LBNL-50704

# Becoming Allies: Combining Social Science and Technological Perspectives to Improve Energy Research and Policy Making

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## ABSTRACT

Within the energy research community, social sciences tends to be viewed fairly narrowly, often as simply a marketing tool to change the behavior of consumers and decision makers, and to "attack market barriers." As we see it, social sciences, which draws on sociology, psychology, political science, business administration, and other academic disciplines, is capable of far more. A social science perspective can re-align questions in ways that can lead to the development of technologies and technology policy that are much stronger and potentially more successful than they would be otherwise. In most energy policies governing commercial buildings, the prevailing R&D directives are firmly rooted in a technology framework, one that is generally more quantitative and evaluative than that fostered by the social sciences. To illustrate how social science thinking would approach the goal of achieving high energy performance in the commercial building sector, we focus on the U.S. Department of Energy's Roadmap for commercial buildings (DOE 2000) as a starting point. By "deconstructing" the four strategies provided by the Roadmap, we set the stage for proposing a closer partnership between advocates of technology-based and social science-based approaches.

## Introduction

Researchers in the broad area of energy efficiency, and the policy determinations propagated by such research, are largely confined to technological considerations. Though the interplay of social and cultural components is often acknowledged, its impact is variously regarded as too difficult to measure, too removed from the central concerns of technology and policy, or too unpredictable by any model-based theory. Thus, this interplay has had little place in the physical and economic models typically used in current research focused on reducing energy use in buildings. However, the social and the technical, far from being independent realms, inform each other in important ways. To overlook the synergism that binds them is to shortchange the potential we have to understand the ways that people interact with the built environment, and how this impacts energy use.

We examine these interactions through the use of anecdotes, and other stories that we have collected by talking to others, reading, and working in the field. This activity itself leads to a crucial methodological issue in the practical application of social science. As one colleague mentioned to us, "the plural of anecdote is not data!" We generally agree with this claim, but we would like to push the matter a bit further. First, whether formally recognized or not, anecdotes can have powerful effects in challenging assumptions, although they may be ignored when they confront popular preconceptions of what is true (cf. Kuhn 1970).

Second, it is a precept of modern folkloristic theory (as well as common sense) that anecdotes are told *because* they illustrate or crystallize important concepts. Accordingly, anecdotes can provide extremely valuable information, if their significance is actually understood and they lead to greater knowledge of how people actually think or behave.

In addition to addressing how people interact with the built environment, social science can also provide an intellectual framework for identifying, and constructively criticizing, how energy policy and R&D activities *themselves* define the problems they strive to solve. This critical approach can accelerate the pace of the "natural" tendency of a community to gradually redefine questions, whether in response to individual results (e.g., observed technological failures), specific events (e.g., an energy crisis or deregulation), or on-going trends (e.g., changes in how buildings are used).

Social science researchers often are faced with trying to answer questions such as "Since energy efficiency is so good, why isn't more of it being done?" (Beamish, Kunkle, Lutzenhiser & Biggart 2000). Though the answer to this question presupposes human activity, this is a relatively technical question that seems to demand a technical answer, ideally leading to specific actions. However, the next logical step in this line of questioning is one that requires a bit more reflectivity: "Or is energy efficiency just not so great as we think?" (Lutzenhiser et al. 2001). We face a similar set of problems in trying to bring social science perspectives to bear on policy and technology development: If social science is so great (for understanding energy use, say) why isn't more of it being done? Or is it just not so great as we think? This simple question, we will argue later, is actually a critical one that tells not only social science but also about the constraints of current analytic and policy paradigms.[1] In combination, these two sets of questions (the one about energy efficiency, the other about social sciences) lead directly to the crux of the matter. What can energy policy do, and not do, and how can we better understand the process so that it can be improved? And what can we expect from social sciences for helping build this process and how should these results be "measured", given practical and political needs for evaluating research results? How might we think about the value of social science (or other) research, if some of the most important results are ones that are not readily measurable because they change the framing of the problem?

