Title

COMMENTS ON PROPOSED AMENDMENTS TO THE REGULATIONS FOR THE DOE RESIDENTIAL CONSERVATION SERVICE (10 CFR Part 456; F.R. 11/12/81)

Author

Harris, J.P.

Publication Date

1981-12-01

LBL-14151

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

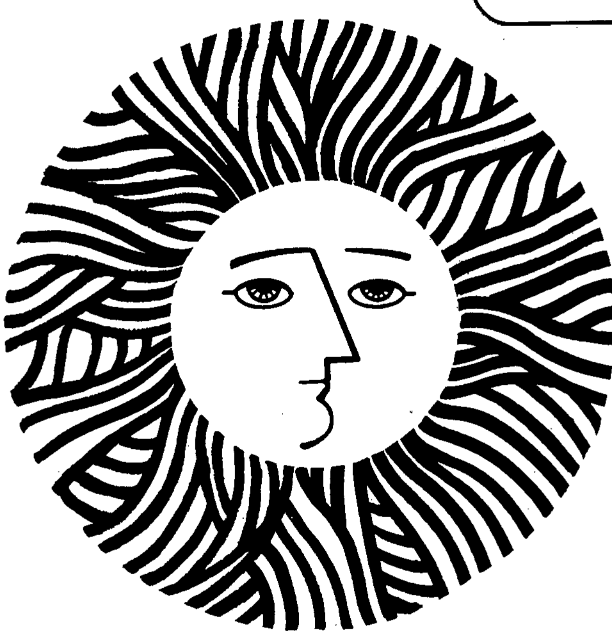
ENERGY & ENVIRONMENT DIVISION

Presented at the Department of Energy Public Hearings, San Francisco, CA, December 11, 1981

COMMENTS ON PROPOSED AMENDMENTS TO THE REGULATIONS FOR THE DOE RESIDENTIAL CONSERVATION SERVICE (10 CFR Part 456; F.R. 11/12/81)

Jeffrey P. Harris

December 1981



Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

DISCLAIMER

LBL-14151
EEB 81-16

50th ANNIVERSARY 1931-1981

Lawrence Berkeley Laboratory
University of California • Berkeley, California 94720

COMMENTS ON PROPOSED AMENDMENTS TO THE REGULATIONS FOR THE DOE RESIDENTIAL CONSERVATION SERVICE

(10 CFR PART 456; F.R. 11/12/81)

DOE PUBLIC HEARINGS
SAN FRANCISCO, CALIFORNIA
DECEMBER 11, 1981

JEFFREY P. HARRIS
VISITING RESEARCHER
ENERGY EFFICIENT BUILDINGS PROGRAM
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720

(415) 486-4362

SUMMARY OF COMMENTS AND RECOMMENDATIONS

DOE has proposed changes (Federal Register, 46:218, 11/12/81) to eliminate or simplify the regulations governing state and utility implementation of the Residential Conservation Service (RCS), contained in 10 CFR Part 456.

DOE proposes to modify the earlier regulations to allow states and utilities some badly-needed flexibility in administering the program. But the proposal also eliminates several provisions that are necessary to assure a program cost-effectiveness, minimum safeguards for consumers' health and safety, and equitable access to program benefits for all residential customers.

In other instances, the sections proposed for elimination would have provided valuable technical guidance to states and utilities without much prior experience in residential conservation. These provisions should be retained in the regulations, but administered more flexibly (or else made advisory rather than mandatory).

DOE has also made it clear, in the introduction to the proposed regulations, that it believes the RCS program is not needed, since rising energy prices will encourage consumers to seek, and utilities and private firms to provide, equivalent conservation actions without the need for a government program. This theoretical view is not backed by evidence.

Indeed, there is evidence to the contrary, that rising energy prices may increase, not lessen, the need for a program like RCS, to accelerate the market's normal response, increase savings and lower the cost of conservation actions, and help assure that low-income and rental households can take advantage of energy-saving opportunities denied them under purely private market mechanisms.

Major points raised in the text include:

(1) There is a well-defined need for a program that fills the objectives set by Congress for RCS:

- DOE's own RECS survey data show that low-income and rental households are far less likely than the general population to invest in conservation, in response to rising energy prices.

- The proposed regulations further hamper the retrofitting of rental units (which are disproportionately low-income, as well) by restricting the definition of program eligibility to those who both own (or occupy) and receive a utility bill for a residence.

- Monitored data for conservation retrofits are not as widely available as they should be, but those that do exist (Attachment 2) show a wide range of savings and cost-effectiveness (three to four times) between the best and worst current practice.

Unless a program like RCS helps the emerging conservation products and services industry to move toward the high end of this achievable range, the cost to consumers in just five years could be in the billions of dollars, due to inappropriate or incomplete audit recommendations, poor product performance, or low quality installation work. The consequent loss of consumer confidence and willingness to invest further in conservation will be even more costly to consumers, industry, and the national economy.

- Data on new residences built during the 1970's (Attachment 3) suggest that the market can lag by as much as 25 years in approaching the levels of energy efficiency that are economically optimal (lowest life-cycle costs). Much of this market lag can be corrected by information programs such as RCS—or, in the case of new homes, building energy labels.

(2) DOE's proposal to eliminate the requirement that RCS audits address low-cost/no-cost "practices," as well as conservation "measures," is counterproductive in all respects, and probably in conflict with applicable federal law:

- Low-cost practices have been repeatedly shown to represent one of the most important and lowest-cost energy saving opportunities. In one LBL study of California homes, these practices represented one-fourth of all potential electicity savings, and one-half of the natural gas savings (Attachment 4). Their total potential amounted to saving California consumers at least $750 million/year, at a fraction of the cost of new energy supplies.

- Practices should always be implemented prior to or in conjunction with more expensive conservation measures; in some cases they can significantly affect the sizing, initial cost, and expected savings from the measures.

- Even though, as ratepayers, low-income and rental households must share the utility's cost of RCS, eliminating the low-cost/no-cost practices from the audit would effectively block many of them from any direct benefits of the program.

- Each state and utility should be required to include in RCS audits an appropriate set of low-cost/no-cost practices, but allowed more latitude than in the original regulations to determine which ones are best for their climate and housing stock.

(3) DOE's proposal to reduce RCS program costs by eliminating measures from the audit purports to address a legitimate concern--the need for increased utility flexibility and reduced program costs--but is in fact seriously flawed:

- DOE is only concerned with the cost side of the ledger, not with program effectiveness in saving energy. Both dimensions are important in achieving what should be the program's objective: maximizing cost-effective conservation in existing homes.

- o Even DOE's concern with costs is too narrow, since it ignores customer costs. There is no point in reducing the cost of RCS to utilities, states, or the federal budget if this will result in even greater increases in consumer costs, due to sub-optimal choice of measures, poor product or installation quality, or overpaying.

- o The regulations should explicitly state that DOE will continue to interpret these (and other) provisions as minimum, not maximum, standards for what states and utilities can do in implementing RCS.

- o Utilities and individual auditors should have increased latitude for including or excluding measures from the audit to meet the needs of each customer, and in general to scale the level of services to the types of residences and initial levels of energy use.

- o At the same time, this flexibility must be accompanied by adequate auditor skills and analytical tools, feedback to auditors on the results of their previous recommendations, and incentives for utilities and auditors to maximize cost-effective energy savings--not just increase the "body count" of audits or recommendations. All of these issues of program cost-effectiveness tend to be ignored or undercut by other DOE changes to the regulations.

(4) Since the cost of an on-site audit is still a valid concern, DOE requirements (and technical assistance) should encourage the best use of that on-site time. One option is for the visit to include actual implementation of some conservation measures, rather than simply recommending actions to the customer. In almost all cases this could include installation of simple, low-cost measures (as several utilities are already doing); in selected cases it could also include more intensive "house-doctoring."

Results of initial demonstrations of house-doctoring (several of which have been co-funded by DOE) are promising, suggesting savings of 20% or more from a combined intensive (instrumented) audit and day-long partial retrofit (Attachment 5). The cost of conserved energy from these demonstration projects is only about half the average residential cost of natural gas.

(5) The proposed seven-year payback rule for including measures in the RCS audit is applied in a one-sided manner. Former measures are dropped if they do not meet the new test, but measures now found cost-effective are not to be included in the audit because this would be too "disruptive."

More significantly, DOE has no plans to review this one-time determination of eligible measures, despite the likelihood (according to DOE's own projections) that after deregulation natural gas prices for the residential sector will double, in real dollars, over the next five years.

(6) Without adequate data on the actual results of the program--which measures were implemented, at what cost, and with what resulant energy savings--neither DOE, Congress, nor the states and utilities

involved will have any sound basis for judging RCS a success or a failure. And yet this is precisely the direction in which we are headed.

The earlier RCS regulations were totally inadequate on the subject of "scorekeeping," and DOE's new changes further weaken the requirements by asking only for narrative information that is easily derived from existing records--regardless of how inexpensive or valuable it would be to collect additional data to see if the program is really working.

DOE regulations should require that all utilities do what a few have already shown is feasible: collect and analyze the data necessary to determine which conservation actions result from the program, their costs to customers and utilities, and their energy savings--measured rather than guessed at.

(7) Assuring the accuracy and completeness of audit recommendations, the effectiveness and safety of products installed, and the quality of installer workmanship are all central to the success of RCS. But they are equally crucial to the market success of the many new private firms that are beginning to provide conservation products and services.

The requirements in the original regulations for assuring auditor qualifications, post-installation inspection, and materials safety and effectiveness should be reinstated--not discarded as DOE proposes--except where they substantially duplicate other federal or non-federal regulations in place and working effectively.

In general, DOE's proposed changes in the RCS regulations seem designed not just to eliminate the least justified restrictions in the earlier regulations, but to eliminate all possible requirements--including those that are vital to the program's success. Thus, the proposed regulations, in concert with DOE's elimination of funding for all RCS support activities, are not a means of streamlining the program to work better or more cheaply, but rather a *de facto* attempt to guarantee its failure.

INTRODUCTION

Good morning. My name is Jeffrey Harris; I am currently a visiting researcher with the Energy Efficient Buildings Program at Lawrence Berkeley Laboratory (LBL), one of the DOE-funded National Laboratories engaged in basic and applied energy conservation research. Prior to that I was with the California Energy Commission for five years. Most of that time I was responsible for statewide energy conservation planning and policy analysis.

My work at LBL has focused on compiling and evaluating data on conservation savings and cost-effectiveness in real buildings, and extending these data to estimates of "least-cost" conservation technical potentials in the buildings sector. I have also studied the economic and institutional barriers to achieving this technical potential, and some of the policy options for overcoming these constraints.

Most recently, I co-authored the Buildings Chapter of the report by the Solar Energy Research Institute on conservation and solar potentials, "A New Prosperity" (SERI/LBL 1981). The study included a number of recommendations on strengthening the RCS program (see below, and Attachment 1).

My comments today will deal with:

- the need for the RCS program;
- the proposed exclusion of important RCS measures and practices;
- the inadequate provisions for monitoring and evaluation; and
- the need for quality assurance through auditor training, validation of computer models, and performance and safety requirements.

These comments express only my personal views. However, at several points I will draw upon the results of recent and ongoing research at LBL, much of which is not yet widely known outside the research community. Unfortunately, in the future it will be even less likely that the results of federally-funded conservation research of value to programs like RCS, will be widely disseminated. This is due to DOE withdrawing almost all support from applied research, demonstrations, and technology-transfer activities, and to the Administration's intent to drastically curtail or eliminate funding for even the basic research work on energy efficiency in buildings.

<u>DOE's intent in revising the regulations</u>. Let me begin by saying that I applaud DOE's stated objective of modifying the RCS regulations to make them simpler and more flexible for states and utilities to implement. This has long been needed, both to encourage innovation and to reduce unnecessary costs to taxpayers and ratepayers.

But many of the other changes proposed would work in the opposite direction, severely limiting the cost-effectiveness of the program. This is perhaps not surprising, given DOE's second statement, that it believes the RCS program should be abolished and will seek the repeal of its authorizing legislation.

I emphatically disagree with this point of view, as the following comments will make clear. My recommendations concerning the proposed changes in RCS regulations are based on the assumption that, as long as the program is authorized by law, it should be administered so as to maximize its chances for success and cost-effectiveness. DOE appears to assume the opposite.

I will argue below that, even as a short-term strategy, DOE's posture is hardly in the interest of states, utilities, consumers, or conservation-related businesses.

Over a year ago I completed work on recommendations for RCS program changes that were included in the SERI report (Attachment 1). The concerns stated then included:

- improving the technical skills of RCS auditors;
- making available better tools for building energy analysis;
- allowing and encouraging a combined audit and retrofit service ("house-doctoring");
- promoting participation in the program by small businesses;
- providing better access to financial incentives and loans for low-income households and for owners or occupants of rental units; and
- strengthening DOE's internal staff and increasing its external technical support to states and utilities.

Sadly, none of these issues has been constructively addressed by DOE. Rather than spending the last year trying to make the program work, the evidence of these revised regulations, along with the dismantling of DOE's RCS staff and funding, suggests that the RCS program has either been ignored, in the hopes that it would go away, or set up for failure.

COMMENTS ON PROPOSED CHANGES

Is RCS needed?

In the introduction to the proposed regulations, DOE states that the RCS program is not needed because rising energy prices and tax incentives are accelerating homeowner conservation efforts, and this consumer demand provides all the incentive needed for utilities and private firms to offer the necessary information, products, and services.

I am led to the opposite conclusion: that rising energy prices and increasing consumer interest in conservation may make a program like RCS all the more essential!

There are two reasons for this. First, the ability to respond to rising energy prices is extremely limited for two rather large groups: low-income families and renters. Second, accelerated demand for energy-conserving products and services is no guarantee, in the short run, that there will be an adequate supply of competent technical advisors, reliable and reasonably priced products, or proper installation services.

The case for limited market intervention, as represented by the RCS program, thus rests on the grounds of both equity and consumer protection--but it is also an argument aimed at strengthening an emerging industry (home energy analysis, retrofit products, and services). Consumer confidence and opportunities to market to the entire residential sector--not just upper-middle class homeowners--are essential to a viable conservation products and services sector, with its multi-billion dollar potential.

Let me offer three pieces of evidence that the need for RCS is increased, not diminished, by recent market trends.

<u>Excluding rental and low-income households.</u>

First, there is the question of participation by renters and low-income households. Data from the Residential Energy Consumption Survey (DOE/EIA, 1981, Table 14) show that, for the 1978-79 period, those who owned their home were nearly three times as likely as were renters to invest in one or more energy-saving measures. The same DOE report found that poor households were only about half as likely to add a conservation measure as were non-poor households.

It is quite clear that rental units, representing about one-third of all homes, are excluded <u>de facto</u> from nearly all price-induced incentives to invest in energy conservation. It is disturbing that DOE's proposed change in the RCS definition of an "eligible customer" would in many cases add a <u>de jure</u> exclusion of renters, by requiring that the customer both own (or occupy) the building <u>and</u> receive the utility bill for it.

This change would exclude from the program those owners of rented houses who, even if they are not billed directly by the utility or heating oil supplier, might still be willing to invest in conservation measures, either to keep a desirable tenant, to make their building more rentable or saleable, to take advantage of tax benefits, or to comply with local or state retrofit requirements.

Although DOE asserts that states will be allowed on their own to extend program eligibility to additional households, there is no justification for DOE to change this definition in its own regulations. It is difficult enough to get rentals retrofitted, why add to the burden? The very use of the term "eligible customer" in the DOE regulations will continue to create an impression--to utilities, private contractors, and the general public--that all others are ineligible.

Good practice vs. bad practice. Beyond the issue of groups that are consistently excluded from market incentives (or the ability to respond to them), there is a need for the RCS program to help the private market respond better to consumer demand for conservation products and services. Evidence for this can be found by looking at the wide range of results actually achieved in retrofitting homes. The only systematic compilation and comparison of such data from around the country is being assembled now through a project at LBL (see Attachment 2).

Based on measured energy use before and after retrofits, the data in Attachment 2 show two things. First, the majority of retrofits (but not all) were cost-effective even at current average energy prices. But even more interesting was the significant range of results, in terms of both energy savings and cost-effectiveness.

Figures 2(a), 4(a), and 4(b) illustrate most clearly that, even when retrofitted homes are grouped by similar levels of conservation investments or initial energy intensities (in MBtu/1000 sq.ft.), their savings and cost-effectiveness (measured by the cost per unit of conserved energy) can differ by factors of three to four times!

Certainly some of this range is due to different physical conditions in the buildings, occupant behavior, and differing owner preferences. But a great deal is also due to the varying quality of auditor recommendations, products and materials used, and installation workmanship.

This difference is non-trivial--for consumers, utilities, and their ratepayers. At the rate of program participation once envisioned by DOE (7 percent of households would install a total of 41 million measures each year--see DOE [1979]), the difference between retrofits performing at the low end of the range of recent experience, and those at the high end could easily amount to several billion dollars, cumulatively, over the first five years of the RCS program.

Market lag. The third piece of evidence on the need for RCS concerns the built-in time lag in the market's response to rising energy prices. Unfortunately, this evidence is somewhat indirect in the case of retrofits; the only quantitative data come from the new residential sector (Levine/McMahon, forthcoming). Attachments 3(a) and 3(b) compare energy usage estimates for actual new homes built from 1973 through 1979, to the energy use that would have been achieved if these homes had instead been built--as market rationality dictates--to minimize lifecycle energy costs.

For electrically-heated new homes, the market lag can be as long as 25 years; for gas-heated residences it is only slightly less. Similar data on the market lag for residential retrofits are needed, buthave not yet been collected.

