In this paper, I set out an organizational model of energy conservation decision making, developed to explain the apparently low levels of energy conservation implementation found in the literature. The organizational model is fundamentally different from an economic model in that it highlights the importance of power distribution and information acquisition and analysis. It also shows how providing stronger incentives, through organizational decentralization, does not necessarily improve energy conservation behavior, it simply changes it. In addition to providing insight into critical dimensions of new technology design, this model provides a tool for analyzing policy. It indicates the need to move away from policy models derived strictly from economics to those which treat institutional issues as central.

The model emerged from a comparative, qualitative study of energy management at four universities. I constructed both energy conservation and organizational histories. Data was collected primarily by interviews, with some use of archival records. Data from two sites is presented here.

The results suggest that effective energy policy can do three things. It can (1) foster technologies more compatible with organizational limitations, (2) compensate for specific limitations in organizations, and/or (3) encourage management practices which make energy management less constrained.

INTRODUCTION

Institutional energy conservation behavior is paradoxical. Many energy conservation projects will both save money and increase user comfort or plant reliability. This benefits both the public, by reducing pollution and fuel dependency, and the organization in question. Therefore, if institutions were rational, we would see rapid and complete implementation of both behavioral and technological energy conservation options in the workplace. However, real performance falls far short of this. For example, Ross (1986) observed that hurdle rates of return for projects vary considerably between companies, often in the same industry. Similarly, government conservation programs often subsidize projects with simple pay-back periods of less than a year (Cebon 1990).

These could presumably be funded from annual budgets, without raising extra funds. Finally, Miller, et al. (1990) estimated that New York state's residents could consume 40% less electricity and save money.

Given that rational choice models do not appear to explain institutional decision making behavior, alternative explanations are needed. In this paper, I will draw from organizational theory to present and discuss data from an exploratory study into institutional obstacles to energy management in four universities. I made no prior hypotheses as to why universities might be poor decision makers, other than that it may be related to organizational factors.
This very open-ended approach was selected because, at the time, there was no obviously relevant literature available.

The findings which emerged can be understood at two levels. At the first, two variables appear critical to understanding organizational decision making. They are (1) the information gathering and analysis capacity of the people charged with formal responsibility for energy conservation, vis à vis the information gathering and analysis requirements implicit in a given solution, and (2) the power these people have, through coercion or incentives, over the people whose cooperation or support is necessary for successful implementation of a given technology, versus the amount needed for that technology. At the second level, the structure of the organization and its institutional environment prescribes managers' abilities to command all the information and power needed for a given solution. If energy conservation is accorded a relatively low priority, energy managers are, in general, relatively peripheral. The solutions they develop map onto the rest of the organization's technology as they map onto the rest of the organization. That is, energy managers favor the solutions least constrained by power and information, generally add-ons to the organizations' core technology.

METHOD

Universities were selected for two reasons. First, they are microcosms of this society's capital base. They contain the full range of space use, equipment, and technology found in the society at large. Second, they are true ‘life cycle' managers of their assets. They conceive, design, construct, use, refurbish, and demolish their own buildings on a campus of spatially connected structures. ‘Life cycle' management eliminates distortions caused by third-party construction or ownership of buildings.

The research was guided by a recognition that organizations have a multitude of options available for energy management. The key question was whether the nature of the organization told us anything about the choices that were made once people chose to act. That is, in what way does the nature of the organization delimit the smorgasbord of economically feasible options to the small subset from which the organization actually selects?

Data was collected primarily through seventy-five interviews of 60 to 90 minutes duration, 22 of which were transcribed, and from archival records at four sites; the two universities discussed here, plus a major state school, and a medium-sized private one. I aimed to obtain histories of the organization, energy management, and relevant events outside the university. I also sought to understand current practices, including equipment maintenance and replacement procedures, the way energy conservation was incorporated into new buildings, and the way energy managers interacted with both users and people responsible for physical facilities. Where these practices had changed over time, I also examined their evolution. I solicited information and opinions from all management levels, from first level supervisors through to the vice presidential level, or equivalent. Where possible, I interviewed users. I also interviewed architects, shared savings contractors, HVAC engineers, and union officials, in person or by telephone.