## The Roadmap for High Performance Commercial Buildings

The U.S. Department of Energy convened a series of workshops to create a vision for the next generation of U.S. commercial buildings. Drawing on collaborations between government and industry, it produced the report, *High Performance Buildings: A Technology Roadmap,* which noted that:

> Commercial buildings can be dramatically reshaped in the coming decades by combining the results of sound, but separate, research in such fields as energy-efficient building shells, equipment, lighting, daylighting, windows, passive and active solar, photovoltaic, fuel cells, advanced sensors and controls, and combined

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[1] See Lutzenhiser and Shove (1999) for an examination of the institutional landscape of energy policy research and the limits this organization puts onto the research that can be conducted.

> heating, cooling, and power. Such technologies—together with a whole-buildings approach that optimizes interactions among building systems and components—will enable commercial buildings to respond effectively to the changing needs of today's businesses, while also helping to meet our national goals of environmental protection and sustainable development.

In developing this Roadmap to guide the future of commercial buildings, DOE laid out four major strategies designed to ensure that energy efficiency would be more effectively integrated into a reshaped commercial building landscape (DOE 2000). These strategies are subsumed under the topics of: Performance Metrics, Technology Development, Process Change, and Market Transformation.

Consonant with a social science perspective, we have chosen to examine Roadmap strategies using the approach of "deconstruction." For our purposes, deconstruction is a critical technique that seeks to plumb the text to uncover hidden assumptions and models. These assumptions and models may be logically flawed or incomplete given the complex nature of the subject, and may lead to conclusions that don't hold up under close scrutiny. In short, deconstruction is a method of pulling apart models that are implicit in texts. The objective of deconstruction, in general and here, is not to dismiss the arguments made, but, rather, to search for a deeper understanding that ultimately allows us to make critical adjustments, even wholesale replacement of existing models. What we see as a key objective in taking this approach is that a social science perspective will help us understand the complex interactions of the technical and the social in ways that will lead to better energy research and policy. This, in turn, will ideally lead to a broadening of methodological practices within the policy-oriented energy research community, with critical social sciences providing the impetus for expanding or shifting policy and research paradigms.

## Roadmap Strategy #1: Performance Metrics

> The Roadmap lists the following activities under Performance Metrics:
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> Strategy: Establish core definitions and metrics for high-performance commercial buildings. Activity: 1) Define what to measure; 2) Define how to measure; and 3) Determine how to apply the metrics to enable key audiences to evaluate costs and benefits of high-performance buildings investments (US DOE 2000).

Performance metrics are identified in the Roadmap as an important way to quantify attributes of a building's performance that are often ignored because they couldn't be otherwise "counted". In order for such attributes as "energy-efficient," "high-performing," or "green" to be weighed and evaluated by the individuals who build, own, finance, operate and inhabit buildings, it is necessary to have a common understanding of what these concepts mean, and an agreed on way to measure them. The argument is that performance metrics will allow decisions that affect energy use to be made, not on a "first-cost" basis, but by a life cycle cost analysis (DOE 2001). This argument, in turn, relies on an economic decision-making framework that assumes rational consumers who can be convinced (through education and reduction of transaction costs) or cajoled (through rebates and other rewards) to see all purchases as investments. Indeed, a recent report on market transformation in commercial buildings suggests that the best way to understand energy consumption in commercial buildings is to see these buildings as investments (Lutzenhiser et al. 2001). Thus, efforts to promote energy efficiency in buildings should reflect this fact, rather than rely on a simplified technology adoption model. On the other hand, it is important to admit that some key energy-related problems, such as consumer acceptance of new technologies, may not be reasonably addressable within an investment model, and may be better suited to other modes of market entry (e.g., regulation).

As MacDonald (2000) points out, performance metrics are often expected to satisfy many goals simultaneously, not only to convince owners about desired targets, but to measure performance, to diagnose problems, and to allow for comparisons. Performance, however, means different things to different people. An architect, owner, leaser, manager and occupant will all have different definitions of performance. The best a metric can do is to try to capture some aspect of performance, which may be a characteristic most easily measured, but not the one that matters most to the individuals involved. As an example, the standard metric for “lighting efficiency” is watts per square foot, which is easy to calculate, but tells us nothing about the amount of illumination produced, nor the quality of the light in the space. A performance metric, at worst, may even steer a designer away from better solutions, either by suggesting “wrong” directions, or by diverting attention from more substantive issues of building performance. For example, linear (one-dimensional) metrics do not easily incorporate such critical non-linear concepts as risk or “smartness.” Ignoring risk overlooks the way industry “thinks”; ignoring degrees of smartness may lead to overlooking or over-promoting “smart” and adaptive building technologies.