A program like RCS was designed precisely to help reduce this market lag, in the interest of consumers and utilities alike.

Eliminating Conservation "Practices" - Why Save Energy Cheaply?

DOE's proposal to eliminate the "low-cost/no-cost" energy conservation practices from the RCS audit (formerly in Section 456.307(b)(1) of the regulations) makes absolutely no programmatic sense--that is, in a program designed for success rather than failure.

This is true even if DOE continues to require that a list of such practices be included with the program announcement, and even if states are free, in principle, to include such practices in the RCS audit on their own.

The importance of "practices." First, it is clear from a number of studies (including DOE's own well-known experiments with a "low-cost/no-cost" conservation demonstration project) that a significant fraction of the energy savings in homes--and most of those that are extremely attractive in terms of cost per unit of energy saved--can be achieved through low-cost/no-cost "practices."

Attachment 4 provides one detailed example of the potential contributions from low-cost practices to a comprehensive residential conservation program. The material is excerpted from a recent LBL study of energy-saving opportunities in existing California homes. The basic approach was to array several dozen conservation measures in order of increasing unit cost-of-conserved energy. This creates what economists will recognize as a conventional "supply curve," in this case a supply curve for conserved energy.

By examining the components of the two supply curves, one for gas-heated homes and one for all-electric homes, we find that over one-fourth of all the potential electricity savings, and more than one-half of the potential natural gas savings, would results from low-cost/no-cost "practices." Adding these together, and valuing savings at today's average energy prices, this translates into a potential for saving residential customers more than $750 million dollars annually--just in California--if these simple, low-cost measures were implemented throughout the state!

(Note that Attachment 4, and the study from which it is drawn, look only at the technical and economic potential for conservation; they stop short of considering the degree to which this potential might actually be realized through market forces and utility or government programs. Also, the items considered as low-cost "practices" in California homes differ somewhat from those listed in the previous version of the RCS regulations. Window shading, for example, was not considered in the California list, but replacing incandescent bulbs with screw-in fluorescents was.)

Legal requirements. I must disagree with DOE's finding that section 215(a)(4) of NECPA does not require the "specific identification of energy conserving practices, and therefore that the decision whether or to include them can be left to the states. The law seems fairly clear in that particular section, calling for:

"...suggestions of energy conservation techniques...such as adjustments in energy use patterns and modifications of household activities which can be employed by the residential customer to save energy and which do not require the installation of energy conservation measures..."

Technical issues and equity. But whether or not the law specifically requires energy-saving practices to be included in RCS audits, there is no doubt that they are needed to carry out Congress's intent for the program. This is because a failure to encourage them, prior to recommending that consumers install more expensive measures, will mean that:

- auditors will be likely to provide misleading estimates of energy savings and paybacks from the expensive measures. For example, recommended R-values of added insulation might be too high, if the effects of thermostat set-backs are not taken into account.

- failure to implement some low-cost items might actually preclude (or at least increase the expense and difficulty of) installing other retrofit measures. One well-documented example is the need to plug air leaks from the house into the attic before installing attic insulation. Once the insulation is in place it becomes far more difficult to find and fix the air leaks.

There is also an equity issue at stake. Many low-income households (who are also contributing as ratepayers to the cost of RCS) may be unable to afford much beyond the low-cost or no-cost practices--yet DOE's proposed change would deprive them of an auditor's help in identifying which measures made the most sense in their home.

The question of whether or not to include low-cost practices as part of the RCS audit should not be ignored in the regulations. They are one of the least costly and least onerous requirements--especially given their possible payoffs.

Each state or utility should be required to include such measures, but allowed more flexibility than was provided in the original RCS regulations to determine which items to include, for its climate and building stock.

Eliminating "State Measures" - When Does a Floor Become a Ceiling?

It is difficult to disagree with one objective stated by DOE in its preamble to the revised regulations: that states should be allowed to add their own measures to RCS audits without the necessity of DOE approval. But does the simple striking of all references to state measures accomplish this? Or do the DOE provisions become, in the absence of other guidance, a floor rather than a ceiling for most states? The same questions apply to DOE's exclusion of passive solar measures and others found to be cost-effective under the proposed new 7-year payback rule--on the grounds that states are of course free to include such measures on their own.

At a minimum, the states' implicit option to add measures as they see fit should be made explicit in the regulations, not just mentioned in DOE's commentary when proposing them. Also, most states will want to administer their programs from a single planning document, rather than prepare a separate, complete plan plus an abridged version for DOE.

Therefore, the regulations should make it clear that conservation measures (or other program elements, such as auditor qualifications or consumer protection) that states wish to include to strengthen their RCS programs will be accepted by DOE, so long as the "minimum" federal requirements are met. States should have no grounds for concern or uncertainty whether submittal of a more aggressive program document will jeopardize prompt, unbiased DOE review and approval.

Failure to do this would mean that DOE has turned its presumed "minimum" requirements into pre-emptive, maximum ones.

Of course, it is also clear that a full class-A (on-site) RCS audit, because of its cost, is inappropriate and inherently non-cost-effective for many customers with low initial levels of energy use, or few options for major conservation retrofits. Both utilities and their auditors need the administrative flexibility to eliminate from the audit measures that are obviously not relevant, and, more generally, to scale the level and type of RCS services to each type of customer, to improve cost-effectiveness of the overall program.

At least one state, California, is taking the initiative to increase the range of services offered under the RCS program, to scale the level of effort to the circumstances of each customer, and to test new service-delivery concepts through well-monitored utility demonstration projects. All of these represent program- optimizing efforts abandoned by DOE, and thus far less likely to occur in states with less extensive conservation experience.

To add one positive note: I am heartened to see that DOE proposes to eliminate the requirement (formerly in Section 456.307(e)(1)) that formerly restricted an RCS auditor from providing estimated savings or costs for any measure not on the approved list. Auditors need this increased flexibility--but at the same time they need the technical skills and organizational incentives to use it wisely (issues we return to below).

Reducing Costs vs. Reducing Cost-effectiveness

I have a more general concern with one of DOE's assumptions that apparently underlies efforts to reduce the number of measures included in RCS audits. As stated in the introduction (p. 55840):

> "DOE estimates that the audit is the single most expensive RCS program element. By reducing the requirements for an audit, DOE proposes to significantly reduce program costs."

First, the Department is correct in identifying the on-site audit as the most expensive single element of the RCS program. But if this is the case, it would seem obvious that the objective should be to both improve its impact and, where feasible, reduce its cost. What is missing from the DOE formulation is any real concern with the effectiveness side of the equation. (Again, this is not inconsistent with DOE's objective to reduce the cost to zero, once the program itself is eliminated.)

If we are concerned with effectiveness, we need to consider each link in the chain:

- the accuracy and completeness of auditor recommendations (which in turn depend on their skill and training, validity of the analytical tools available to them, and degree of feedback they get on the accuracy of their past recommendations, once implemented);

- the likelihood that the customer will be willing (and able, given adequate financing) to invest in most or all of the recommended actions--and to implement the recommended low-cost conservation practices; and

- the quality of products and installation work.

As noted below, it is precisely these determinants of RCS audit effectiveness that the proposed regulations are trying to remove. Once this is done, it will matter little to the program's cost-effectiveness how much the cost per audit is reduced.

But even on the cost side, "program" costs to utilities, state agencies, or DOE cannot be looked at in isolation from consumer costs. Ultimately, it is the same people who wear the hats of ratepayer, taxpayer, and RCS customer. If eliminating utility or government costs for the RCS program results in substantially higher costs to consumers who invest in conservation--because the wrong measures were recommended, the customer was not encouraged to shop for the best deal, or the products or installation were inferior-- where is the cost savings?

One final point concerns the expense of an on-site audit. Since a major part of this cost involves the time and expense of simply getting the auditor to the building site, it may make sense in many cases to have the auditor do something to actually improve the home's energy efficiency before leaving. The result of the visit, then, is not just a better-informed customer, but actual changes that will begin to save the customer (and the utility) energy and money.

At one end of the spectrum, the auditor could leave with the homeowner, or actually install or demonstrate, a few simple, low-cost items. Examples include water heater insulation blankets, low-flow shower and faucet fittings (along with adjusting the water heater storage temperature, where needed), and replacing clogged furnace filters.

A number of utilities are already doing this as part of their "pre-RCS" conservation programs; if DOE were concerned about the cost-effectiveness of the program, not just the cost of each audit, it would strongly encourage or even require(!) such helpful, low-cost actions as part of the audit.

At the other extreme is a combined audit and partial retrofit, including low-cost measures and an intensive one-day effort to find and fix air infiltration leaks. This process, termed "house-doctoring," is based on several years of field research work, mainly at Princeton University and LBL. House doctoring is now relatively well understood within the research community, but has yet to become a common feature of utility programs or private contractor services.

However, this situation may be starting to change. A few private house-doctor firms are becoming established, several franchise organizations are being formed, and a few utilities are beginning to experiment with house doctoring demonstration projects. The results of one such demonstration, sponsored by the Pacific Gas and Electric Company and LBL, are shown in Attachment 5 (excerpted from LBL's 1980 Annual Report).

The preliminary data in Attachment A show that, for an additional cost of about $365 beyond the standard RCS audit, infiltration reductions of about 30 percent can be achieved (and validated with actual measurements, which are an integral part of the process). Combined with the other low-cost measures installed during the house-doctor visit, this translates into substantial energy savings that cost only about $.22/therm, even in the mild climate of the San Francisco Bay area. Larger and less expensive savings are likely in other parts of the country.

The data from this project and from a larger demonstration now underway at Princeton, involving several local utilities, strongly suggest that DOE should be at least allowing, if not actively encouraging, utilities to add house doctoring to their RCS programs--at least as an option that customers can elect when requesting their audit.

This may mean additional changes in the RCS regulations (e.g.- utilities that perform audits can now install measures, including house-doctoring measures, but private house-doctor firms should also be allowed to perform the RCS audit in the course of their house-doctor visit). But it will also require continued DOE support for utility and private industry demonstrations of house-doctoring, a function that has recently been eliminated along with other budget and programmatic cuts.

Changing the Payback Rule for Program Measures - A One-edged Sword

There are legitimate objections that might be raised to DOE's choice of a criterion as conservative as seven-year simple payback, as the basis for deciding what measures will even be considered as candidates to mention to consumers. But my real concern is less with the seven-year payback rule than with the possibility that, in practice, it may become a ceiling--limiting what measures states and utilities treat as potentially cost-effective--rather than a floor (as DOE says is intended).

An even greater difficulty arises from the way DOE proposes to use this payback rule in the revised regulations. On the one hand, measures that were assumed cost-effective under the old rule (passive solar, intermittent ignition devices) are excluded now, and yet measures such as storm windows and floor insulation, that DOE finds cost-effective under the new payback rule (thanks to recent increases in energy prices) are not included as RCS program measures. This is apparently due to DOE's concern that including them would create complexity and confusion for states and utilities at this late date in the planning process.

It seems strange to argue that including measures is inherently more disruptive than dropping them--especially in the case of storm windows and floor insulation, which are not exactly technically complex or unknown to either utilities or contractors.

My third and most important concern with the payback rule is the implication that DOE will not look ahead even a few months, to the changes that are expected (and actively sought, as part of Administration policy) in residential natural gas prices, due to price deregulation.

The Department itself predicts a doubling of natural gas prices to the residential sector over the next five years (DOE/OPPA, 1981, Table 3-1). Note that this doubling is in real dollars, net of general inflation.

Clearly, this rate of change in energy prices will radically affect, within the next few months, the determination of which measures are cost-effective, even under DOE's conservative payback rule. If DOE is not willing to change the rule now, to anticipate these imminent price increases, it should at a minimum plan to reopen the question in no more than twelve months.

RCS is Like Football - No Scorekeeping Means No Winners

The section concerning recordkeeping and reporting for RCS (456.316) is little short of scandalous--but so was the earlier (November 1979) version of this same requirement.

In the proposed regulations, the only data called for are the number of audits and other services provided, the costs to utilities, and the number of customer complaints lodged. All of these concern program inputs or procedures--there is no mention made at all of program results: what measures were actually installed (or practices undertaken) as a result of audit recommendations, how much energy was saved, and at what total (utility plus customer) cost?

In the absence of these data on program results and cost-effectiveness, as well as inputs, it will be impossible for DOE, Congress, or anyone else to determine whether or not RCS is worthwhile.

For DOE, this question has apparently been answered already, based on predispositions, but for the rest of us, verifiable facts would be preferred.

Congress's General Accounting Office (GAO) apparently agrees with this. In a long series of reports on energy conservation programs, GAO has repeatedly argued the need for better data on energy savings and cost-effectiveness, and vigorously criticized DOE (and others) for its lack of attention to data-gathering and evaluation. GAO's most recent statement of this theme is in a report on the Low-income Weatherization program (GAO, 1981), but the comments made there apply equally well to RCS.

In the absence of both specific guidance in the form of regulations, and an aggressive technical assistance program from DOE, it is extremely unlikely that states and utilities will collect the necessary data, or be able to analyze it efficiently and thoroughly.

Evidence for this can be found in the recent history of the Weatherization program. In a report prepared at DOE's request, a consultant evaluated the quality and completeness of state-level data on the results of retrofitting low-income houses (Urban Systems Research, 1981). The report concluded that, even though all states were required to obtain and analyze such data, only a handful had managed to compile data that were reasonably complete and reliable. In no cases were the data fully satisfactory.

Rather than strengthen the program's monitoring and evaluation provisions, through modest additions to the present regulations and greatly increased technical assistance, DOE has chosen to further weaken the data-gathering and reporting provisions in the original regulations by calling for only a "narrative evaluation of the effectiveness of the program, and not requiring states to provide <u>any</u> information unless it is "easily derived from available records" (section 456.316(b)(1)). And the proposed regulations allow the Assistant Secretary to waive even these modest requests!

DOE's introduction to the proposed regulations invites comments on other types of information that could be easily derived and could assist DOE in evaluating the effectiveness of the program. In response, I would suggest three types of data that are not only of assistance, but <u>crucial</u> to evaluating the program on any basis other than hearsay:

- A record of what <u>conservation actions</u> (measures and practices, if possible) were undertaken by customers in response to the RCS audit, and their reported costs. These data are already routinely collected by utilities offering direct loan financing, as well as by several utilities using engineering/end-use demand forecasting models that require data of this sort. Others could collect it, at modest cost, using sample surveys.

- Monitoring, again on a sample basis, the changes in <u>billed energy use</u> for those receiving audits, those taking action, and one or more control groups (including customers who undertake conservation actions without an RCS audit). Billed energy use data are, of course, available virtually free to any utility with an automated billing system, although there are some needs for coordination among utilities and oil suppliers, for those customers served by more than one entity. These energy use records have to be adjusted for changes in weather, household occupants, and other factors unrelated to efficiency, but the methods for doing this are reasonably well-established (as exemplified in Attachment 2).

- Validating the conservation savings estimated by engineering calculations or computer simulation models, through limited on-site measurements in actual retrofitted buildings. This sort of work is really essential, and can be done on a very small-sample basis (as long as it is a well-chosen one). It is an obvious candidate for cost-sharing among utilities in the same region, and for participation by DOE and the National Laboratories. At this point, a handful of utilities are doing measurements of this sort. While more should join in, what is even more needed is an improved mechanism for the regular exchange and professional critiquing of methods and results.

Quality Assurance for Audits and Retrofits

As noted earlier, there are two main elements of quality assurance needed in the RCS program: assurance of auditor competence (and audit method validity), and provisions for adequate performance and safety of the measures actually installed. Both are crucial to the success of the program, initially and in the long run. There have already been too many examples of poor performance in specifying conservation measures and in producing or installing them, with the predictable unfortunate consequences for consumer willingness to invest further in conservation.

In the case of auditor qualifications, I have little difficulty with DOE's intent to give states more leeway, but the proposed changes go far beyond this. They now tell states only to "require that auditors are qualified," but fail to ask the states themselves to demonstrate that mechanisms are in place to assure this. Demonstrating this was a very explicit state responsibility under the former RCS regulations (sections 456.314 (a) and (f) in the November 1979 rules).

While keeping the more general formulation regarding precise methods of assuring auditor competence, the RCS regulations should restore the earlier language to make it clear that a state must have some means to accomplish the intended result.

The same point applies to qualifications of RCS installers and inspectors, under the proposed new rules.

Equally important is the need for post-installation inspection of at least a sample of the measures installed under each utility's RCS program. The old rules may have been unduly specific in this area, as in many others, but removing the provision altogether does nothing to address a real problem (see Kubitz, forthcoming).

The proposed regulations should once again establish it as each state's responsibility to develop a reasonable program for post-installation inspection, and to make public the data each year. Some basic requirement that assures statistical validity of the sampling results should also be included, but the trade-offs between added inspection costs and increased quality assurance are best left up to states, working with their utilities and contractor organizations.

I would recommend a similar approach to requirements for safety and effectiveness of materials and installation performed under the RCS program. Rather than simply eliminate the complex provisions of the 1979 regulations, DOE should firmly establish that these quality control functions are the responsibility of the states (where not already provided by other state or federal regulations), and require each state plan to show how they are being met and to monitor enough installations to verify this.

Where requirements specific to RCS duplicate others already in place, they should of course be dispensed with. But instead of this common sense test, DOE has proposed a criterion with a grossly unbalanced burden of proof: demonstrating actual harm to health and safety in a significant number of cases, not just a reasonably likelihood of harm. This is akin to refusal to prevent an epidemic, when the vaccine is readily available, until there is an actual body-count.