For brevity I will focus on two representative examples of energy management decisions - computer controllers and light bulbs - from two sites. Although many more decisions were studied, these two are particularly appropriate for several reasons. First, these technologies are very cost effective and are considered the linchpin of effective conservation. Second, they are polar opposites in many respects: compact fluorescent bulbs are very cheap (as a capital expense), simple, and reside in the workplace; computer controllers have historically been very expensive, complex, and hidden in the university's infrastructure. Therefore, they provide good contrasts. Third, neither impedes, to any significant extent, the quality of the academic environment. (In fact, computer control tends to make it more comfortable.) Therefore, implementation buffers the organization's core from the, potentially disruptive, environment (Thompson 1967). Fourth, once

1 By energy manager, I mean members of the organization who make energy conservation decisions as economic agents.
installed, both the light bulbs and the controllers are cheaper and easier to manage than their predecessors. Hence, almost always, they are an unambiguously good idea. Finally, these solutions are not mutually exclusive. Installing one does not alter the other's feasibility.

In the following sections, I will compare and contrast decision making in these two cases at the two sites and attempt to explain each university's decisions. After contending that the explanation can be generalized beyond energy management in universities, I will discuss some policy implications.

Two Sites: Tech-U and Prof-U

The first site, Tech-U, has built its reputation through its strength in the applied physical, biological and social sciences. The other, Prof-U, also a private university, is famous for its professional faculties. They are matched in every respect except student type and organizational structure. They have virtually identical weather, investment criteria (a somewhat ill-defined three to five years simple pay back), and ready access to capital. Both have multiple, virtually independent, campuses. I examined only the main one, which was about the same size in each case. Those responsible for energy conservation considered it important, though only in one case did senior management make it a faculty priority. Both universities have been successful energy conservers. Tech-U was an early implementer of direct digital control, and one Prof-U faculty halved energy use between 1980 and 1985.

Their organizational structures differ. Tech-U is administratively uniform with its different faculties sharing centralized resources, including the Physical Facilities Department (Tech-Maint). As organizational theory predicts (Thompson 1967), a specialist office separate from the organization's core, Tech-Maint's operations division, is responsible for energy management.

Prof-U, on the other hand, consists of ten autonomous faculties. Each manages its own endowment, tuition, and expenditures. Each faculty's facilities office purchases services from either the university's Buildings Maintenance Department (Prof-Maint) or outside vendors. In the study, I examined the major School for Arts and Sciences (S.A.S.) and a Small Professional School (S.P.S.). The S.A.S. had about fifteen people overseeing a part-time army of superintendents (who liaised with the Prof-Maint mechanics) and energy monitors (an administrator in the relevant building who dealt with users). The S.P.S. had a facilities office of three people devoting up to three half-days a week each to facilities. This splitting of responsibility necessitated splitting the energy management task between appropriate people in the facilities offices and in Prof-Maint. 3

Technologies

Computer control systems manage the timing and temperatures of buildings, and monitor equipment and systems. While they have improved incrementally, two discontinuities have punctuated their evolution (Tushman and Anderson 1986). The first generation, supervisory systems, monitored autonomous mechanical control equipment located in the field, often using sophisticated algorithms. The first discontinuity, direct digital control systems (DDC) introduced in 1975-1976, had many improvements. According to interviewees, they were more reliable, centrally programmable, easier to run and maintain, and increased management control over workers (e.g., Edwards 1979). Micro-computer-based systems,

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3 At various times, this responsibility was shifted around in the S.A.S. at Prof-U. From 1973-1979, the Dean took principal responsibility and two people in the facilities office worked on selected problems. From 1980-1985, when energy use was cut 50%, he and the engineering professor who catalyzed the initiative co-chaired an energy management oversight committee. He also expanded the facilities office's energy management staff. At the initiative's end, in 1985, the facilities office assumed responsibility and used an incentive program to move some of the onus to individual buildings.

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2 Centralization differentiates these two sites. See Table 2 for other structural variations.
the second discontinuity, in 1984, were cheaper, enabled systems to be bought for single buildings, and had better user interfaces.