In continuing to deconstruct the assumptions and values imbedded in performance characterization we turn now to three related topics: benchmarking, incentives, and predicted versus actual savings. By looking at an anecdote or case study from each of these topics we ask whether the existing technology model could be strengthened with a social science perspective.

**Benchmarking**. The term “benchmarking” took root in the computer industry in the 1980s, and by the 1990s became a watchword of proper business management. In the late 1990s, the concept was applied to the energy aspects of building performance. In the context of buildings, benchmarking starts from the presumption that buildings will improve only if we know how they compare to other like buildings, or how they compare in terms of an absolute technical measure, such as the amount of electricity used in a year. This assumption leads to several questions. For example, no two buildings, even those with similar uses and schedules, are truly identical, so on what basis are building services identified so that energy use for those services can be compared? In the complex community of commercial buildings, which of its many players cares about, let alone acts on, the basis of measured parameters? If we are to avoid facile correlations between energy use and total building performance, can we afford to ignore the impact on worker productivity, satisfaction, comfort, absenteeism, etc., while avoiding simple metrics that “prove” there have been no adverse effects? And what are the logical implications of using empirical distributions of performance measurements? Does it not mean that no matter what the characteristics of the building population at issue, some percentage of buildings will always perform extremely well and others terribly, and that only 50% will perform better than typical?

A second assumption of benchmarking is that building performance is actually measurable. A very common argument is that people have no incentive to change their energy-consuming behavior because they are unable to track their consumption—like "dieting without a scale." The analogy is worthy of digression, particularly in light of observations that discourage relying on a scale for feedback on weight loss First of all, most people can probably readily tell whether they've lost weight without a scale; the scale may help but to a certain extent it's of symbolic value. Secondly, within moderate ranges, weight reflects neither health nor size. It is considerations such as these that need to be injected into formulaic ways of thinking about energy. Staying with this analogy, the "scale" need not be entirely abandoned, but its "feedback" value needs to be weighed against other driving factors.

In relation to measuring the performance characteristics of buildings, reason tells us to pay attention to contrary incentives that may be dictating the behavior of those who use or occupy or manage the building. Building managers, for example, often care most about issues that are immediate to their day-to-day job functions, such as avoiding complaints from building occupants. Or take, for example, the case of the New York City public housing department. Boiler operators were told they had to keep their monthly energy use below a set level, an average of their previous annual kBtu per month. If they didn't, they had to explain why to their boss. If they did, they got a gold star (Diamond 1988). Skeptics were convinced that without a financial incentive, there would be no change in behavior. On the contrary, the fear of having to report to the boss, coupled with recognition for their achievements, turned the mandate into an informal competition among the boiler operators to see who could get the most gold stars.

**Predicted vs. Actual Performance**. Another question about metrics that we want to raise leads back to the technically fundamental question of what is performance anyway, and how should it best be expressed? Is a computer simulation of a building's energy use more "real" than a set of data collected over a finite period of time? And to whom? Because of the difficulty of defining and measuring energy savings, we often credit *predicted* savings as being "real." Think for a moment of such diverse activities as LEED ratings, design competitions, and computer simulations. What all these have in common is the popular acceptance—and often a belief by experts as well—that they represent actual performance. But look at what can come of this easy acceptance: A much awarded energy retrofit project continued to present its "predicted" savings, even after measurements showed that these savings were not realized (Diamond 1999). Of course measured performance data is also a "model" of a building—a snapshot of only some characteristics of the total building. This finding has methodological implications for energy research, development, and policy: how can we better promote and take advantage of real-world evidence (whether scientifically measured or anecdotal) and bring this evidence to bear on our activities, especially given the very real political pressures that the research community faces to produce "successful" programs?

## Roadmap Strategy #2: Technology Development

The Roadmap lists the following activities under Technology Development:

> Strategy: Develop systems integration and monitoring technologies that enable whole buildings to achieve optimal, targeted performance over their life cycles. Activity: 1) Develop verifiable design and performance analysis and models and tools, 2) Develop methods to improve interoperability, and 3) develop cost-effective, reliable monitoring and control technologies (US DOE 2000).