I might add that it is particularly ironic for DOE, in the proposed regulations, to ask for commentors to submit "additional data on health and safety risks" of RCS measures when the Administration is currently engaged in dramatically cutting back and quite possibly eliminating its own involvement in research on these same issues. This includes, notably, research on the indoor air quality consequences of reduced air infiltration in homes, and on possible means of mitigating any health risks.

CONCLUSION: THE FREEDOM TO FAIL?

A careful reading of the proposed changes to the RCS regulations tends to lead to just one conclusion: that states and utilities are being left with a special kind of "freedom" from the excessive restrictions of the original regulations--the freedom to prove that RCS will not work.

DOE has not only eliminated all of the genuinely restrictive and unnecessary rules, but also those that were truly central to an effective, efficient, and equitable conservation program. It has also proposed to eliminate, not only in the Federal Register but in the federal budget, any information or resources that might have provided useful guidance to states and utilities with a genuine concern for the "right way to implement the program." The problem is merely intensified by DOE's explicit statement, in the introduction to the proposed changes, that it does not believe the program should even be seriously tried.

DOE may express dismay at not being able to scuttle the legislatively authorized RCS program outright, but by casting states and utilities adrift in this fashion, it is doing the next best thing.

ACKNOWLEDGEMENT

This work was supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Buildings and Community Systems, Buildings Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

REFERENCES

(1) K. Kubitz, "Conservation Consumer Protection: Quality Control or Regulatory Lag?", in Proceedings of the 1980 ACEEE Summer Study on Energy Efficient Buildings (forthcoming).

(2) Lawrence Berkeley Laboratory, "Energy and Environment Division Annual Report, 1980," May 1981 (LBL-11985).

(3) M.D. Levine and J.E. McMahon, "Residential Energy Conservation and Market Behavior," LBL Report in preparation.

(4) Solar Energy Research Institute (and Lawrence Berkeley Laboratory), "A New Prosperity: Building A Sustainable Energy Future," Brick House Publishing, Andover, Massachusetts, 1981.

(5) U.S. Congress, General Accounting Office, "Uncertain Quality, Energy Savings, and Future Production Hamper the Weatherization Program," October 26, 1981 (EMD-82-2).

(6) U.S. Department of Energy, "Regulatory Analysis of the Residential Conservation Service Program, October 1979, (DOE/CS-00104/1).

(7) U.S. DOE, Energy Information Administration, "Residential Energy Consumption Survey: 1979-1980 Consumption and Expenditures" (part 1), April 1981 (DOE/EIA-0262/1).

(8) U.S. DOE, Office of Policy, Planning and Analysis, "Energy Projections to the Year 2000," July 1981 (DOE/PE-0029).

(9) Urban Systems Research and Engineering, Inc., "Analysis of Preliminary State Energy Savings Data," Task 8, Draft final report to DOE, Contract # DE AC01-79CS63021, April 1981.

Attachment 1

(Excerpt from SERI/LBL, 1981)

Strengthen the Residential Conservation Service Program

The programs described thus far are designed to reinforce private market mechanisms by generating better information on energy use and efficiency, and by ensuring that the information is adequately communicated. The Residential Conservation Service (RCS) program is designed to encourage utilities to move actively to broaden their investment portfolios with investments in building. The program should be adjusted to encourage smaller, nonregulated enterprises to benefit and to respond more immediately to the products of applied research program just described. In addition, this program should be recognized as possibly the most effective means of providing homeowners with specific information on the possible investments in their residence, encouraging their undertaking cost-effective measures, and facilitating a more productive use of capital by providing easy access to financing.

Five major changes in the currently authorized RCS program are recommended:

- improving the skills of energy auditors;
- allowing or requiring auditors to make simple retrofits during their visit to the residence;
- providing incentives for private auditing firms not associated with utilities, and direct federal credits for homes served by oil and bottled gas companies;
- providing easy access to financing through the RCS process; and
- increasing the DOE staffing effort for RCS at both Washington and Regional office levels.

Improving the Skills of Auditors

The key to a successful nationwide home-energy-audit program is the development of a sufficient number of auditors skilled in determining the most economical way of saving energy in homes, and in persuading the owners of the buildings to take action on the recommendations. This requires both technical skills and a talent for dealing with people. A program capable of meeting the conservation and solar potentials described in this analysis would require approximately 10,000-20,000 auditors working for 15-20 years.

Plainly, recruiting, training, and continuing to refine the skills and knowledge of such a large number of auditors will be a major challenge. The program for training these individuals should be carefully integrated with the applied research program discussed earlier. In that program, it was suggested that 5000 carefully measured and monitored retrofits be undertaken each year over a 5 year period. If auditor training (and re-training) were made an integral part of this program, it would allow the thorough training of 20,000 auditors, each of whom had participated in 30-40 well-documented retrofits (assuming that two auditor-trainees participate at each retrofit site).

A program for improving the knowledge and abilities of RCS auditors should consist of the following:

- An Intensive Training Program. The federal government should subsidize the training of auditors by providing text materials, equipment for training facilities, and scholarship funding for individuals interested in receiving training in these skills. It may be most attractive to undertake these training programs in technical colleges and schools which are located in most parts of the nation. It seems possible to give an auditor rudimentary skills in auditing in 6-8 weeks; a one-year program, including periodic classroom sessions and supervised field experience, should be adequate to train a skilled professional.

- Auditor Certification. While each state RCS plan must provide some form of qualification procedure for RCS auditors, states should be encouraged to more formally certify or license skilled auditors. If necessary, the federal government may need to require that states have such certification procedures to be in compliance with the RCS statute. The federal government could provide assistance by developing a model certification program. Certification should require completion of an approved training program, as well as at least 6 months of supervised apprentice work. Examinations could be used to test the applicant's understanding of energy flows in buildings, practical skills in identifying and correcting defects in buildings, use of diagnostic equipment, familiarity with all efficiency and solar energy techniques which are likely to be employed in that region's climate and building stock, and communication skills needed to persuade homeowners to follow through on recommended actions.

- Subsidizing the Purchase of Diagnostic Equipment for Auditors. Several readily available measurement devices can be used to improve the quality of audits. For example, pressurization systems and hand-held infrared scanners have proven useful in identifying sources of heat leaks in buildings, and flue-gas analyzers can be used to time furnaces and water heaters for improved combustion efficiency. Calculation of an appropriate set of recommendations can be speeded and simplified with the use of hand-held programmable calculators at remote computer terminals. The federal government could encourage the use of this equipment by providing direct grants to utilities and other qualified auditing organizations for the purchase of such equipment.

- Feedback to individual auditors. A final means of improving the quality of residential audits is to provide for regular feedback to individual auditors, on both the accuracy and completeness of their recommendations, and their personal effectiveness in persuading building owners to take action. Under the federal regualtions for state RCS plans, each utility must make some provision for monitoring the results of audits, through follow-up inspections and other means. The results of all such follow-up visits, even if done only on a sample basis, should be routinely made available to the individual auditor, in order to sharpen his or her analytical skills and ability to communicate recommendations.

DOE is already committed to providing assistance to auditor training; $25 million was provided for FY's 1981 and 82. It is important that this program continually advance the capabilities of state auditor training programs, and minimally be maintained at that budget level through the next 3 to 5 years.

Partial Retrofits in RCS Audits

The RCS regulations should be changed to encourage or require that all residential and small-commercial audits include at least some immediate partial retrofits with measures that are quick and economical.* Utilities should also provide those customers who don't receive utility audits with vouchers to obtain comparable (free or comparably subsidized) materials to do their own low-cost partial retrofits, or obtain such services from private home-improvement contractors.

A number of retrofit items are so inexpensive and simple to install that once a trained utility auditor is already visiting the residence or commercial building, it makes no sense to leave these measures for possible later follow-up by the customer—which requires additional effort, as well as increased expense. In general, those measures which can be installed in about an hour or less, require little training or specialized equipment, and create few concerns for safety or other side-effects, are good candidates for immediate onsite retrofits. Examples of such measures include water heater insulation in some commercial buildings as well as residences, low-flow showerheads and faucet fittings, adjustment of refrigeration doors and seals, and in many cases demonstration of caulking and weather-stripping products and techniques. A number of these measures have paybacks of a year or less, and in many service areas it would probably pay for the utility to simply provide the materials free (or at a very nominal, subsidized charge) as part of the audit package--based on the utility system savings (replacement energy costs minus average customer costs). Incorporating immediate, partial retrofits as part of the RCS audit would serve as an incentive for more customers to sign up for audits, would be equally applicable to rentals as well as owner-occupied buildings (unlike many of the more expensive retrofit options), and would provide at least some guaranteed savings as a result of the very first visit of an RCS auditor.

The choice of measures to be included as "immediate partial retrofits" could be left largely to state regulatory agencies, within some rather broad federal guidelines concerning auditor time, materials cost, and cost-effectiveness.

To help alleviate concerns over anti-competitive practices, and to reach customers who do not choose to participate in the RCS program (including those who have previously been audited and/or have retrofitted on their own), utilities should also be required to offer comparable subsidies for low-cost partial retrofit measures in the form of vouchers. Customers could use such vouchers to purchase the materials from retail outlets and install them on a do-it-yourself basis or through contractors. Likewise, utility vouchers should be applied to energy audits by private firms, including low-cost partial retrofits. Not only will this help alleviate anti-competitive concerns over partial retrofits by utility auditor, will also encourage healthy competition in the audit field.

*In many cases, the inclusion of partial retrofits will be of advantage to the utility, the homeowner and the public.

Specific federal actions include:

- o Changing the RCS regulations to require that utilities offer their customers an appropriate package of immediate partial retrofits, either at no cost to the customer or at a reduced cost. Also, requiring utilities to develop an optimal system of vouchers for those customers who prefer to obtain the materials or audit elsewhere.
- o Monitoring the utilities' choices of retrofit measures, customer response to each element of the program, and the resultant costs and energy savings; and revising the regulations as needed.

Provide Encouragement for Private Auditing Firms

While utilities represent a major resource for providing audits for many customers within their service territories, there is also a clear need to encourage the growth of qualified private auditing firms. Such firms can provide needed competition for utility audit programs thereby improving the quality of RCS audits. Private firms may provide the only acceptable source of audits for homes not heated with electricity or pipeline gas, or for customers whose servicing utilities have not embraced the RCS program with enthusiasm because of overcapacity or some other reason.

Finally, the creation of a competent, well-trained private sector energy audit "industry" offers an important buffer against the possibility of a sudden upsurge in demand for audit and retrofit services--in the event of an emergency fuel curtailment or sudden jump in oil prices, for example. DOE should extend to these firms the same support services it provides to utilities. Man of the program initiatives described ealier would also be of direct benefit to the private auditing firms, including: auditor training, grants for purchasing diagnostic equipment, and applied research programs.

In addition, the RCS regulations should be amended to require that utilities offer to share costs with private auditing firms that provide at least comparable services to their customers and meet RCS requirements. The utility share of costs should be at least equal to the cost of audit conducted by the utility itself. Thiscould be done either through physical voucher or by the utility making payment directly to state-certified auditing firms. Of course, provisions whould be made to spot-check the audits conducted under this program to ensure that audits by private firms meet the federal and state standards. Customers should have effective means of recourse if audits are not adequate, just as with utility company audits.

Private auditing firms, moreover, will be especially useful in regions where a significant fraction of the homes use oil or bottled gas for heat. In these cases, the RCS program currently relies upon the oil jobbers to provide audit services. While it is reasonable to expect that at least some utilities would be willing to partially fund a private firm audit for its customers whose primary energy is oil or bottled gas (since the utility is fulfilling its legal requirement under RCS without the need to hire and train additional personnel) there will be little enthusiasm to make major inroads into these markets due to a lack of any clear economic incentive. The oil jobbers may be willing to undertake audits, but will either be faced with "hiding" the audit cost by increasing retrofit costs or be placed in a poor competitive position with utility audits which are largely rate-based or expensed. While the oil heating market should be the immediate focus of RCS, it seems to have been side-stepped by the legislative structure of the program.

The federal government should provide funding for a voucher program involving audits by qualified energy audit firms for all owners of residential units heated by oil or bottled gas at least on a demonstration basis. Including administrative costs, these vouchers might cost $150-$200 each. In some cases, the oil jobbers may find it attractive to extend their line of work and offer such audits themselves if they can hire or affiliate with trained RCS auditors. This could offer them the further advantage of a more stable income, during periods of widely fluctuating oil prices and supplies.

Since approximately 31% of all housing units use a fuel other than electricity or utility supplied gas, the total cost of supporting such audits will be high. Some additional source of revenues must be found to pay for the audit if this program is extended nation-wide. One possibility would be a 2.5 cents/gallon tax, which would cover the full cost of such audits, or a proportionally lower tax covering a portion of the audit cost. Whatever system is used, even considering general revenues, the extension of RCS to oil and bottled gas heated residences would correct a flaw in the current structure of the program and could have a significant impact on our current oil import problem.

One-Stop-Shopping Loans

Recent analysis has shown that few individuals are taking the extra steps or are willing to pay today's high interest rates to finance retrofits with the available home improvement loans (Sandra Rennie, Aceee Summer Study). Instead they are relying on savings and out-of-pocket funds. In order to extend conservation actions beyond a certain segment of the market (middle- and upper-income homeowners), and to increase access to the more expensive measures which have an even higher savings potential, it is important that loans be easily arranged at the same time that the auditor is explaining his recommendations to the building owner. If the owner finds it necessary to both shop for products and installers and to arrange financing himself, it is likely that many potential customers will find the process to be too troublesome, time consuming, or otherwise risky, and many promising retrofit investments will not be made. If the auditor is able to offer the client a single form which describes the recommended options, the contractors who can do the work, the financial institutions able to provide full financing, all available tax credits or other incentives (like grants from the Conservation/Solar bank), and offers to handle the contracting and financial arrangements for the homeowner it is reasonable to expect a much higher response rate, and significant amount of financing of more expensive but still cost-effective retrofits will result.

The RCS program should proceed rapidly with its currently planned demonstrations of a "one-stop-shopping" approach to loans, and if these demonstrations prove successful, require such a program nationwide by 1983. In the interim, DOE should pay careful attention to the compliance with existing requirements for utilities to facilitate financing, and insure that the intent of the law is being met.

Need for Expanded DOE Staffing of RCS

The current staffing of the RCS program by the Department of Energy is completely inadequate. For a major program of its nature and scope, particularly one with its experimental nature, a staff of 20 or 30 in Washington and representatives in the DOE regional offices would seem minimal to support the required state and utility programs. For the past year efforts have been underway to increase the staffing of the RCS program, however, they have proceeded slowly. This should be corrected immediately, and the RCS program should be allotted the necessary qualified staff.

Programs for Low-Income Households and Rental Housing

Actions recommended under this program are:

- development of a program to shift the funds (available from the Windfall Profits Tax Bill) from fuel-bill subsidies to permanent savings, through weatherization of low-income households;

- development of an experimental grant program for low-income households, which, if successful, should be expanded nationwide by 1984;

- financial support for state and local demonstration programs for conservation in rental buildings; including financial incentives, local retrofit mandates, and programs aimed at tenant information and energy-using behavior; and

- inclusion in the Energy Management Partnership Act of a requirement that states develop specific plans to address rental buildings.

The number of housing units occupied by renters and low-income families is large--representing 30 to 40 percent of all residential units. Many of these low-income and rental dwellings are among the worst energy wasters. When categorized into low-, medium-, and high-energy efficiency; nearly twice as many low-income and rental dwellings fall into the "low" energy efficiency rating (66 and 51 percent respectively).

The programs described previously have assumed that households are able to respond to information made available to them about economical retrofits. Low-income families and families living in rental housing, however, may be unable to take advantage of this information or of the many forms of financial incentives (like low-interest loans or tax credits).

For low-income households, large-scale retrofitting can only be accomplished thru some form of direct financial assistance such as that now available through the weatherization program. Approximately 16 million units now qualify for this program, but only a fraction of these will be served in the next ten years at the present level of funding. These households are the ones most often forced to respond to rising fuel bills by sacrificing comfort and health. Thus, improvement in these units should be measured by improvements in living conditions as well as the net energy that can be realized. From either viewpoint a more effective way of approaching low-income housing must be implemented.

Designing programs to assist renters has proven extremely difficult. While financial incentive programs that have been available to the rental market have received poor responses, such programs have been limited since the rental market has rarely been specifically addressed by utility or government initiatives. In addition to financing programs, there are a number of actions that should be undertaken to encourage retrofitting of the rental stock. These initiatives include: (1) an experimental locally-administered program to mandate retrofits for rental property at the time of sale; (2) other local demonstration programs designed to modify rent control laws and rental contract agreements to allow building owners to pass retrofit costs through to tenants, when retrofit investments would work to both the tenants and owners advantages. These demonstration programs could be funded and in fact emphasized through the proposed Energy Management Partnership Act (EMPA) if this or similar legislation becomes law. We recommend that EMPA specifically require each state energy plan to address the rental market.

Low-Income Households

- A major share of the funds designated for subsidizing the energy costs of low-income families through receipts from the Windfall profits Tax Act should be shifted to the weatherization of these same homes--to focus effort on the cause of high heating bills and uncomfortable (or unlivable) homes, rather than just alleviating the symptoms through subsidization of energy costs.

The Congressional Conference Report on this Act suggested that $36 billion in expected receipts should be directed to assist low-income families' energy needs. If the current programs are continued, most of this funding will be used to simply subsidize the purchases of fuel, unless a major program is initiated to use it more effectively as a supplement to the present Weatherization program. Use of the full $36 billion to improve building energy efficiency would allow an investment of over $2000 per housing unit. If this funding were used for retrofits, it could finance approximately 50-70% of the costs required for the full package of conservation and solar retrofits examined in this study. Moreover, if more effective techniques can be found for making use of the CETA program, the labor requirements for weatherizing those homes can make major contributions to reducing unemployment and improving job skills and job opportunities for low-income or disadvantaged groups. The funding available is reduced, of course, if significant amounts of funds are used during the next few years as direct subsidies for fuel bills.