Lighting technology changed radically in 1984. Incandescent (Edison) bulbs could be replaced with compact fluorescent tubes which, though expensive initially ($10.00 - $15.00 each) have a lower capital cost once the cost of changing bulbs is considered. They use 70% less energy and hence generate 70% less heat. While shape, weight, and the chance of theft preclude installation everywhere, the decision to use these is generally elementary; the economics straight forward; and the technical task as simple as changing a light bulb.

DATA

The obvious way to examine the research question is by studying which solutions the given organizations did, or did not, implement. However, this approach would miss two very important elements of the data: the timing of decisions and extent of implementation of solutions. In some cases, implementation was virtually simultaneous with introduction of a technology to the market. In others, there were lags of up to twelve years. If lags occurred, action was generally precipitated by a (generally external) event. Hence, timing is best understood using a binary variable: the existence, or not, of a significant lag. Second, all sites attempted virtually all options at one time or another. However, their success varied. Therefore the other indicator of performance became extent of implementation (proportion of climate controlled buildings retrofitted). We can see from Table 1 that both of these varied for the two technologies.

Tech-U was a very rapid implementer of centralized DDC (it was actually a prototype site) and it upgraded the system in a timely manner as new technology became available. It has achieved big savings with the system (for example, in 1986 an engineer rewrote algorithms and shaved the annual energy bill by $1,000,000). Although compact fluorescent light-bulbs are much simpler and cheaper, the lag here was relatively long, three years. In contrast, Prof-Maint failed to even consider DDC when upgrading the simple supervisory computer control system it had installed in the early 1970s. Further, the S.A.S. and S.P.S. only started using the supervisory computer for conservation in 1980 and 1986 respectively. Third, Prof-Maint considered how it would accommodate microcomputer-based DDC systems only after the faculties started installing them. Finally, interviews indicate the S.P.S. lacked skills to decide whether to purchase a DDC system when a shared-savings contract ended. Compact fluorescent light bulbs were introduced promptly by the S.A.S. in 1984.

This pattern was repeated throughout. Tech-U implemented complex, expensive, technical solutions which did not require interactions with users (e.g., preventative maintenance, building maintenance, steam pipe management, chilled water production, etc.) much better. Prof-U, on the other hand, was much better at implementing cheap, simple technologies or those which involved users. These included putting controllers on fume-hoods, dealing with users, limiting times and temperatures, simple retrofits, and so forth.

EXPLAINING THE DATA: ORGANIZATIONAL LEVEL LOCAL RATIONALITY

Given these organizations are otherwise identical, I concluded that differences in structure and events in the institutional environment could explain almost all differences in decision making (i.e., decisions with virtually no lag, and the nature of the events which interrupted the long lags). Allocation of responsibilities, which reflected prior choices of centralized versus decentralized structures,
Table 1. Extent and Lag of Implementation for Computer Control and Compact Fluorescent Lights

<table>
<thead>
<tr>
<th></th>
<th>First Marketed</th>
<th>Tech-U</th>
<th>Prof-U</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yr</td>
<td>Maint Yr Lag Bldgs (Yrs) (115)</td>
<td>Maint Yr Lag Bldgs (Yrs) (No)</td>
</tr>
<tr>
<td>Centralized DDC</td>
<td>1976</td>
<td>1976 0 34</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1978 # 50</td>
<td></td>
</tr>
<tr>
<td>Microcomputer based DDC</td>
<td>1984</td>
<td>1987 # A/A</td>
<td>I/A</td>
</tr>
<tr>
<td>Scheduled control systems</td>
<td>I/A</td>
<td>1976 3 34</td>
<td>I/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1978 # 50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1987 # A/A</td>
<td>I/A</td>
</tr>
<tr>
<td>Compact fluorescent bulbs</td>
<td>1984</td>
<td>1987 3 A/A</td>
<td>I/A</td>
</tr>
</tbody>
</table>