While the specific items identified by the Roadmap teams for technology development are clearly worthwhile, again, they lend themselves to some probing: For example, who in the process of designing, constructing and inhabiting new commercial buildings will interact with the new technologies? Will their input, needs and desires be solicited so that appropriate technological modifications can be made? Who decides which technologies will be implemented? What will be the impact of these new technologies in areas other than energy performance, e.g., will a new energy management control strategy frustrate building operators with its inherent complexity so that they will constantly over ride it? Having seen repeated resistance or failure in previous studies gave us the incentive to ask how social science perspectives might be brought to bear on specific aspects of technology development in the commercial building sector. We believe our analysis suggests important ways of integrating socio-behavioral factors into existing research protocols.

**What is the value of demonstration projects?** The Energy Edge demonstration project was a multiyear effort to advance new energy-efficient technologies in commercial buildings in the Pacific Northwest (Piette 1994). The final impact evaluation, based on extensive monitoring and modeling, showed that the 26 buildings as a group were more energy-efficient than comparable new construction. A surprising finding, however, was that a large number (over 50%) of the measures, especially in HVAC and lighting control systems, failed to operate as intended. The reasons were varied, but included flaws in design, construction, installation, operation and maintenance, as well as a number of “people” related issues related to familiarity, comfort, and different preferences among the building populations. A technology-based assessment might have concluded that the demonstration project was a limited success. But in this case, the research team combined technical and social scientists, which uncovered several of the reasons for the building “failures” and were able to propose solutions.

**Why do people override controls?** The daylight controls in the Energy Edge demonstration project were frequently overridden by building occupants some of whom felt there was not enough light, or there was too dramatic a change in light (Heerwagen 1992). These early systems used stepped rather than continuous dimming controls, so the change in light levels was quite apparent to the workers in the spaces affected. In many cases people thought the change in light levels were because the lights were “broken”—no one had explained to the workers that the lights were changing in response to the daylight availability. The workers also objected to the occupancy controls in private offices, and would override the switches to leave the lights on, even when they were not occupying the spaces. When the social scientists studied this phenomenon, they learned that the workers were afraid that if they stepped out and the lights were automatically shut off, people could tell they were not working. In this case the lights were not being used for illumination, but to signify that someone was "at work".

**Do we want smart buildings or smart people?** One of the recurring themes in the Technology Roadmap—and popular culture—is the futuristic portrayal of "smart" buildings. In these scenarios buildings are portrayed that automatically control temperature and light based on occupant needs, smart sensors recognize individual preferences for space needs, equipment, and even coffee. In the novel *Grid* by Philip Kerr, a high-rise office tower is designed as a technology showcase, with a building operating system that has fully integrated all aspects of the building (Kerr 1996). Unfortunately for the characters in the story, the building control software is accidentally updated with video game software put on by the architect's son. The building's control system develops a sense that its mission is to destroy the occupants, which it does by making particularly ingenious use of the HVAC, security, plumbing and other systems. This popular example of technology running amok, not unlike the computer, Hal, in Arthur C. Clark's *2001*, and the evil ducts in the movie *Brazil* (1985), reflects a growing fear on the part of the public with our increasing dependence on building technology.

In a reaction against the technology-controlled work environment, designers in Northern Europe are exploring "mixed-mode" buildings, which use a combination of natural ventilation with mechanical ventilation systems (Ring 2000). Social scientists could investigate whether such systems meet occupant needs for comfort, and whether having local control actually allows for a wider range of acceptable temperatures. We are not arguing here that all control systems in office buildings be simple, familiar to the occupants, and under their direct control, but we are suggesting that occupant comfort involves attitudes that cannot be discounted in the design of energy-efficient systems in the commercial sector. To ignore personal preferences, usage habits, and a cultural norm that honors individualism is to invite technological failure.