There is another very important effect that would substantially reduce the net federal cost of such a program. The federal government currently subsidizes the rent of approximately 3.3 million low-income residential units at an annual cost of roughly $6 billion. Rising energy costs are contributing to the rapid increase in budget requirements for these programs. Investments of the kind recommended in this analysis could save the federal government more than $1.3 billion annually in fuel bills, if all of these units are retrofitted fully. Nearly the amount of funding necessary to support a program of retrofitting <u>all</u> low-income housing!

- An alternative approach of direct grants or vouchers, similar to the Canadian Housing Improvement program should be demonstrated, and if successful should be adopted nationwide as an option to the current Weatherization program.

The Weatherization program as now formulated should be simplified and freed from many procedural entanglements. An alternative approach of direct grants or vouchers might reduce admininstrative costs, and by involving private contractors as well as CETA trainees, allow a significant expansion and acceleration of the weatherization program. Grants or vouchers along the lines of the Canadian Housing Improvement Program (CHIP) should be initiated and, if successful, the nationwide Weatherization program should allow such an option beginning in 1984, if not earlier.

This program could operate through qualified auditors and contractors thus building upon the same infrastructure as RCS. The government would simply pay for an audit and recommended cost-effective retrofits conducted by certified private, non-profit, utility, or local government organizations, including CETA programs. There would be advantages in working with a utility in the region, particularly if the utility were able to provide financing that could complement or partly replace the direct federal grant. Due to the many structural problems in low-income housing, up to one-third of the grant should be allowed for necessary structural improvements.

Rented Buildings

Approximately 26 million units, or 35% of all residential units in the United States, are rented. It has proven difficult to design programs which will adequately motivate the owners of these buildings to make necessary retrofits. Often other kinds of investments appear more profitable to the building's owner--even if access to capital is not a problem. A national apartment association survey found that 72% of apartment owners would undertake energy improvements only if the payback period were 3 years or less. Because owners of rental housing often expect a 2- to 3-year return on investment, they are reluctant to make major investments in conservation or solar energy, even though they may be extremely cost-effective over the building's remaining useful life. Only measures such as caulking or weatherstriping, that have short paybacks and minimal initial costs, would be undertaken in this sector, given such an investment criterion.

Whether or not the landlord pays the fuel bills, there is little incentive for either owner or tenant to make energy-efficiency improvements in rental buildings. Landlords can usually pass on fuel cost increases to their tenants, while the tight housing market in many areas makes energy costs a relatively minor consideration for most prospective tenants. Also, in a number of communities, restrictions in rent-control ordinances may make it difficult for landlords to pass costs and savings through to their tenants in an equitable fashion.

Information programs, such as including the cost of utilities along with monthly rental payment in apartment advertisements, or rating the energy efficiency of rental buildings with rights to inform prospective tenants of a building's rating, may be effective in those limited rental market areas where available rental units exceed demand. However, most rental markets are extremely "tight," and such information programs may make little impact on rental decisions or, therefore, on owner decisions to retrofit.

Basically, most conservation programs to date have had little or no impact on the rental stock. It appears that a carefully designed package of low-interest, deferred-payment loans and financial incentives may offer some opportunities for encouraging retrofits in rental units. The early TVA loan program included rental units but received only a 0.02% response rate from rental sector. However, recent loan programs by TVA and Portland General Electric have received higher response rates from the rental sector, the PGE program, in particular, had a rental response rate equivalent to that from owner-occupied housing in the case of rental units with electric heating. Other utilities could be encouraged to try similar programs, offering zero-interest deferred payment loans to the rental market. The investment criteria of rental property owners, cited earlier may limit the effectiveness of loan programs alone.

The only completely effective approach may be to require by law conservation retrofits of existing buildings. This is, in fact, beginning to happen in many local communities around the country. Portland, Oregon and the state of Minnesota have recently enacted mandatory retrofit laws for rental housing. Davis, California, has a local ordinance applying to all existing residences. For political acceptance and equity, such retrofit requirements should be coupled with a well-designed system of loans and other financial incentives.

Until more is learned about how to make mandatory retrofit programs effective and equitable, the appropriate federal role is to provide financial support for a variety of promising local and state-level demonstrations, along with assistance in monitoring the results. Once the most effective approaches are determined, it may be desirable to impose some form of requirements for improved efficiency in existing buildings, if market pressures and non-mandatory programs have not made substantial headway in the meantime.

Another useful step would be for the federal government to channel HUD funds through the existing state housing agencies to help provide subsidized loans wherever a mandatory retrofit standard has been adopted at the local or statewide level. Either approach to a retrofit mandate/loan program should be carefully coordinated with state and local governments, especially where local rent control ordinances exist.

The final design of an appropriate loan and retrofit program could be left up to each state, with the federal role limited to financial and technical help, for at least a five-year period. At that time, it would be reasonable to reconsider the need for a nationwide requirement for improved efficiency in existing (rental) buildings, possibly implemented through provisions of the proposed Energy Management Partnership Act as a condition for states to receive federal funds. Initially, though, EMPA legislation should at least require each states to develop a specific plan to deal with the rental market.

Retrofit requirements imposed without financial assistance and incentives could increase the risk of building abandonment or condominium conversion. Abandonment may indeed be the only solution where the property is only a marginal income-producer and retrofit is so difficult that the costs of meeting the standard are prohibitive.

Abandonment is already becoming a serious problem in many communities, and skyrocketing energy costs bear a large part of the blame. For some of these older, inefficient buildings, monthly energy costs are substantially higher than monthly mortgage payments. In Massachusetts, the state government estimates that as many as 25% of the buildings in the low-income area of Springfield risk abandonment because of rising energy costs. Ironically, some of these buildings may in fact be saved from abandonment by a combined incentive/mandate program, since cost-effective conservation improvements to basic components such as leaks, roofs, missing or broken windows, and worn-out heating systems would greatly reduce the energy expenses of these structures while improving their habitability. A conservation loan programs could provide the necessary capital for such investments, in a form that is attractive to the building owner. For those buildings that are incapable of being substantially retrofitted in a cost-effective manner, case-by-case exemptions may be necessary, in a combined incentive/mandate program.

For those multi-family buildings already converted to condominium ownership, energy-efficiency improvements can be encouraged by the programs discussed earlier, for owner-occupied units. However, mandatory local retrofit laws could also be extended to require substantial improvements at time of condominium conversion, as many communities already require, for fire safety, parking, and other measures.

In addition to the programs to encourage the physical retrofitting of rental units, the Department of Energy should encourage and support programs designed to induce changes in tenant behavior that affects energy use and efficiency. There is growing evidence that improved information, feedback, and other behavioral inducements can achieve significant savings in the rental market. Demonstration programs to highlight energy costs as a separate item in the monthly rent bill—even where these costs are centrally metered and paid by the building owners—have shown 15 to 30% reductions in energy use by tenants which is in the same range as (or slightly higher) than the percentage savings by owner-occupants in response to utility bill "feedback" (see above). Additional efforts should be undertaken to test and demonstrate such feedback methods to reduce energy usage, and state and local governments should be encouraged to assist or require owners of rental units to implement these measures once they have been proven effective.

Financial Incentives

In the section of this report dealing with technical potentials, we argue that virtually all of the conservation and solar measures considered are clearly cost-justified, even at today's average cost of energy. Nevertheless, there is still a justification for using well-designed and carefully monitored financial incentives, wherever these can help to offset institutional and market barriers and speed the widespread adoption of such measure.

Attachment 2

DRAFT

Prepared for ICEUM III, the International Conference on Energy Use Management, Berlin (West), October 26-30, 1981

LBL 13385
EEB-BECA 81-1
DRAFT: October 13, 1981

Building Energy Compilation and Analysis
PART B: North American Residential Retrofit

Leonard W. Wall*, Charles A. Goldman, Arthur H. Rosenfeld
Lawrence Berkeley Laboratory
Berkeley, California 94720 U.S.A.

Gautam S. Dutt
Center for Energy and Environmental Studies
Princeton University
Princeton, New Jersey 08544

The work described in this report was funded by the Office of Building Energy Research and Development, Assistant Secretary for Conservation and Renewable Energy, of the U.S. Department of Energy under contract W-7405-ENG-48.

*Permanent Address: Department of Physics, California Polytechnic State University, San Luis Obispo, California 93407

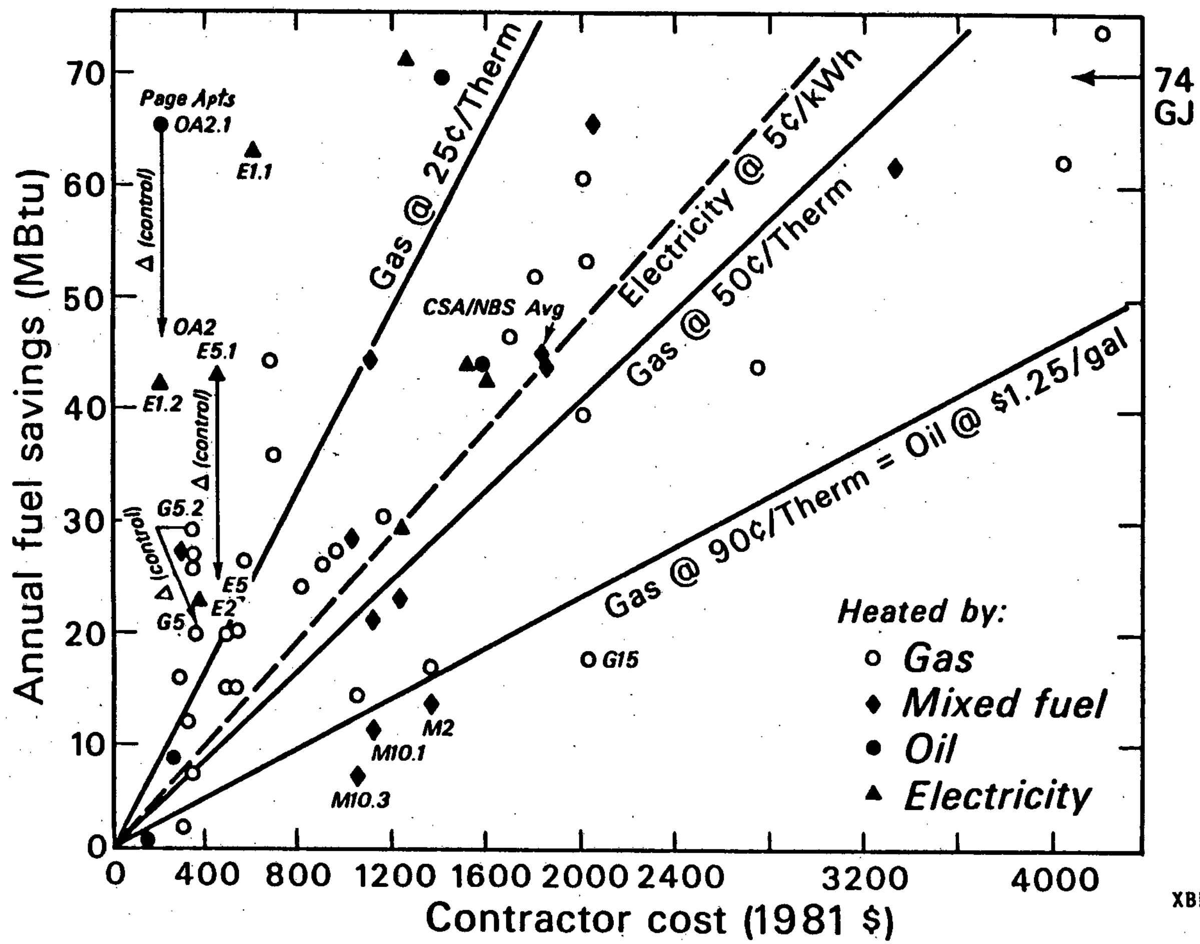
ABSTRACT

We have compiled and analysed 78 samples, each typically of 6-60 homes in the U.S. and Canada which have been retrofited to conserve heat. The median savings is 23%, contractor cost $1000, cost of conserved energy $3.5/MBtu (based on a 15-year loan at 6% real interest).

In one public housing complex, an investment of $200 per apartment reduced annual fuel use from 640 to 285 gallons, saving 355 gallons worth about $500/year today.

The median cost of conserved energy of $3.5/MBtu is very attractive compared with purchasing gas at $5/MBtu or fuel oil at $10. For all 8 electrically heated samples, the cost of conserved electricity was less than the current average price of 5¢/kWh.

Contents



XBL 819-1347

Fig. 2(a). Annual savings of fuel or resource electricity vs. contractor cost for 57 entries in Table I. The 4 sloping lines represent prices of purchased energy corresponding to the horizontal lines on Fig. 4(a). To compete with simply paying these energy prices, a retrofit dot must lie above the appropriate line . In most cases the plotted savings apply to space heat only, but in Table I, some 11 samples (where Col. J shows H,W) addressed both hot water and heating. In those 11 cases, we plot the combined H+W savings.

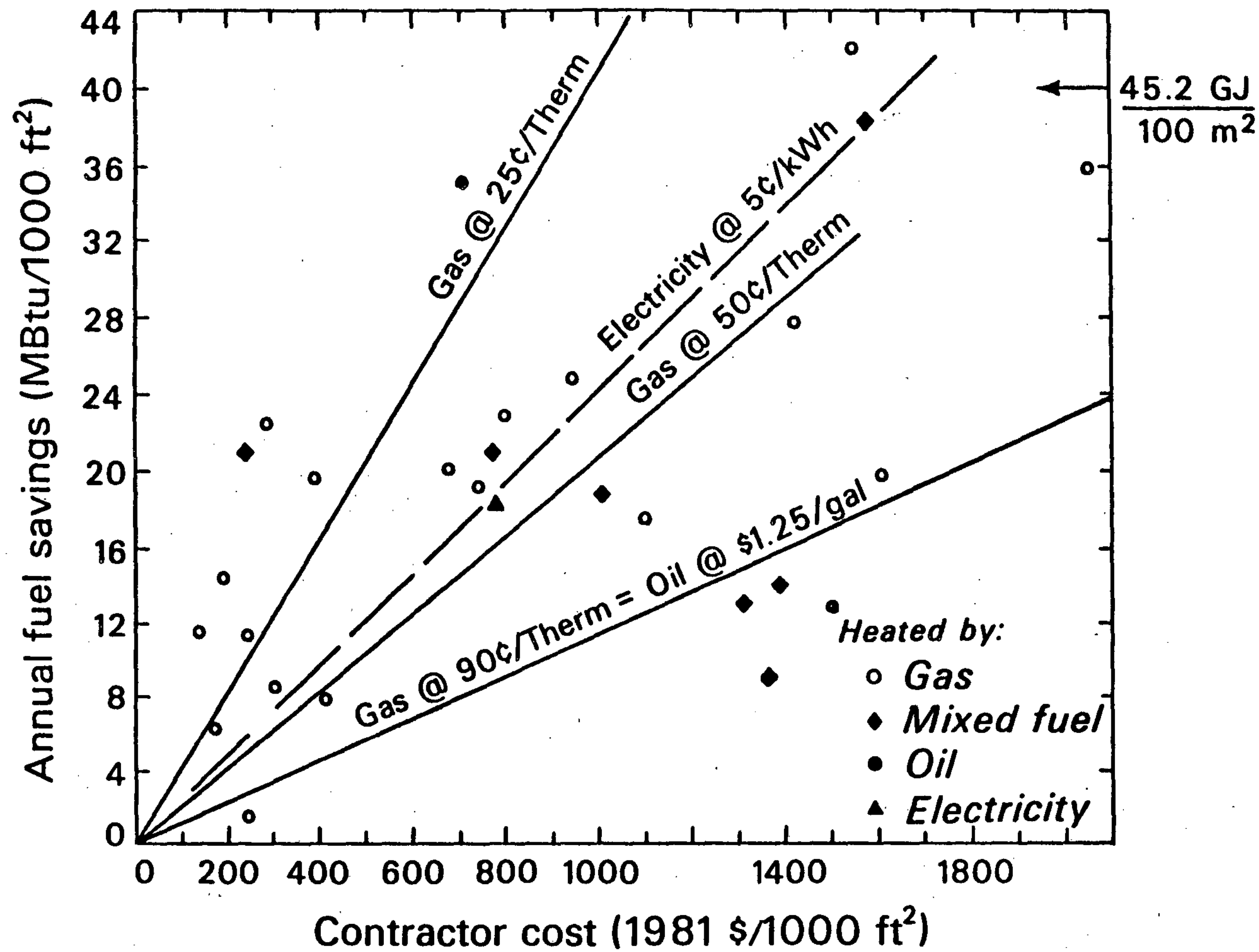


Fig. 2(b) is identical with Fig. 2(a) except that it is restricted to 27 higher quality samples where we also know the floor area. This allows for a more valid comparison of costs and savings among houses of different size. (The data points shown here represent houses ranging from 774 to 2500 square feet.)