* Action not taken by 1987/88  
# Lag not relevant once other actions are considered  
I/A Action inappropriate for this organization or part thereof  
A/A All appropriate buildings. At Tech-U, for computer control, this was about 65 (excludes dormitories and unconditioned and remote buildings). For compact fluorescent bulbs, about 100 buildings. In the S.A.S. at Prof-U, for computer scheduling, about 100 buildings, and for lights, extensive changes in 15 buildings and minor changes in many others.  
+ Services purchased through shared-savings contract

dramatically affected the universities' decision making capacities. The organization acted as a set of filters which sieved the set of feasible (in an engineering and economic sense) options (and problem definitions which led to feasible options) to a much smaller sub-set from which it selected. As a result, the sub-units exhibit what Cyert and March (1963) termed local rationality (i.e., consideration of a reduced sub-set of options because of organizational level constraints). The institutional environment, at key junctures, provided inputs which compensated for the organizations' deficiencies and facilitated decisions. However, I extend Cyert and March's argument to suggest that for problems accorded low priority, as is often the case for energy conservation, the filter is very systematic and has a very fine mesh. To understand why that should be, it is essential to consider the information and power requirements for decision making.

Information Acquisition and Analysis

Every decision requires the bringing together of three distinct classes of information; technical information, contextual information, and connected information. Technical information is the most obvious. It generally comes from outside the organization, with potential solutions. Decentralization reduces an organization's ability to collect and analyze technical information in three ways. First, decentralized organizations must reproduce their decision making apparatus for each sub-unit (e.g., faculty), making the gathering of technical information inefficient. Second, decentralization reduces the

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Human Dimensions 2.21

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skills each sub-unit can aggregate, making information gathering incompetent. We see this played out in the technical capacities of the universities. Tech-U had 13 facilities engineers, Prof-U had two for Prof-Maint and the faculties on the campus. Third, decentralization is not the norm for universities, so external vendors often cannot identify key people to approach at Prof-U (see (DiMaggio and Powell 1983)). For example, the smaller faculties at Prof-U stood to benefit enormously from the utility-sponsored shared-savings retrofit program Tech-U used to replace its lighting. However, the utility took a year to find them (i.e., until after the program was initially scheduled to finish). Similarly, only the S.A.S. installed compact fluorescent lights. It seems, the vendor assumed that either there was only one faculty, or because one faculty had purchased the technology, all had considered it.

Given its low information acquisition capacity, it should be no surprise that Prof-Maint did not even know about DDC technology until the faculties purchased small systems in 1984, eight years after DDC came to market. Further, some lag-ending key decisions in the faculties at Prof-U were precipitated by exogenous inputs of technical skills and information. Most important, the move to scheduling the computer system, the five-year 50% reduction in energy consumption, and the purchase of microcomputer based controllers in the S.A.S can all be traced to a lunch a professor with an expertise and interest in energy conservation had with the Dean in 1979. Prior to that, the faculty's energy conservation attempts had been disastrous. Similarly, the S.P.S.'s decision to schedule energy use was precipitated by its entering into a shared savings contract for one of its buildings.

Technical information, however, is insufficient. Every solution involves a real location which carries contextual information about the space, its use, the intricacies of people's lives and the idiosyncrasies of the equipment. The energy manager needs this contextual information to implement effective solutions. We expect the energy manager to have much more information about the spaces and people with whom she deals regularly. Hence, decentralization makes contextual information more available within units and less accessible across organizational partitions. Therefore, the energy managers at Prof-U are likely to know more about academic domains than those at Tech-U, while those at Tech-U are likely to know more about the university's infrastructure than the energy managers at Prof-U. This is reflected in the solutions. For example, when Tech-U finally installed compact fluorescent light bulbs, many were installed in inappropriate locations and manners. The nature of the retrofit program made poor solutions more politically acceptable, and therefore reduced the need for contextual information. Similar conclusions can be drawn for computer control scheduling and motion sensor installation.

Finally, a host of people connected institutionally or geographically to the site of projects (e.g., allocators of resources, safety professionals) carry important information. With decentralization, we expect organizations to have more trouble implementing solutions which span between units. The fact that the first two generations of computer control spanned the faculties at Prof-U diminished implementation incentives (Lawrence and Lorsch 1967).