**Smart operators vs. smart controls: tools vs. technology?** A recent DOE/FEMP energy award went to an agency that upgraded its HVAC system with a new energy management control system. Not mentioned in the citation was the information that the expected savings included the salaries of the laid-off building managers who were "replaced" by the smart controls. It is hard to imagine a scenario with a lower probability of success: a new technology with no human oversight. A more promising strategy is to allow for the training of building operators to manage the new technology rather than be made redundant by it. Building performance cannot rely solely on smart tools—it demands smart operators. Surprisingly, few people have investigated this particular interface (Piette 2000).

**How do we get feedback and access to information on building performance?** A constant problem in the design profession is that several of the players never learn whether their designs have been "successful"—and there is no commonly agreed on definition of what constitutes "success". For an architect, success could be a write-up in an architectural journal, a design citation, or a repeat project. Rarely does a designer receive any feedback on the performance of their buildings. And very few architects are paid to evaluate the performance of their buildings. In addition, they lack both objective criteria (e.g., rents received for the leased space) or subjective criteria, e.g., user satisfaction, that could allow them to improve their designs. Without any information on what works, the architects are reluctant to adopt new technologies in their designs. Building operators, on the other hand, often have the knowledge to make improvements in the design or retrofit of buildings, but lack the professional status to do what needs to be done or to be listened to by those who could make the changes.

**Why do demonstration buildings often use more energy than predicted?** Although there are notable exceptions (ACT2, Zion Visitor Center, among others) a common finding in showcase buildings is that they use more energy than predicted. Sometimes the problem is as simple as poor predictions. Other times operating hours or uses of the building have changed substantially from the time it was originally modeled. The energy-showcasing Enerplex buildings in Princeton, New Jersey, used two-to-three times the predicted energy use (Diamond 1989). The new award-winning Adam Joseph Lewis Center at Oberlin College uses more energy than predicted (Scofield 2001). Proponents of showcase buildings, as noted earlier, often continue to claim the *predicted* savings, arguing that the building was changed in significant ways. A social science enquiry would look beyond the "measured" performance criteria at other services and benefits that might have been achieved, or missed, in the evaluation of the demonstration building.

**Roadmap Strategy #3: Process Change**

The Roadmap lists the following activities for Process Change:

> Strategy: Create models of collaborative whole-building design and development, and establish the tools and professional education programs needed to support these processes. Activity: 1) Develop, pilot and document new models of collaborative whole-building design and development and create implementation guidelines for applying such processes, 2) Create tools, (e.g., software, communications) to support integrated decision-making in commercial building design, construction, operation and renovation, and 3) Establish educational programs for professionals who are key to implementing and supporting commercial whole-building approaches (US DOE 2000).

One of the several assumptions underlying the strategy for process changes is that the desired end result—"whole-building" design—has not been realized because of the fragmentation of the building industry. Tool creation, another topic in process change, identifies new tools to bring about change, without asking who uses the tools, and what purposes might these tools be used for. A third topic, education, raises additional questions where a social science perspective would ask who needs to be educated, how, and about what?

**Will "whole-building" design produce higher energy-performing buildings?** The fragmentation of the US building industry is well documented. Buildings are an assemblage of countless individual components brought together and assembled by a myriad of players. There is evidence from Japan, where building construction is much more integrated, that indicates that better integration leads to better construction quality (Buntrock 2001). A social scientist would ask whether the factors of integration led to better quality, or whether other cultural and social aspects were responsible. In other cultures, such as the US, a more integrated building industry could lead to cheaper, not better, construction. Building integration could be a desirable goal, but it may not result in energy-efficient or high performance buildings. The social and cultural context will influence these outcomes, and the better we understand how these forces work, the better we can predict their results.

**Will new tools change how we design buildings—and do we want those changes?** Again, the underlying question here is: will a new tool change how we do business? Or will it simply make it easier to do what we are already doing poorly? Will tools that make it more efficient to deliver buildings allow us to deliver bad buildings faster? We shouldn't assume that a new tool could make the fundamental changes that are needed to create a demand for buildings that use less energy. When there is a societal demand for using less energy—such as during an electricity crisis—having tools will be important, but in an environment where energy is ignored, new tools are unlikely to create that demand.