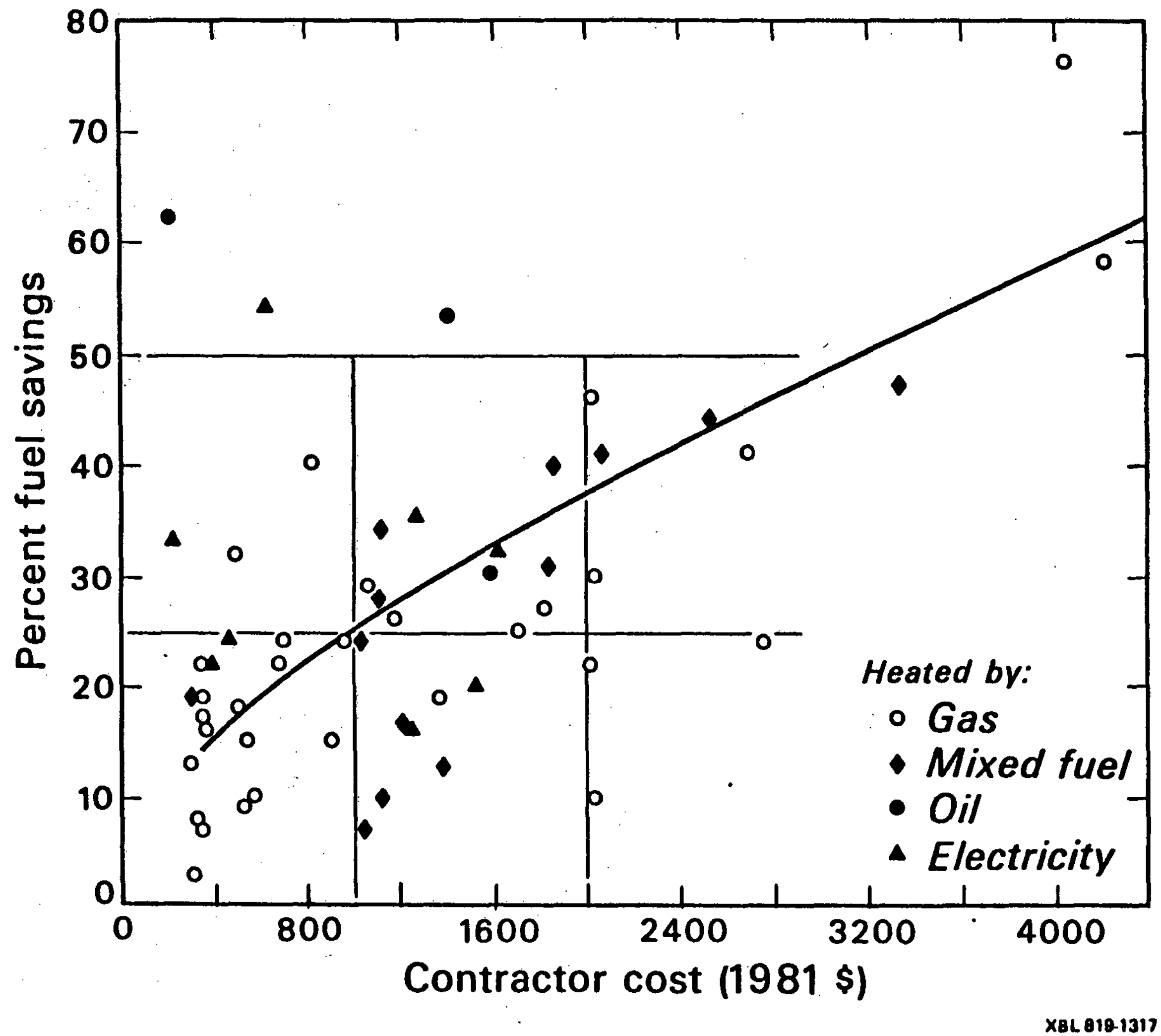


Fig. 3(a). Percent savings in space heat vs. contractor cost for 57 entries from Table I. The curve is an "eye-ball" fit, reflecting a law of diminishing returns.

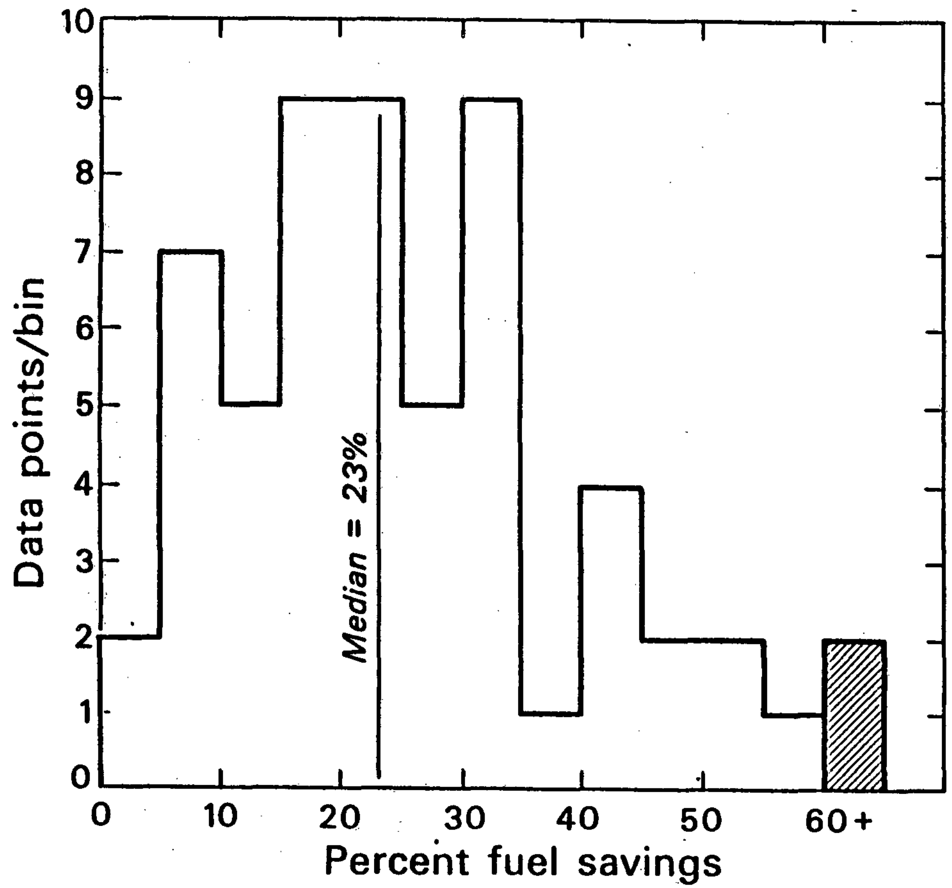
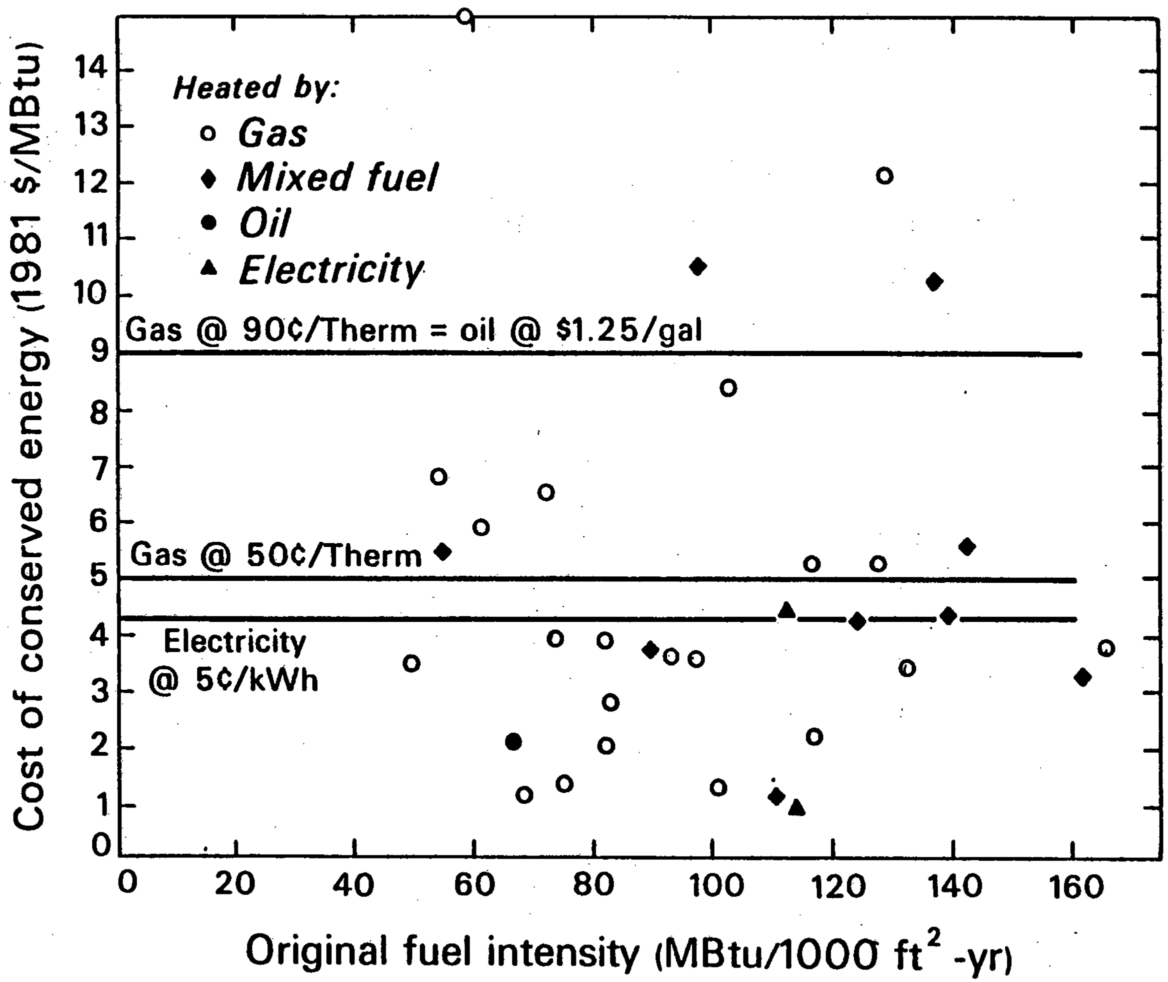


Fig. 3(b). Histogram of the results of Fig. 3(a). The median savings is 23%.



XBL 819-1344

Fig. 4(a). Cost of Conserved Energy, CCE (Table I, Col. M2), vs. Original Fuel Intensity. The CCE is amortized over 15 years; real interest rate of 6%. In this plot, as throughout the paper, electricity is measured in resource units of 11,500 Btu burned per kWh sold. The horizontal lines represent various prices of purchased energy. The U.S. average gas price is approaching 50¢/therm. After deregulation, gas should approach today's price of heating oil, i.e., 90¢/therm.

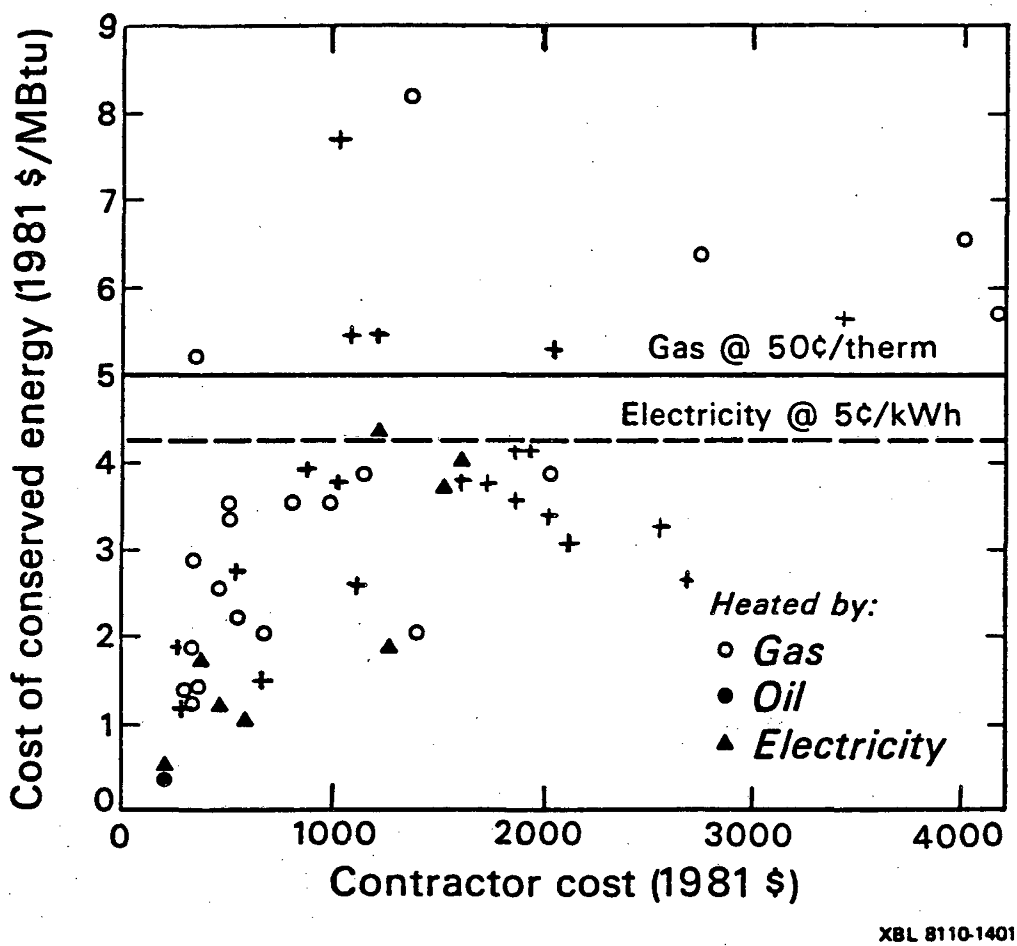


Fig. 4(b). Cost of Conserved Energy, CCE (Table I, Col. M2) vs. Contractor Cost for 29 samples with Low-Income Weatherization retrofits excluded. The CCE is amortized over 15 years, real interest rate of 6%. The horizontal lines represent current prices of purchased energy, except for heating oil, which is off scale. NOTE ADDED IN PROOF. For comparison, all the low-income weatherization samples have been added as + marks. Twenty-one are plotted, and five fall above $8/MBtu.

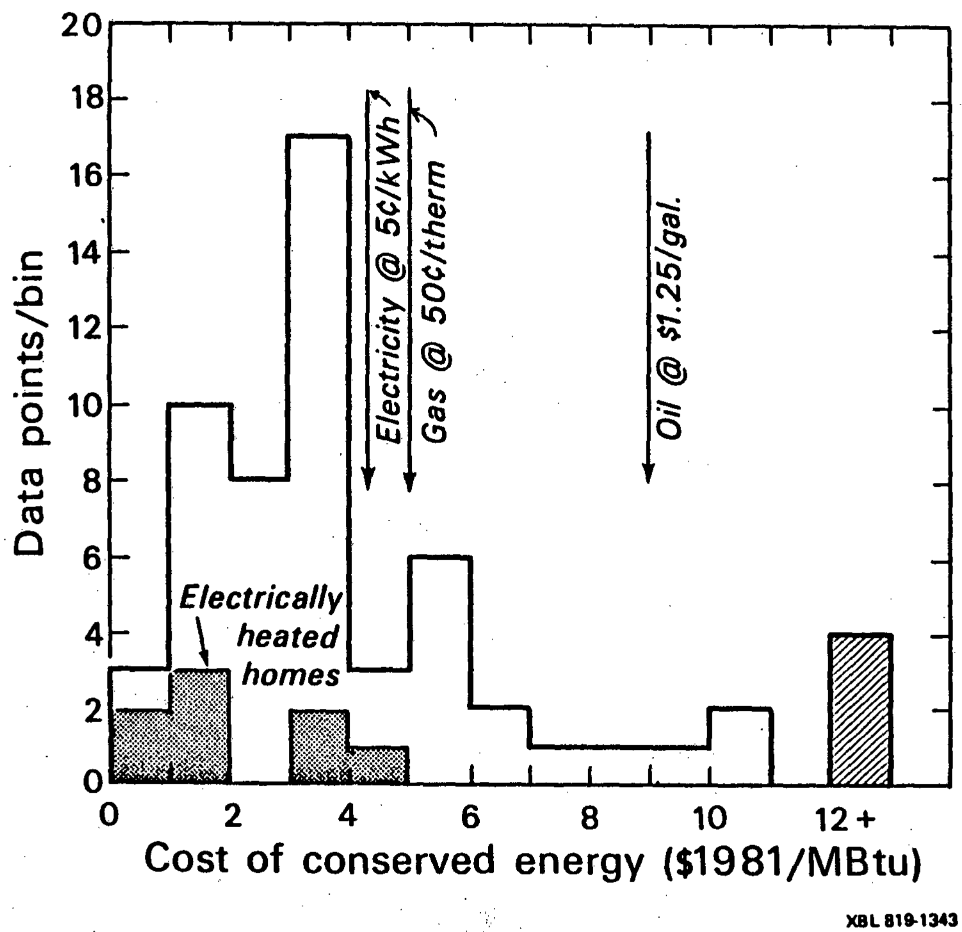


Fig. 4(c). Data of Fig. 4(a) binned into a histogram. Note that electricity in this plot, and throughout this paper, is measured in resource energy.