Power, Incentives and Resources

Power, making people do what you wish, is important for three reasons. First, every change in technology, no matter how simple, changes the social relations between people, [e.g., (Winner 1986)] and therefore potentially threatens everyone affected. For example, compact fluorescent light bulbs make 90% of bulb changers redundant. Second, the decision and implementation processes for any technological change disrupt all people involved. Third, resources which are allocated to a given project are not being allocated to alternatives. Therefore, unless the solution is very robust, the specialist manager must bring on-side every person who can possibly obstruct implementation of a project. This can be done by aligning a project with their interests (e.g., through incentives or simplifying their job task) or through coercion. Important people to consider include workers, users, resource
allocators, and other 'connected' people (e.g., the safety office).

Decentralization, by definition, increases people's incentives. Similarly, people are less likely to behave selfishly in small groups. Therefore, it increases the specialist manager's power over people within her sub-unit, but decreases it across organizational partitions. We see several examples of this being played out in the data. First, for resource allocation, despite their apparently identical capital allocation criteria, people at Tech-U find it easier to raise $1,000,000 than $50,000. Senior management makes large capital decisions. Capital beyond annual allocations must be large to attract attention. Hence, the program with which it installed compact fluorescent bulbs enabled it to package $10.00 bulbs in multi-million dollar contracts. Prof-U facilities managers, in contrast, have reasonably easy access to capital within their faculty's jurisdiction. Beyond that, requests must go to the central university with the dean's support. This is problematic for the smaller, poorer faculties. Hence, the microcomputer-based DDC systems, which are less than the $50,000 cut-off, are easy to acquire. A large DDC system, in contrast, would have required extensive negotiation between Prof-Maint and the faculties. Second, to create incentives, the facilities office in the S.A.S. set up a shared savings program of sorts with the individual buildings at the finish of the formal energy conservation program. Third, at Tech-U, where the energy managers have low power over users, there have been few successful projects within academic spaces. Projects whose costs are borne by maintenance workers, however, are common. This contrasts sharply with the experience at Prof-U, where extensive work has been done in academic spaces. Traditionally, the faculties had little power over Prof-Maint. In order to achieve its 50% energy use reduction, the S.A.S. had to force a renegotiation of the contract joining it to Prof-Maint, and increased its power considerably.

DISCUSSION

I have argued, from rational choice assumptions, that organizations' structures dramatically constrain their decision making. Energy managers must have a greater information acquisition and analysis ability and more power than is required by a given solution. If we neglect risk taking--selection of solutions outside the local bounds--organizations are restricted to solutions whose characteristics fall within the envelope inscribed by these variables. Structure greatly prescribes these capacities, especially if the responsible sub-unit is separate from core activities and has low power. This is because any structural change which increases an organization's capability along a particular dimension penalizes it in another. For example, decentralization increases incentives and contextual information but decreases skills and access to technical information. Table 2 shows the *ceterus parabus* effects of various changes in structure on decision making capacity. Events outside the organization can change the balance of attributes and therefore make more solutions accessible.

Beyond Universities

I argue that this finding extends beyond universities. We can see this generality in several ways. First, the two cases presented here resemble many businesses, rather than universities. They lack many state schools' crippling resource constraints and capital allocation procedures. They have better access to capital than some businesses, and worse access than others. They are larger than many businesses, and therefore can develop reasonable competence if they want. Finally, the energy managers' power has ranged from low at most times to high during key periods. This appears to match that of their industrial counterparts.

Second, the variables are generic, though the balance might differ in business. In industry, we expect power and the ability to master contextual information to be major constraints, while commercial firms, lacking armies of engineers, are more likely to be skills and technical information deficient.

Third, the data are consistent with studies of industrial energy conservation. For example, Ross (1986) notes some firms' hurdle discount rates drop.
Table 2. Effect of Structure and Emphasis Changes on Decision Making Capacity

<table>
<thead>
<tr>
<th>Decentralization</th>
<th>Information (Technical)</th>
<th>Information (Contextual)</th>
<th>Information (Connected)</th>
<th>Power (Lg $)</th>
<th>Power (Sm $)</th>
<th>Power (Workers)</th>
<th>Power (Users)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Decrease</td>
<td>Increase</td>
<td>Decrease</td>
<td>Decrease</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>Delegation</td>
<td>Increase</td>
<td>Increase</td>
<td>Decrease</td>
<td>Decrease</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>Contract Maint.</td>
<td>Decrease</td>
<td>Increase</td>
<td>Decrease</td>
<td>Decrease</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>Priority</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
<td>Decrease</td>
<td>Increase</td>
</tr>
</tbody>
</table>

Notes:

1. Power is divided into four categories; ability to attract large and small amounts of capital and power over workers and users.