**Will educating design professionals result in higher energy performing buildings?** While continuing education is clearly beneficial to all kinds of professionals, an obvious response to this suggested activity is to ask *who* is to be educated? Many programs sponsored by state- and utility-funded energy centers target architects and energy consultants. As Lutzenhiser, Beamish and others have pointed out, however, the critical decision makers for most large commercial building projects are financiers and investors, people who do not typically attend classes at energy centers. In many cases, well-educated and well-intentioned designers may be frustrated when their efforts to produce a high-performance building are frustrated by others. In a similar way, financiers could be frustrated by architects presenting sustainable designs without their making the business case for them.

For the past 200 years (and probably longer) there has been a dynamic tension in design education between the elements of style and the forces of technology. This battle continues to play out whenever there are cries to educate designers about technology. While there have been successful examples of professional firms that integrate technology and design as well as classroom experiences that combine the two, they are in the minority. Social scientists looking at the specific case of design (Cuff 1992) have noted how the different traditions of architecture and engineering evolved. Ignoring these differences undermines any efforts to educate mainstream designers about energy-efficient technology.

**What impact do contractors, subcontractors, and tradesmen have on construction quality, and how do they affect whole-building design strategies?** The performance of most energy-efficiency measures depends not only on their design, but also the degree to which they are correctly constructed, installed, and ideally, commissioned. Despite this critical connection, the role of the contractor and building trades—those who install the lighting fixtures, controls, and windows in buildings—has not been fully accounted for in evaluations of how buildings perform. Yet we know that the following example is not an isolated occurrence: A building with high-performance glazing optimized for each orientation was built with the windows on the wrong elevations. If we are to realize improvements in the way buildings operate, we need better design tools, interoperability improvements, and the like, but we also need to factor in the contribution of the many players and the context in which they work.

**Why aren't buildings designed for optimal energy performance?** The roadmap talks about achieving "optimal targeted performance" as a strategic goal (DOE 2000). Several factors, however, can work against the optimization for energy efficiency. As is commonly reported, HVAC equipment for commercial buildings is often grossly oversized (Brown 2002). Why? For the most part, to prevent tenant lawsuits over failure to maintain comfort conditions. In such cases, the designer (or owner) has made a trade-off between the costs of energy use and the potential costs of litigation. Social scientists are in an excellent position to investigate the context in which these trade-offs are made, and to propose incentives or changes that would permit energy goals to be met without compromise.

### Roadmap Strategy #4: Market Transformation

The Roadmap outlines the following strategy and four activities for Market Transformation:

> Strategy: Stimulate market demand for high-performance commercial buildings by demonstrating and communicating compelling economic advantages. Activity: 1) Demonstrate and document the economic case, 2) define and promote tax and financing incentives 3) Develop and implement a strategic communications and marketing plan and 4) Develop and promote a "brand name" for identity (US DOE 2000).

Market transformation (MT), has been defined as "a policy objective of encouraging or inducing social, technological and economic change in the direction of greater energy efficiency" (Blumstein, Goldstone, and Lutzenhiser 2000). A key assumption is the concept of market barriers. As Blumstein et al. (2000) argue, market transformation implies a theory, but this theory must be articulated and then used in conjunction with observation to develop both better theory and better programs.

One assumption in MT-focused policy arguments is that once people recognize what benefits energy efficiency will bring, and are given the opportunity to pursue them, they will naturally take it because it is in their best interest to do so. For example: “Market transformation programs are specifically designed to bring about lasting changes in energy-related decision making, by reducing or eliminating market barriers to efficient practices so that various market actors have a self-interest in making efficient decisions” (Meyers, Hastie, and Hu 1997). While this may sometimes be true, a recent social scientific study on market transformation for new office buildings (Lutzenhiser et al. 2001) raises critical issues bearing on this assumption. First, buildings already are energy efficient—as efficient as they need to be—in terms of what matters to the building industry (Lutzenhiser 2001). In fact, “it is clear that increasing the energy efficiency of buildings is of little value to the building industry”; for most, trying to do so would be “nothing but risky”. Moreover, the building industry itself is a complex system (comprised of many of actors and linkages) that is itself embedded and determined by other systems, including environmental systems, regulatory systems, and the like (Lutzenhiser et al. 2001).

In turn, these observations lead to some general questions relevant to the roadmap strategy for encouraging MT. First, does the production side of the market, i.e., the side that develops technology and the policy to promote it, truly respond to what will work in the market? Second, do markets know whether commercial buildings work? Buildings are complicated systems providing different needs to different populations, and thus defining what “works” can be hard to determine. The definition of what works in a commercial building can be interpreted variously from the perspective of operations, maintenance, worker satisfaction, etc.