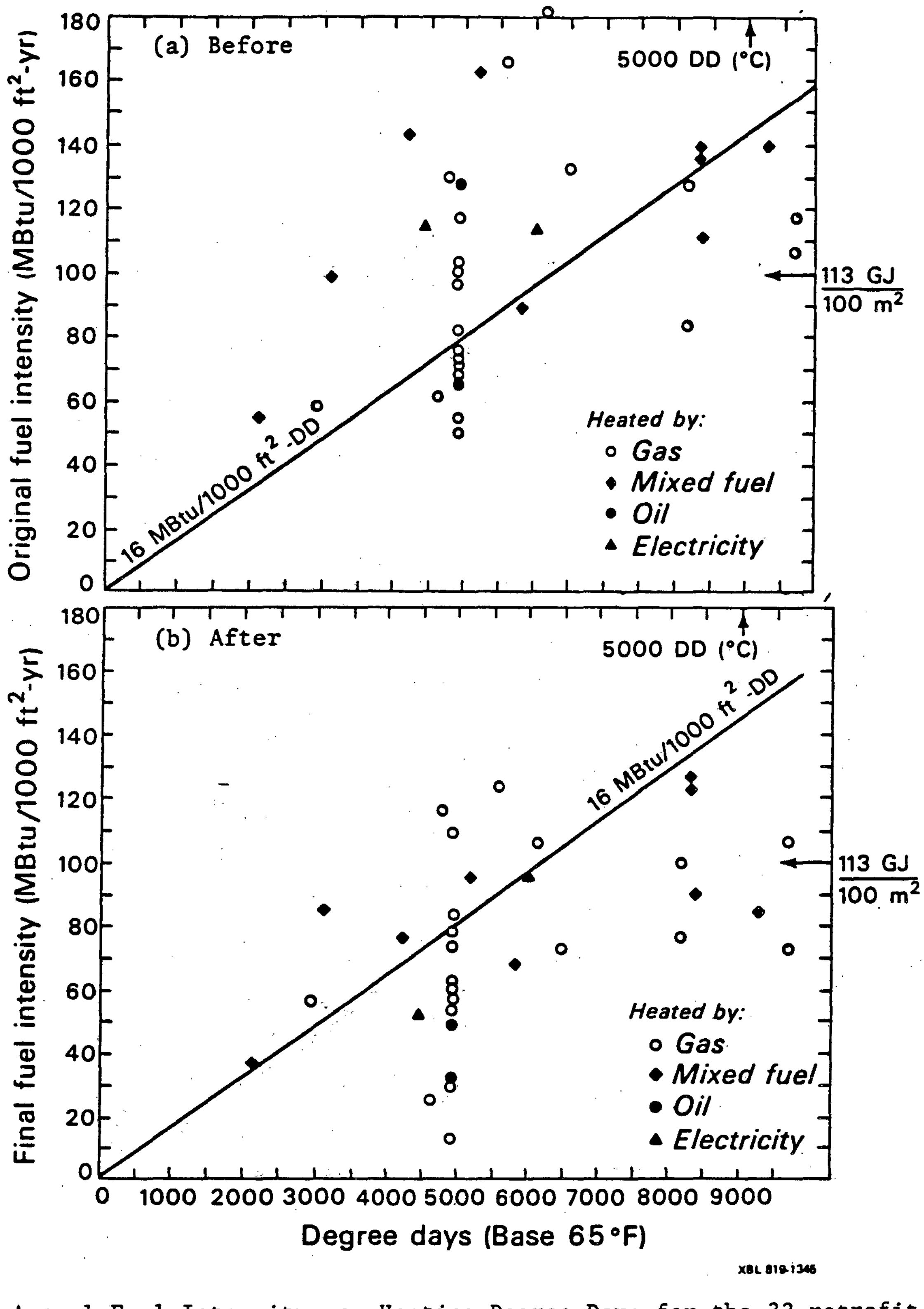


Fig. 5. Annual Fuel Intensity vs. Heating Degree Days for the 33 retrofit samples in Table I with data on square footage. The sloping line labelled 16MBtu/1000 ft^2 DD represents U.S. stock (see BECA-A) and also fits these 33 points. Note that 11 points labelled H+W in Table I (mainly in N.J. lined up above 4911 DD) show savings of hot water as well as fuel, as discussed in the caption for Fig. 2(a).

IV. DATA AND TABLE I

This Section presents our 80 samples in the form of Table I, which has one line per sample and 28 columns. Columns A through L are input data, of which the most important are Savings (Col. K) and Cost (L). On the right-hand page of the table, Columns M through R contain derived results: Cost of Conserved Energy, Payback, Fuel Intensity, and Thermal Integrity.

The 80 samples are ordered by fuel used, in the sequence Gas, Oil, Mixed, and Electricity. "Mixed" means that within a sample of say 10 homes, the heating fuel differed from house to house.

The meaning and convention of each column is explained in the two pages below the table titled "Explanations of the Columns in Table I."

Note that a typical scatter plot has about 55 points, not 80. This is because 12 lines represent Active Controls (whose labels end with an A) and 8 are Passive, or "Blind," controls (labels end with B). That leaves 60 retrofits. Finally, on a typical plot, a few points overflow the scales, so that we typically see only 55.

Table 1. Summary of our data files. Note that in this table, as throughout this paper, electricity, when not measured directly in kWh, is measured in

(caption continued on right-hand page of Table 1)

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K1.	K2.	K3.	K4.
										ANNUAL ENERGY (MBTU)		SAVINGS	
LABEL	SPONSOR CAT.	NO OF HOMES	LOCATION	SPONSOR	HDD	YR OF RETRO FIT	SQFT	RETROFIT TYPE	HEATING OR HEAT+WATER	BEFORE	AFTER	(MBTU)	PERCNT
G1	R	1	BOWMAN HOUSE,MD	NBS	4610	75	2054	I,W,C	H	125.6	52.1	73.5	59
G2	R	1	TWIN RIVERS,NJ	PRINCETON	4911	77		I,W,C,P	H	81.0	19.2	61.8	76
G3	R	1	HS 11,NJ	PRINCETON	4911	79	1200	I,W,H,P	H	59.6	35.7	23.9	40
G4	R	1	HS 22,NJ	PRINCETON	4911	79	1560	I,D,H,P	H	114.4	84.1	30.3	26
G5.1	R/U	6	MRE/FREEHOLD,NJ	PRINCETON/NJNG	4911	80	2500	I,T,P	H,W	178.8	135.1	43.7	24
G5.2	R/U	12	MRE/FREEHOLD,NJ	PRINCETON/NJNG	4911	80	2500	T,P	H,W	171.9	142.9	29.0	17
G5.3B	R/U	6	MRE/FREEHOLD,NJ	PRINCETON/NJNG	4911		2500			184.0	174.9	9.1	5
G6.1	R/U	6	MRE/TOMS RIVER,NJ	PRINCETON/NJNG	4911	80	850	I,T,P	H,W	87.2	70.4	16.8	19
G6.2	R/U	12	MRE/TOMS RIVER,NJ	PRINCETON/NJNG	4911	80	850	T,P	H,W	99.2	92.4	6.8	7
G6.3B	R/U	6	MRE/TOMS RIVER,NJ	PRINCETON/NJNG	4911		850			98.0	98.0	0.	0
G7.1	R/U	6	MRE/OAK VALLEY,NJ	PRINCETON/SJG	4911	80	1200	I,T,P	H,W	116.3	88.9	27.4	24
G7.2	R/U	9	MRE/OAK VALLEY,NJ	PRINCETON/SJG	4911	80	1200	T,P	H,W	120.9	94.0	26.9	22
G7.3A	R/U	6	MRE/OAK VALLEY,NJ	PRINCETON/SJG	4911		1200			128.6	115.0	13.6	11
G7.3B	R/U	43000	MRE/OAK VALLEY,NJ	PRINCETON/SJG	4911		1200			[illegible]	[illegible]	[illegible]	10
G8.1	R/U	5	MRE/WHITMAN SQ,NJ	PRINCETON/SJG	4911	80	1800	I,T,P	H,W	147.2	111.8	35.4	24
G8.2	R/U	9	MRE/WHITMAN SQ,NJ	PRINCETON/SJG	4911	80	1800	T,P	H,W	134.8	109.1	25.7	19
G8.3A	R/U	4	MRE/WHITMAN SQ,NJ	PRINCETON/SJG	4911		1800			133.8	112.4	21.4	16
G8.3B	R/U	43000	MRE/WHITMAN SQ,NJ	PRINCETON/SJG	4911		1200			[illegible]	[illegible]	[illegible]	11
G9.1	R	5	SASKATCHEWAN,CANADA	EN.CONS INFO C./NRC	10939	80	2157	I,C,P	H	177.1	123.8	53.3	30
G9.2	R	5	SASKATCHEWAN,CANADA	EN.CONS INFO C./NRC	10939	80		C,P	H	163.5	148.6	14.9	9
G9.3	R	10	SASKATCHEWAN,CANADA	EN.CONS INFO C./NRC	10939	80		I	H				
G10.1	R	1	BUTTE,MT	NCAT	9669	79	2300	I	H	269.2	243.0	26.2	10
G10.2	R	1	BUTTE,MT	NCAT	9669	80	2300	I,C,A	H	243.0	165.9	77.1	32
G11	U	84	RAMSEY COUNTY,MINN	NSP	8159	79	1900	I,C	H	156.7	144.9	11.8	8
G12.1	U	33	BAKERSFIELD,CA	PGE	2185	79		I	H	83.0	68.1	14.9	18
G12.2	U	16	FRESNO,CA	PGE	2650	79		I	H	61.5	42.0	19.6	32
G13	U	33000	COLORADO	PUB SERV CO	6016	77		I	H	119.2	99.6	19.6	16
G14.1	G	8	OAKLAND,CA	CSA/NBS	2909	79	1300	I,C	H	76.1	74.0	2.2	3
G14.2A	G	4	OAKLAND,CA	CSA/NBS	2909					116.9	128.4	-11.5	-9
G15	G	18	ST LOUIS,MO	CSA/NBS	4750	79	1355	I,W,C	H	174.7	157.3	17.4	10
G16	G	10	CHICAGO,ILL	CSA/NBS	6127	79	1464	I,W,C,H	H	264.8	155.1	109.7	41
G17.1	G	16	COLORADO SPRINGS	CSA/NBS	6473	79	998	I,W,C,H	H	132.0	71.6	60.4	46
G17.2A	G	4	COLORADO SPRINGS	CSA/NBS	6473					164.8	164.6	.2	0
G18.1	G	17	ST PAUL,MINN	CSA/NBS	8159	79	1421	I,W,C	H	180.9	141.6	39.3	22
G18.2A	G	5	ST PAUL,MINN	CSA/NBS	8159					286.1	262.7	23.4	8
G19	G	30	LUZERNE CTY,PA	DOE	6277	79		I,W,C	H	157.9	134.2	23.7	15
G20	G	89	LOUISIANA	DOE	1800	80			H	48.3	34.1	14.2	29
G21.1	G	21	KANSAS CITY,MO	DOE	5161	77		I,C	H	135.0	115.0	20.0	15
G21.2	G	45	KANSAS CITY,MO	DOE	5161	77		I,C	H	196.0	152.0	44.0	22
G21.3	G	44	KANSAS CITY,MO	DOE	5233	78		I,C	H	191.0	139.0	52.0	27
G22	G	138	KENTUCKY	DOE	4729	79		I,W,D,C	H	118.5	102.8	15.7	13
G23	G	30	INDIANA	DOE	5577	78	1102	I,C,H	H	182.1	135.7	46.4	25

Table 1, continued.

01	R	1	HS 21,NJ	PRINCETON	4911	79	1990	I,W,H,P	H	132.0	62.5	69.5	53
OA2.1	G/P	159	PAGE APTS, NJ	HUD/TRENTON	4911	81	830	H,E	H	105.1	40.3	64.8	62
UA2.2B	R	1500	PAGE APTS, NJ	HUD/TRENTON	4911					116.7	98.3	18.4	16
OA3	P	521	MF COMPLEX,WASH DC	SCALLOP THERMAL MAN	4211	78		H,E,O	H,W	116.3	108.4	7.9	7
OA4	P	752	MF COMPLEX,MD	SCALLOP THERMAL MAN	4211	78		H,E,O	H,W	84.9	83.1	1.8	2
OA5	P	60	COOP BLDG,NYC	SCALLOP THERMAL MAN	4848	78		H,E,O	H,W	167.3	152.1	15.2	9
U6	G	13	VERMONT	DOE	7876	80		I,W,O	H	143.5	100.0	43.5	30
M1.1	G	13	CHARLESTON,SC	CSA/NBS	2146	79	1111	I,C	H	62.5	41.4	21.1	34
M1.2A	G	5	CHARLESTON,SC	CSA/NBS	2146					36.3	30.7	5.6	15
M2	G	8	ATLANTA,GA	CSA/NBS	3095	79	1055	I,W,C	H	108.1	94.1	14.0	13
M3	G	4	WASH,DC	CSA/NBS	4211	79	915	I,W,C,H	H	130.5	69.1	61.4	47
M4.1	G	9	TACOMA,WA	CSA/NBS	5185	79	978	I,W,C	H	168.8	99.8	69.0	41
M4.2A	G	5	TACOMA,WA	CSA/NBS	5185					59.5	50.1	9.4	16
M5.1	G	13	EASTON,PA	CSA/NBS	5827	79	1334	I,C,H	H	121.7	93.1	28.6	24
M5.2A	G	3	EASTON,PA	CSA/NBS	5827					44.0	39.9	4.2	9
M6.1	G	14	PORTLAND,ME	CSA/NBS	7498	79	1008	I,W,C,H	H	187.3	105.4	81.9	44
M6.2A	G	4	PORTLAND,ME	CSA/NBS	7498					232.5	203.8	28.7	12
M7.1	G	12	FARGO,ND	CSA/NBS	9271	79	786	I,W,C,H	H	109.5	65.8	43.7	40
M7.2A	G	5	FARGO,ND	CSA/NBS	9271					145.1	131.3	13.8	10
M8.1	G	142	CSA/NBS	COMPOSITE		79	1168		H	146.7	101.9	44.8	31
M8.1A	G	41	CSA/NBS	COMPOSITE						145.2	138.7	6.5	4
M9	G	65	NW WISCONSIN	CSA	8388	76	1292	I,W,D,C	H	143.0	115.9	27.1	19
M10.1	G	59	MINNESOTA	DOE	8310	78	806	I,W,C	H	110.8	99.6	11.2	10
M10.2B	G	37	MINNESOTA	DOE	8310					78.2	80.1	-1.9	-1
M10.3	G	19	MINNESOTA	DOE	8310	78	774	I,W,C	H	103.6	96.7	6.9	7
M11	G	13	WISCONSIN	DOE	8820	79			H	139.3	116.3	23.0	17
M12	G	86	ALLEGAN CTY,MI	DOE	6801	80			H	156.0	112.0	44.0	28
											(kWh)		
E1.1	U	69	TENNESSEE	TVA	4436	76	1013	I,C	H	11270.0	5148.0	6122.0	54
E1.2	U	105	TENNESSEE	TVA	4421	76		I	H	12383.0	8271.0	4112.0	33
E2	U	546	TENNESSEE	TVA	4010	78		I	H	10148.0	7937.0	2211.0	22
E3.1	R/P	29	DENVER	JOHNS MANVILLE	6016	78	1600	P	H	17615.0	14779.0	2836.0	16
E3.2A	R/P	30	DENVER	JOHNS MANVILLE	6016					20606.0	17715.0	2891.0	14
E3.3B	R/P	30	DENVER	JOHNS MANVILLE	6016					23886.0	21034.0	2852.0	12
E4	U	1896	OREGON	PAC PWR LIGHT	4800	79		I,W,D,C	H	21305.0	17044.0	4261.0	20
E5.1	U	133	SEATTLE,WA	SEATTLE CITY LIGHT	5185	79		I	H	17107.0	12934.0	4173.0	24
E5.2B	U	551	SEATTLE,WA	SEATTLE CITY LIGHT	5185					16843.0	14634.0	2209.0	13
E6	U	8802	WASHINGTON	PUGET POWER	5500	79		I,W	H	20000.0	13070.0	6930.0	35
E7	U	161	OREGON	PORTLAND GEN ELEC	4792	78		I,W,D,C	H	13000.0	8879.0	4121.0	32

(caption for Table 1--continued) resource units of 11,500 Btu per kWh sold. In these units, 1 MBtu of gas and of electricity both cost about the same (currently $4.50). The column headings are explained below the table.

