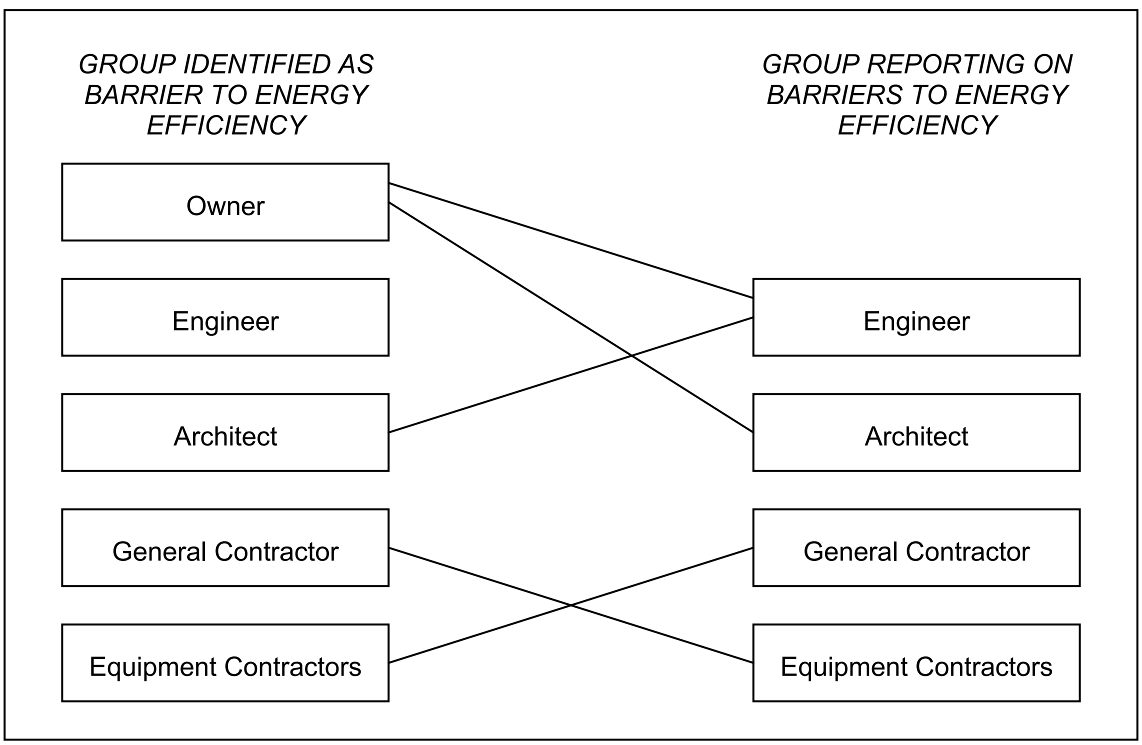

Figure 4. Market Actors Identified as Barriers to Efficiency

Reducing Barriers to Energy Efficiency

Our research points to the need to increase the involvement of designers, contractors, and suppliers in energy efficiency. It is necessary to work with these professionals to increase their: (1) motivation to pursue energy efficiency with clients; (2) knowledge of energy efficiency solutions (technologies, applications, benefits, costs); and (3) ability to communicate with clients about energy efficiency in terms consistent with the clients' objectives for their projects.

It is necessary to increase the communication among the construction professionals about energy efficiency. They would benefit from knowing firms in each discipline that pursue energy efficiency (to facilitate teaming), knowing how to talk to each other about efficiency (how to address each other's principle concerns), and understanding how energy efficiency can be integrated into each step of the construction process.

An "integrated design" approach represents the ideal level of communication among the professionals. In such an approach, the designers, contractors, and owners work together as a team to ensure that the building's design and equipment function together to minimize energy use in the facility best meeting the owner's functional and aesthetic requirements. Among current practices, the design-build approach is more collaborative than traditional design and in this way offers a starting point for integrated development. However, design-build approaches are most often used in "no frills" construction and "value engineering," where cost-minimization equals or exceeds functional and aesthetic considerations.

It is necessary to recognize that although the construction objectives of traditional design more readily encompass energy efficiency than the objectives of design-build projects, the professional relationships in design-build projects more readily encompass the teaming necessary for energy-efficient integrated designs.

It is necessary to reduce the barriers of assessing the suitability of efficiency options for given applications and the costs and benefits of these applications. This can be accomplished by providing end-users or design professionals with financial incentives to cover analysis or by making accurate information readily available to design professionals interested in conducting such analyses.

It is necessary to include suppliers in program efforts to educate and motivate professionals. Engineers identified equipment suppliers as one of the two parties that most influence equipment decisions. Yet we found equipment suppliers to be among the least informed market actors in Vermont and the least willing to participate in our survey. This suggests that suppliers are not being educated by the manufacturers, and that designers, contractors and C&I firms are not demanding energy efficiency solutions from them.

Conclusion

Our study suggests energy efficiency efforts will have the greatest impact when they increase the ability of each of the market actors to talk about efficiency with clients and other professionals. Certainly, each market actor needs to know about available incentives and technical assistance options. Each market actor also needs an opportunity (from outreach, conferences, or training) to learn about efficiency options relating to their specific areas of expertise and how to discuss the options with other professionals and with clients. Efficiency Vermont's *Better Buildings by Design Conference* is expanding its sessions to cover topics specific to the different market actors' roles and needs. When efficiency programs only target owners, architects, and engineers, they are reaching only half (or less) of the market players who affect efficient building construction.

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