## Bringing Together Social and Technical Perspectives

In this paper we have used the BTS Commercial Buildings Roadmap as a way of showing where different types of social science approaches could complement the predominant technical strategy for R&D. Social science inquiry can be fundamentally different from the quantitative engineering approach often used in energy technology research. For example, a well-developed case study, or even an anecdotal report can be as fruitful in understanding a problem of how people interact with their built environment as compared to the more traditional approach of gathering physical data or simulating energy performance.

We have looked at how a social science approach could add value to the technology roadmap for commercial buildings. Many of the examples were anecdotes that showed how a lack of understanding or lack of acknowledgement of social and behavioral factors led to unanticipated consequences. But in planning there is by definition no benefit of hindsight. How, then, can we use these insights from past experiences to improve and strengthen future R&D activities?

We have identified two main types of social science analysis, and this question falls between them. The first type of analysis, and the more common in energy research, is one that pursues advancing knowledge through methods such as field observation (whether anecdotal or formal), surveys, interviews, and the like. The second, that which we address through our example deconstructions, is a mode of critical analysis intended to draw attention to the mental models and institutional structures that characterize much of current energy research and policy: what stories ("true" or not) are told, what is assumed, and what is missed?

Table 1 gives a few examples of social science-based questions of the first type, relevant to the energy performance of commercial buildings, along with corresponding engineering-based questions. In looking at these questions the defining difference is that the engineering questions are usually focused on determining energy flows and systems behavior whereas the social science questions seek to uncover distinctions among people that might potentially affect building design and operation.

**Table 1. Comparison of Engineering-Based and Social Science-Based Questions Concerning Energy Use in Commercial Buildings**

| Engineering-Based Questions | Social Science-Based Questions |
|---|---|
| • How much energy is used in a building, either predicted or measured? | • What services do owners and occupants value in commercial buildings? |
| • Where is the energy being used? | • How are design decisions made that ultimately affect the health, productivity and comfort of occupants? |
| • How much energy can be saved? | • Who determines changes in the building operation? |
| • What is the time period for technology adoption? | • Who gains and who loses in any proposed change? E.g., how do manufacturers and DOE come to mutually satisfying "solutions"? |
| • What are the market barriers? | • Do markets reflect the true costs of energy-related choices? |
| • What are appropriate energy targets for new construction? | • What are possible unintended outcomes from a proposed change? |
| • How do you add more functionality to the energy management system? | • What information and incentives do building operators need to effectively operate their buildings? |
| • What are the carbon credits for improved energy efficiency? | • How does society recognize the consequences of increased energy consumption? |

Can a social science-based inquiry bring value to and complement the current engineering-based approach that predominates in energy R&D? Can an engineering model that focuses on buildings and energy flows be enhanced by integrating a social science approach that investigates how buildings are perceived and acted on by their users? We certainly need to recognize that these two "camps" approach problems differently; they use different tools and ask different questions. Engineering questions tend to require answers that are constant over time and space, while social science questions seek answers that may only be valid for certain times and places. One approach values the collection of data and measurements. The other values collection of experiences and anecdotes (social science questions of the first type), and what may be mistaken as "destructive", rather than "progressive" analysis (social science analysis of the second type). The challenge is to regard both the technical and the social scientific as valid approaches, capable of joining forces to achieve as yet unrealized ends in the area of energy use in buildings. That those who come from these different perspectives have difficulty communicating should be no surprise. The question is whether the goal is worth the effort required. We think it is, but it cannot be accomplished without building trust between these alternative camps, which in turn requires fostering open dialogue.

## Acknowledgments

This work was funded by the Assistant Secretary of Energy Efficiency and Renewable Energy, Office of Building Technology, State and Community Programs of the U.S. Department of Energy under contract number DE-AC0494AL85000. We thank Dru Crawley, US DOE for his continuing support, and our colleagues for their comments and discussion. We would also like to acknowledge the enormous contributions of our thoughtful, anonymous reviewers, and our editor, Laurel Cook, for her ever-helpful comments.

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