A.	L1.	L2.	L3.	M1.	M2.	M3.	N.	O1.	O2.	P1.	P2.	Q.	R.
	AVG. RETRO COSTS			CCE = 1981 COST OF CONSERVED ENERGY ($/MBTU) AT CAP. REC. RATES			SIMPLE PAYBACK	FUEL INTENS. (MBTU/KSQFT)		THERMAL INT. (BTU/SQFTDD)		CONFI- DENCE	
LABEL	ORIG$	81 $	81 $/ KSQFT	8.3%	10.3%	12.4%	(YEARS)	BEFORE	AFTER	BEFORE	AFTER	LEVEL	COMMENTS
G1	2840	4203	2046	4.80	5.89	7.09	16.1	61.1	25.4	13.3	5.5	A	FIRST EXTENSIVE STUDY
G2	3000	4035	2690	5.48	6.73	8.10	16.2	54.0	12.8	11.0	2.6	A	TOWNHOUSE
G3	700	813	678	2.86	3.50	4.22	7.9	49.7	29.8	10.1	6.1	A	ELIMINATE BYPASS LOSSES
G4	1000	1162	745	3.22	3.95	4.76	8.9	73.3	53.9	14.9	11.0	A	ELIMINATE BYPASS LOSSES
G5.1	2562	2749	1100	5.28	6.48	7.80	13.0	71.5	54.0	14.6	11.0	A	H. O. AND CONTRACT RETR.
G5.2	325	349	140	1.01	1.24	1.49	2.5	68.8	57.2	14.0	11.6	A	H. O. ONLY
G5.3B								73.6	70.0	15.0	14.2	A	BLIND CONTROL GROUP
G6.1	1272	1365	1606	6.83	8.37	10.08	16.8	102.6	82.8	20.9	16.9	A	H. O. AND CONT. RET.
G6.2	325	349	411	4.31	5.29	6.36	10.6	116.7	108.7	23.8	22.1	A	H. O. ONLY
G6.3B								115.3	115.3	23.5	23.5	A	BLIND CONTROL GROUP
G7.1	911	956	797	2.93	3.59	4.33	6.2	96.9	74.1	19.7	15.1	A	H. O. AND CONTRACT RETR.
G7.2	325	341	284	1.06	1.31	1.57	2.2	100.8	78.3	20.5	16.0	A	H. O. ONLY
G7.3A								107.2	95.8	21.8	19.5	A	ACTIVE CONTROL GROUP
G7.3B													BLIND CONTROL GROUP
G8.1	664	697	387	1.65	2.03	2.44	3.5	81.8	62.1	16.7	12.6	A	H. O. AND CONT. RETR.
G8.2	325	341	189	1.11	1.37	1.65	2.3	74.9	60.6	15.2	12.3	A	H. O. ONLY
G8.3A								74.3	62.4	15.1	12.7	A	ACTIVE CONTROL GROUP
G8.3B													BLIND CONTROL GROUP
G9.1	1976	2027	940	3.19	3.92	4.72	12.9 (b)	82.1	57.4	7.5	5.2	B	SEALED AND INSULATED
G9.2	514	527	301	2.97	3.64	4.39	12.0 (b)	93.3	84.8	8.5	7.8	B	SEALED ONLY
G9.3												I	INSULATED ONLY
G10.1	500	570	248	1.83	2.24	2.70	5.4 (b)	117.0	105.7	12.1	10.9	B	PHASE I
G10.2	13100	13742	5975	14.97	18.36	22.10	44.6 (b)	105.7	72.1	10.9	7.5	B	PHASE II, INCLUDES PASSIVE WALL
G11	290	324	171	2.31	2.83	3.40	8.3	82.5	76.3	10.1	9.3	B	LOW-INCOME WEATHERIZATION
G12.1	427	496		2.80	3.43	4.13	5.8					B	ATTIC INSUL PROG IN SAN JOAQUIN VALL
G12.2	417	485		2.08	2.55	3.07	4.3					B	ATTIC INSUL PROG IN SAN JOAQUIN VALL
G13	272	350		1.54	1.89	2.28	4.4 (b)					B	LOW INT LOANS FOR ATTIC INSUL
G14.1	274	312	240	12.13	14.88	17.91	18.9	58.5	56.9	20.1	19.6	A	DEMO PGM. LOW-INCOME WEATHERIZATION
G14.2A												A	ACTIVE CONTROL GRP.
G15	1781	2030	1498	9.80	12.02	14.47	43.6	128.9	116.1	27.1	24.4	A	DEMO PGM. LOW-INCOME WEATHERIZATION
G16	2347	2676	1828	2.05	2.51	3.02	7.3	180.9	105.9	29.5	17.3	A	DEMO PGM. LOW-INCOME WEATHERIZATION
G17.1	1765	2012	2016	2.80	3.43	4.13	12.0	132.3	71.7	20.4	11.1	A	DEMO PGM. LOW-INCOME WEATHERIZATION
G17.2A												A	ACTIVE CONTROL GROUP
G18.1	1761	2008	1413	4.29	5.26	6.34	15.7	127.3	99.6	15.6	12.2	A	DEMO PGM. LOW-INCOME WEATHERIZATION
G18.2A												A	ACTIVE CONTROL GROUP
G19	789	900		3.19	3.91	4.71	9.3					C	LOW-INCOME WEATHERIZATION
G20	1044	1058		6.26	7.67	9.24	17.9					C	LOW-INCOME WEATHERIZATION
G21.1	407	538		2.26	2.77	3.34	13.0					C	LOW-INCOME WEATHERIZATION
G21.2	525	676		1.29	1.58	1.91	7.6					C	LOW-INCOME WEATHERIZATION
G21.3	1494	1810		2.92	3.59	4.32	15.5					C	LOW-INCOME WEATHERIZATION
G22	254	290		1.55	1.90	2.29	4.6(c)					C	LOW-INCOME WEATHERIZATION
G23	1375	1701	1544	3.08	3.78	4.55	14.1(c)	165.2	123.1	29.6	22.1	B	LOW-INCOME WEATHERIZATION

Table 1, continued.

O1	1203	1394	701	1.68	2.07	2.49	3.1	66.3	31.4	13.5	6.4	A	ELIM. BYPASS LOSSES
OA2.1	200	200	241	.26	.32	.38	.4	126.6	48.6	25.8	9.9	A	EXTRAP. TO 550 UNITS
OA2.2B												A	BLIND CONTROL GROUP
OA3					3.55	3.65	8.9(c)					B	THERMAL SERVICES CONTRACT
OA4					9.22	9.46	23.1(c)					B	THERMAL SERVICES CONTRACT
OA5												I	THERMAL SERVICES CONTRACT
O6	1506	1580		3.05	3.74	4.50	4.1					C	LOW-INCOME WEATHERIZATION
M1.1	977	1114	1003	4.43	5.44	6.55	6.6	56.3	37.3	26.2	17.4	A	DEMO PGM. LOW-INCOME WEATHERIZATION
M1.2A												A	ACTIVE CONTROL GROUP
M2	1211	1381	1309	8.29	10.16	12.23	18.9	102.5	89.2	33.1	28.8	A	DEMO PGM. LOW-INCOME WEATHERIZATION
M3	2924	3333	3643	4.56	5.59	6.73	6.3	142.6	75.5	33.9	17.9	A	DEMO PGM. LOW-INCOME WEATHERIZATION
M4.1	1807	2060	2106	2.51	3.08	3.70	8.4	172.6	102.0	33.3	19.7	A	DEMO PGM. LOW-INCOME WEATHERIZATION
M4.2A												A	ACTIVE CONTROL GROUP
M5.1	905	1032	773	3.03	3.72	4.47	6.1	91.2	69.8	15.7	12.0	A	DEMO PGM. LOW-INCOME WEATHERIZATION
M5.2A												A	ACTIVE CONTROL GROUP
M6.1	2215	2525	2505	2.59	3.18	3.82	3.8	185.8	104.6	24.8	13.9	A	DEMO PGM. LOW-INCOME WEATHERIZATION
M6.2A												A	ACTIVE CONTROL GROUP
M7.1	1626	1854	2358	3.56	4.37	5.26	5.7	139.3	83.7	15.0	9.0	A	DEMO PGM. LOW-INCOME WEATHERIZATION
M7.2A												A	ACTIVE CONTROL GROUP
M8.1	1610	1835	1571	3.44	4.22	5.08	8.2	125.6	87.2	21.8	15.2	A	DEMO PGM. LOW-INCOME WEATHERIZATION
M8.1A												A	ACTIVE CONTROL GROUP COMPOSITE
M9	219	307	238	.95	1.17	1.40	2.4	110.7	89.7	13.2	10.7	C	LOW-INCOME WEATHERIZATION
M10.1	906	1121	1391	8.41	10.31	12.41	25.0(c)	137.5	123.6	16.5	14.9	C	LOW-INCOME WEATHERIZATION
M10.2B										11.7	12.0	C	BLIND CONTROL GROUP
M10.3	849	1050	1357	12.78	15.67	18.87	36.0	133.9	124.9	16.1	15.0	C	2 POST-RETRO YEARS SUBGROUP
M11	1088	1240		4.53	5.55	6.69	11.1					C	LOW-INCOME WEATHERIZATION
M12	1050	1101		2.10	2.58	3.10	3.9					C	LOW-INCOME WEATHERIZATION
					(¢/kWh)								
E1.1	440	610	602	.83	1.03	1.24	3.5	127.9	58.4	12.8	5.9	A	DEMO PROGRAM BY PRIVATE CONTRAC.
E1.2	154	213		.43	.53	.64	1.9					B	DEMO PROGRAM BY TVA PERSONNEL
E2	310	383		1.45	1.78	2.15	5.1					A	EARLY PART OF HOME INSUL. PROG
E3.1	1050	1245	778	3.68	4.52	5.44	7.7(b)	126.6	106.2	9.4	7.9	A	STUDY OF AIR LEAKAGE
E3.2A												A	ACTIVE CONTROL GROUP
E3.3B												A	BLIND CONTROL GROUP
E4	1335	1522		2.99	3.68	4.43	13.6					C	ZERO INTEREST WEATH. PROGRAM
E5.1	399	455		.91	1.12	1.35	5.1					C	EARLY PART OF WEATH. PROGRAM
E5.2B												C	BLIND CONTROL GROUP
E6	1110	1265		1.53	1.88	2.26	6.8(b)					C	ZERO INTEREST WEATH. PROGRAM
E7	1357	1609		3.27	4.02	4.84	9.4					C	EARLY PART OF WEATH. PROGRAM

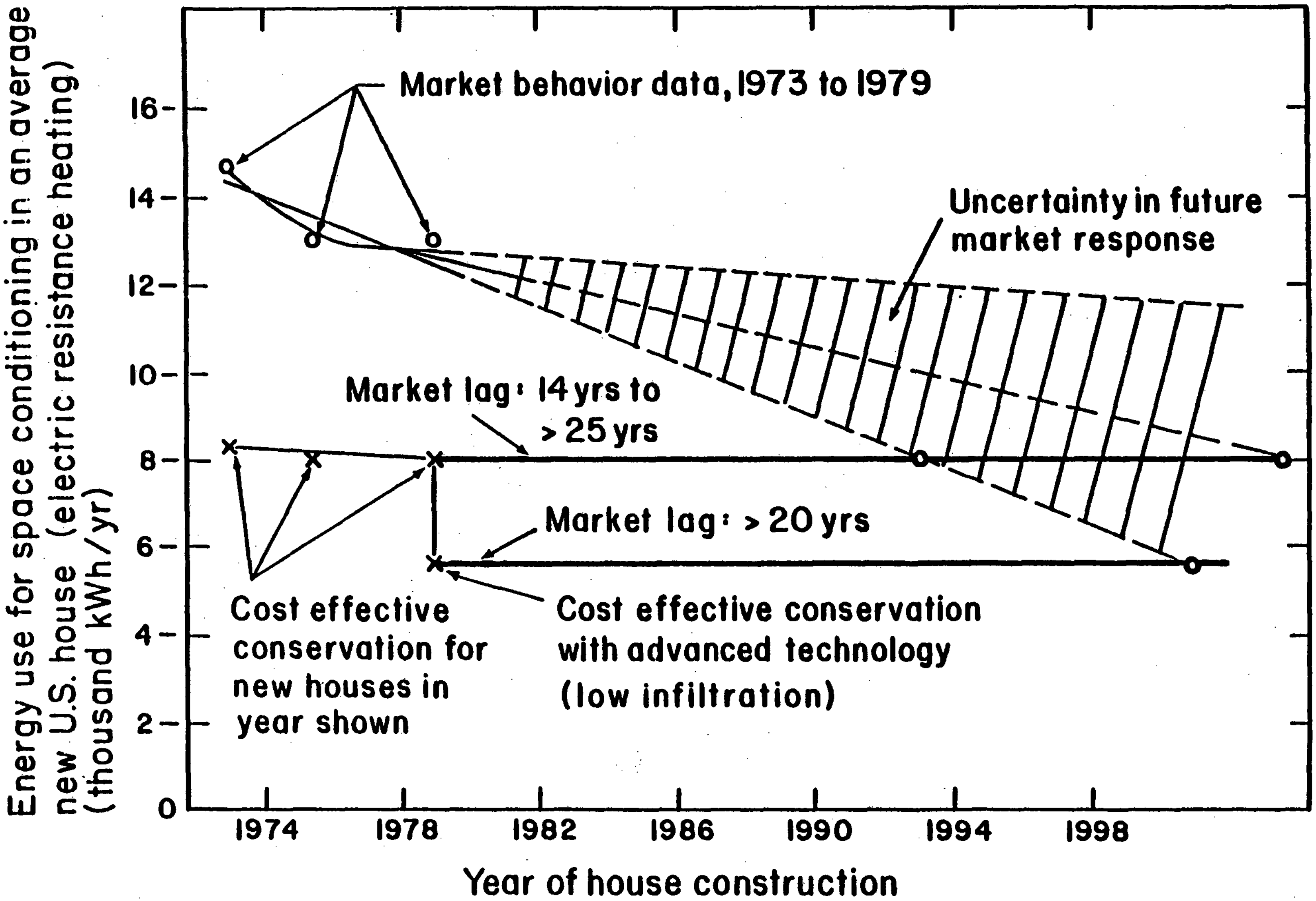


Figure 3(a). Observed market behavior vs. life-cycle cost minima for space conditioning energy used in all-electric new homes (U.S. average) built from 1973 to 1979, with projections of both least-cost usage and market trends to 2000. Market behavior data are based on LBL analysis of new home characteristics, as determined by the NAHB survey of 300,000 new housing units.

Source: Levine/McMahon (forthcoming)

Attachment 3.

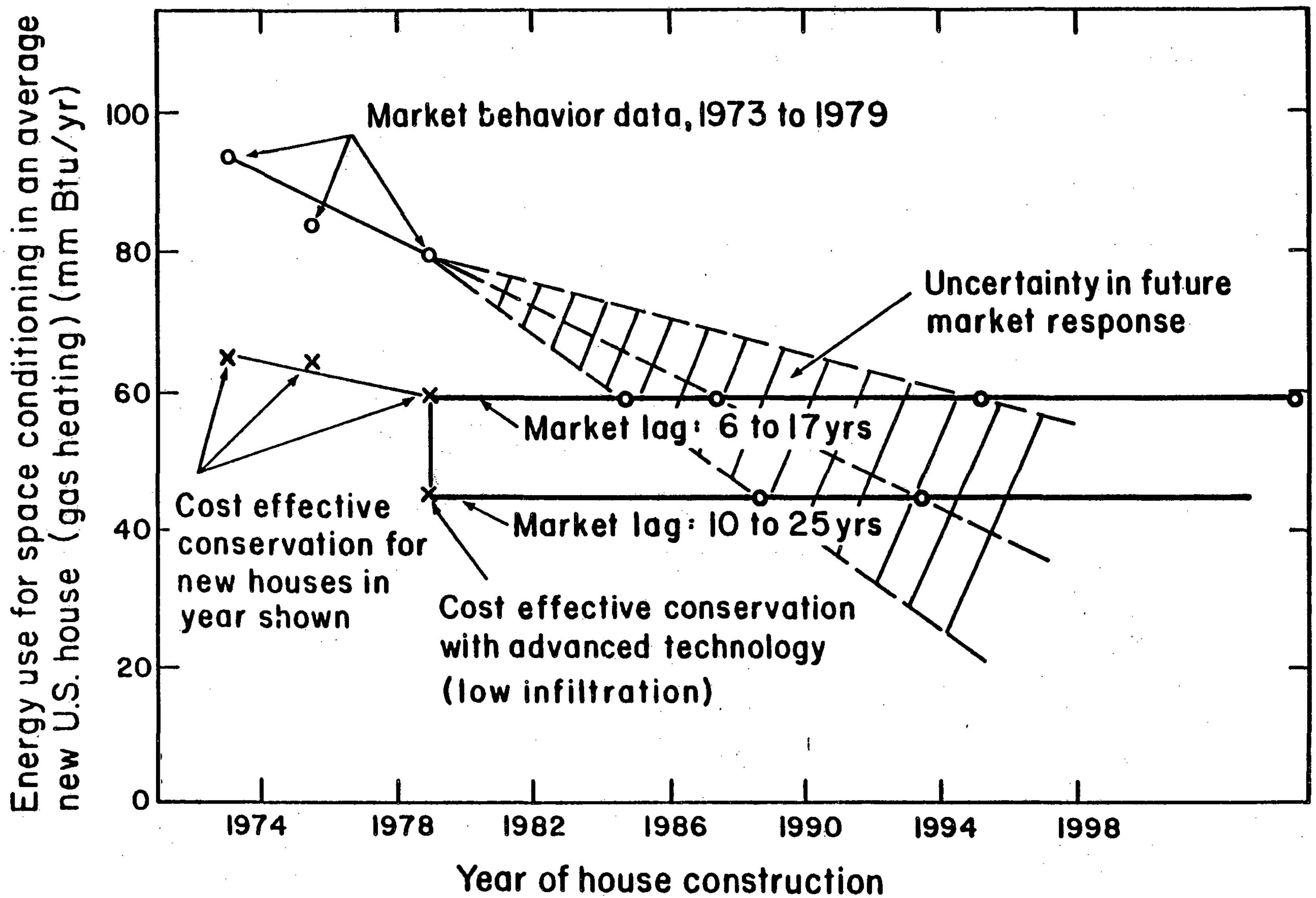


Figure 3(b). Observed market behavior vs. life-cycle cost minima for space conditioning energy used in gas-heated new homes (U.S. average) built from 1973 to 1979, with projections of both least-cost usage and market trends to 2000. Market behavior data are based on LBL analysis of new home characteristics, as determined by the NAHB survey of 300,000 new housing units.