2. Blank cells indicate multiple countervailing pressures operate on the category. E.g. Size affects contextual information by attracting better managers but having more isolated facilities departments.


4. All cells indicate *ceterus parabus* changes. E.g. "Size" = effect of a bigger organization without changing other structural features.

with project size while others' are relatively constant. Consistent with this paper, those with the declining hurdle rate are relatively centralized. He also notes that successful energy managers he observed tended to be very entrepreneurial and work hard to get plant-level management support (private communication). This suggests, again, significant internal constraints. Finally, he notes (1986) that firms with an external cash constraint often centralize resources and therefore stop conservation efforts (cf. Hage 1965). He noted further that this is irrational (private communication). For example, one company he studied expended more effort raising money for a major capital upgrade than would be required to save the money through energy conservation.
Implications for Energy Analysis

This approach allows us to better understand successes and failures of various technologies and policy approaches. Successful technologies will be well matched to the organizations they are designed to penetrate. Since few organizations can master both technical and contextual information, unless they are making energy conservation a priority, technologies which require both are unlikely to succeed. Hence, motion sensors, which fall into this category, were not successful for a long time. Similarly, I suspect people in situations where usage patterns are not highly predictable grossly underutilize computer control systems to avoid dealing with users. Just as installing fume-hood microcomputer controllers precipitated organizational conflicts at Tech-U and concentration of energy management in operations and maintenance led to limited building envelope conservation, other technologies which cut across organizational boundaries can expect limited implementation.

The energy conservation literature tacitly recognizes these realities. Solutions which may precipitate conflict, though often feasible, are never mentioned. For example, Prof-U, since 1980 (and still) keeps dormitory temperatures at 68°F on winter days, and drops them to 64°F at midnight. Rationing is not generally advocated as an option. The S.A.S. at Prof-U attained major savings by turning off the hot water for the summer months in academic buildings, dramatically reducing both steam and cooling loads (the steam pipes run through the buildings). Considerable power was needed to get researchers to switch from steam distilled water to alternative sources (reverse osmosis, electrically distilled water, or filtered water.) Again, changes in the fundamental processes by which people use energy are rarely discussed. The converse implication is that policies which overcome internal conflicts in organizations may well open up whole new classes of options.

Within the framework presented here, demand side policy is an intervention which re-shapes the organization’s bounds, modifying the organization, and/or its institutional environment. Policies can either compensate for specific deficiencies within organizations, or they can aim for permanent management changes to eliminate institutional barriers. Several common policy approaches do one or more of these. For example, in many organizations, subsidy programs probably work by increasing the power of the energy manager much more than alleviating a resource constraint. Otherwise, the simple pay-backs of the projects funded would greatly exceed six months or a year. Similarly, encouraging shared savings contractors does different things for different organizations. The contractors enabled Tech-Maint to create a very large project from several which were too small to finance. Also, Tech-Maint could send someone other than themselves into the laboratories to face the faculty. Simultaneously, the project became so large that it didn’t matter if contextual details were ignored. There was no time to worry about them, and so things were just done badly (e.g., motion sensors in computer terminal rooms). At the Small Professional School at Schools, however, the shared savings contractor compensated for the school’s incapacity to acquire and analyze technical information. Finally, as policy agents, consultants and contractors are fundamentally limited to those services which require little contextual information or power.

CONCLUSION

The organizational model of energy conservation decision making I have set out differs fundamentally from an economic model by highlighting the importance of power and incentive distribution and information acquisition and analysis (in its various forms). It also shows how moving closer to a market, through organizational decentralization, does not necessarily improve energy conservation behavior, it simply changes it. In addition to providing insight into the critical dimensions in new technology design, this model provides a tool for analyzing policy. It indicates the need to move from policy models derived strictly from economics to those which treat institutional issues as central.
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