Source: Levine/McMahon (forthcoming)

LBL-10738
EEB 80-2
Preprint

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

ENERGY & ENVIRONMENT DIVISION

To be submitted for publication

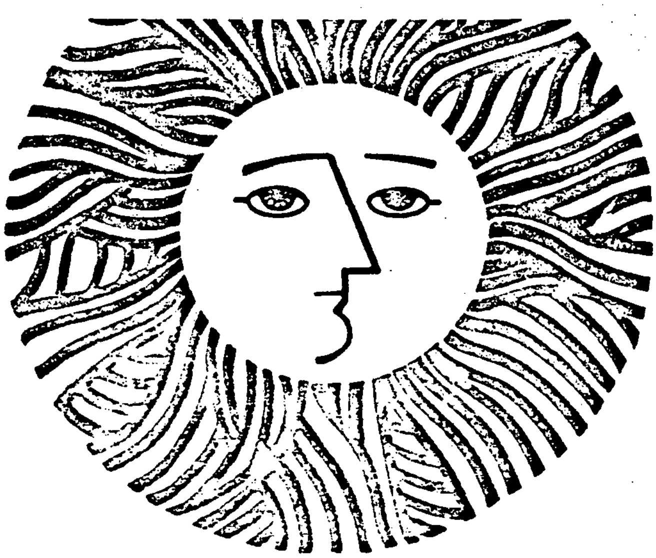
SUPPLYING ENERGY THROUGH GREATER EFFICIENCY: THE POTENTIAL FOR CONSERVATION IN CALIFORNIA'S RESIDENTIAL SECTOR

Janice Wright, Alan Meier,
Mark Maulhardt, and A.H. Rosenfeld

January 1981

ATTACHMENT 4

This 8-page reprint contains only the last chapter of the complete 166-page report, which has been submitted to the Univ. of Calif. Press. Loan copies may be borrowed from Alan Meier (415)486-4740, or A.H. Rosenfeld (415)486-4834.



Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

Grand Supply Curves of Natural Gas and Electricity

In this part, we present supply curves of conserved gas and electricity for the entire residential sector of California. Since these curves summarize our research to some extent, it is worthwhile to review some of our critical assumptions. (Details can, of course, be found in Part 1.) Our critical assumptions are:

- Cost of conserved energy is independent of energy prices
- A real discount rate of five percent
- Amortization times are usually 10 years or less*
- Costs reflect contractor installation (not do-it-yourself)
- Linear appliance turnover model (at historic rates)
- No consumer cost for meeting CEC standards
- Potential savings is from 1978 stock only, i.e., no growth is assumed
- A ten-year time horizon for implementation of conservation measures
- 100% implementation of conservation measures

The supply curve of conserved gas (Figure 3-1) begins with several no-cost measures, rises slightly, continues almost flat until 211 teraBtu, climbs gradually to 288 TBtu, and then rises sharply.† The cumulative savings after the final measure is 313 TBtu, or about 50% of the total natural gas use in the residential sector in 1978.

The supply curve of conserved electricity (Figure 3-2) begins with several no-cost and low-cost measures, climbs steadily to 12 TWh,** and then climbs steeply to 12.5 TWh. The cumulative savings after the final measure amount to about 25% of all the electricity used by the residential sector in 1978.

---

* The exceptions are those where the investment, e.g., for insulation, would be partly recovered on resale.

† One teraBtu (TBtu) equals 10^{12} Btu (a milliquad, if you will).

** A terawatt-hour (TWh) equals 10^9 kilowatt-hours. A typical 1000 MW power plant generates 5.7 TWh per year of useful electricity, assuming a 65% capacity factor. (Transmission and distribution losses reduce this to 5.1 delivered TWh per year.)

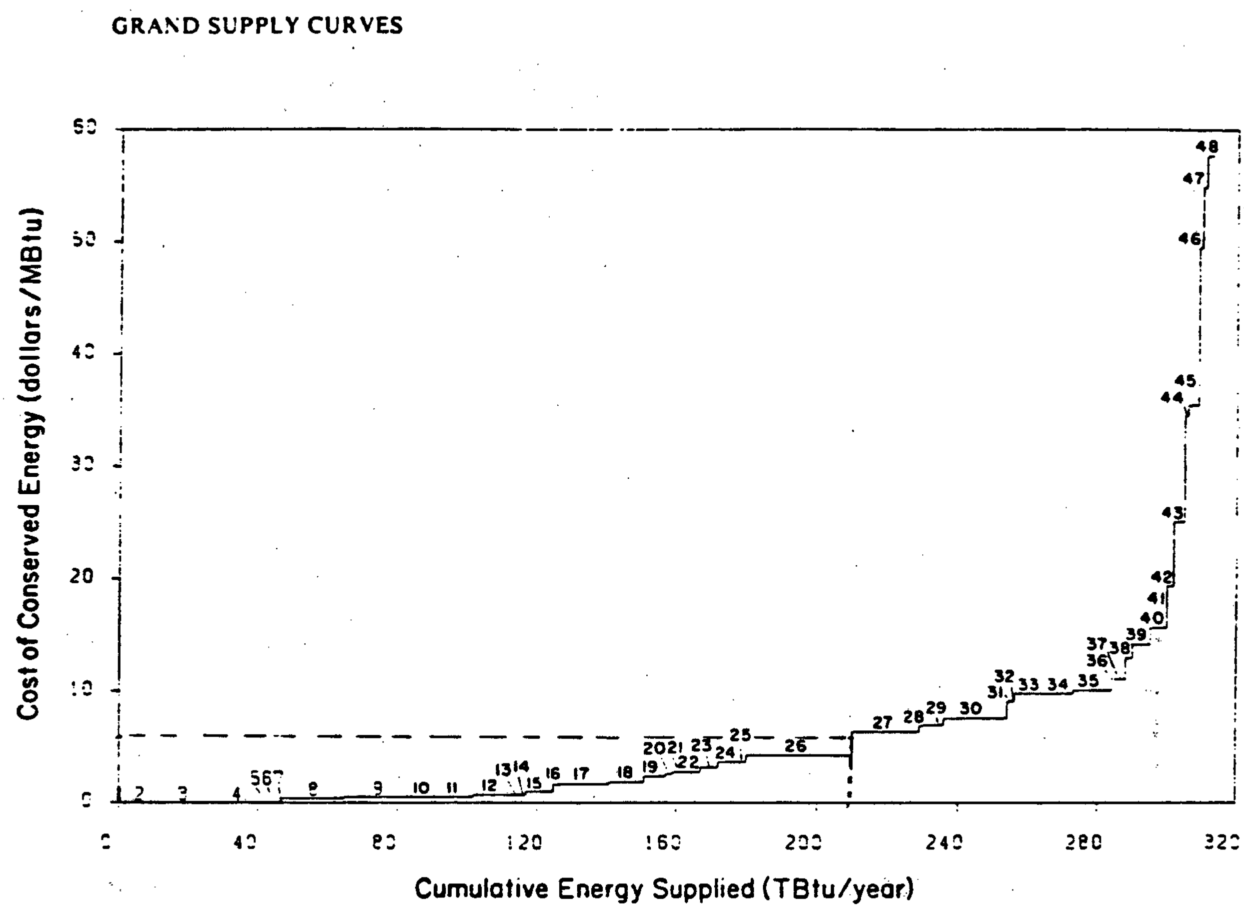


Figure 3-1. The grand natural gas conservation supply curve for California's residential sector. The total residential use in California in 1978 was 612 TeraBtu (or .612 quads). Conservation measures costing up to \$6 per million Btu will save roughly 34% of this. See Table 3-1 for a guide to the measures. Note that 1 TBtu = 10^{12} Btu.

To estimate the reserves of conserved energy, one must choose a suitable cost of conventionally supplied energy for comparison. Those measures for which the cost of conserved energy is less than the cost of conventional fuels are economic. The energy price chosen must reflect prices over the 10-year time horizon and must be expressed in real terms (since a real discount rate is used). Using today's price for comparison implies that energy prices will rise at the same rate as inflation over the next 10 years (this is probably a conservative assumption). The tailblock rate for natural gas is now over \$6 per MBtu.

About 34% of the gas used in the residential sector can be saved at costs of conserved energy below \$6 per MBtu. (Thus, conservation in this sector alone could reduce total gas use in California by 12%.) This reduction corresponds to 60% of the projected flow through the Point Conception liquefied natural gas facility; gas from this facility is expected to cost residential consumers slightly less than \$7 per MBtu.

Table 3-1. Table for the natural gas supply curve (Figure 3-1). The time horizon is 10 years; the discount rate is five percent. Costs of conserved energy are in 1979 dollars. In the description of the measures (first column), N = Northern California, single family; S = Southern California, single family; MF = multifamily. Total residential use of gas in California in 1978 was 612 TBtu.*

Measure*	Cost of Conserved Energy ($/MBtu)		Energy Supplied (TBtu/y)*		Total Dollars Invested (millions)	Meas. No.
	Marginal	Average	Per Meas.	Total		
1 Spark ignition for dryer	0	0	1.4	1	0	44
2 Spark ignition for range	0	0	9.8	11	0	42
(3) Water heater temp. setback	0	0	14.7	26	0	35
(4) Cold-water laundry	0	0	15.6	42	0	34
(5) Pilot off in summer (MF)	0	0	1.3	43	0	28
(6) Pilot off in summer (S)	0	0	3.0	46	0	19
(7) Pilot off in summer (N)	0	0	1.0	47	0	1
(8) Low-flow showerhead	.4	.1	18.5	65	60	36
(9) Night setback of 10°F (S)	.5	.2	18.5	84	171	20
10 Pool cover North CA	.5	.2	7.7	91	178	38
(11) Night setback of 10°F (N)	.5	.3	10.7	102	243	2
12 Pool cover South CA	.7	.3	10.5	113	257	40
13 New furnace w/spark ignit. (S)	.7	.3	2.0	115	274	102
14 New furnace w/spark ignit. (N)	.7	.3	2.0	117	292	100
(15) Night setback of 10°F (MF)	1.0	.3	6.8	124	374	29
16 New furnace w/spark ignit. (MF)	1.0	.4	1.5	125	391	104
(17) Water heater insul. blanket	1.7	.5	16.1	141	510	37
18 Install R-19 in ceiling (N)	1.9	.6	10.0	151	744	4
19 Seal attic bypasses (N)	2.4	.7	6.2	157	931	3
20 Install R-19 in ceiling (MF)	2.6	.7	2.1	159	999	30
21 Retrofit spark ignit. (S)	2.8	.7	4.0	163	1,084	101
22 Retrofit spark ignit. (N)	2.8	.8	4.0	167	1,168	99
23 Seal attic bypasses (S)	3.2	.9	4.7	172	1,354	21
24 Install R-19 in ceiling (S)	3.7	.9	5.1	177	1,588	22

Table continued

* 1 TBtu (TeraBtu) = 10^6 million Btu = 10^{12} Btu.

Table 3-1 continued

	Measure*	Cost of Conserved Energy ($/MBtu) Marginal	Cost of Conserved Energy ($/MBtu) Average	Energy Supplied (TBtu/y) Per Meas.	Energy Supplied (TBtu/y) Total	Total Dollars Invested (millions)	Meas. No.
25	Retrofit spark ignit. (MF)	3.7	1.0	2.6	180	1,662	103
26	Install R-11 in walls (N)	4.3	1.5	31.3	211	3,356	5
27	Storm windows (N)	6.4	1.9	18.2	229	4,800	7
28	Seal attic bypasses (MF)	6.9	1.9	.5	230	4,839	105
29	Install R-11 in walls (MF)	7.0	2.0	6.7	236	5,420	106
30	Install R-11 in walls (S)	7.6	2.4	17.9	254	7,107	23
31	Fireplace damper (S)	9.1	2.4	.7	255	7,159	13
32	Fireplace damper (N)	9.1	2.4	.7	256	7,211	11
33	Water heater flue damper	9.8	2.7	9.7	265	7,620	75
34	Caulking (N)	9.8	2.9	7.2	273	8,168	6
35	Storm windows (S)	10.1	3.2	11.4	284	9,606	25
36	Tune up pool heater North CA	11.1	3.2	.2	284	9,613	86
37	Storm windows (MF)	11.1	3.3	4.0	288	10,163	32
38	Buy most efficient gas dryer	13.0	3.4	1.5	290	10,316	56
39	Caulking (S)	14.2	3.5	5.0	295	10,861	24
40	Additional R-19 in ceiling (N)	15.7	3.7	4.8	300	11,797	8
41	Tune up pool heater South CA	17.5	3.7	.3	300	11,811	87
42	Caulking (MF)	19.4	3.8	1.8	302	12,075	31
43	Additional R-19 in ceiling (S)	25.1	4.0	3.0	305	13,007	26
44	Seal ducts (N)	34.6	4.2	1.5	306	13,232	15
45	Weatherstrip (N)	35.5	4.5	3.2	309	13,730	9
46	Seal ducts (S)	49.5	4.7	1.0	310	13,953	17
47	Weatherstrip (MF)	54.9	4.8	.9	311	14,162	33
48	Weatherstrip (S)	57.7	5.2	2.0	313	14,658	27

Avg. Cost ≅ $6.00/MBtu

*The conservation measures are listed in the order they appear in the supply curve, i.e., according to cost of conserved energy. The measure number (last column) is the number used throughout the report to identify the measure.

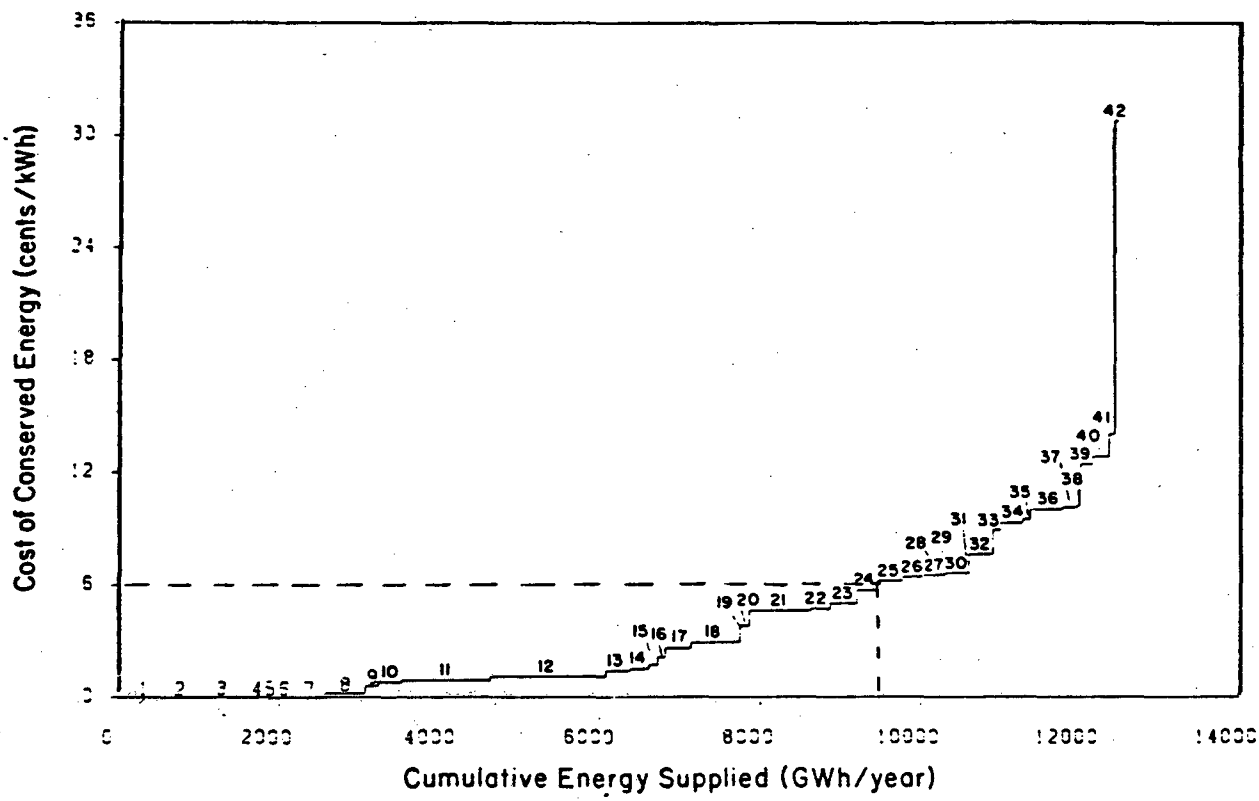


Figure 3-2. The grand electricity conservation supply curve for California's residential sector. The total residential use in California in 1978 was 49,000 GWh. Conservation measures with costs up to 6 cents/kWh will save roughly 20% of current use. See Table 3-2 for a guide to the measures. Note that 1000 GWh = 1 billion kWh.

The tailblock rate for electricity is over 8 cents per kWh. About 22% of the current residential consumption could be saved at costs of conserved electricity below 8 cents per kWh. (Thus, conservation in the residential sector alone could reduce total electricity use in California by 7%.) This reduction corresponds to the output of two standard 1,000 MW power plants.*

In the gas supply curve most of the saved gas (about 86%) comes from water- and space-heating conservation measures. Since these measures are retrofits, the savings can be nearly all realized in the 10-year time horizon; the savings increase only slightly with a 20-year time horizon. A significant amount of water heating energy can be saved cheaply. Many

---

* Here one must carefully distinguish between energy and power. Although these measures may preclude the need for the electrical output (GWh) of two power plants, they may not necessarily save the capacity (GW) of two power plants. We present the savings in equivalent output to give the reader a sense of the magnitude; we do not mean that these measures could save building two new power plants.

Table 3-2. Supply table for the electricity supply curve (Figure 3-2). The time horizon is 10 years; the discount rate is five percent. Costs of conserved energy are in 1979 dollars. Total residential use of electricity in California in 1978 was 49.6 TWh.*

		Cost of Conserved Energy (cents/kWh)		Energy Supplied (GWh/y)*		Total Dollars Invested	Meas.
	Measure*	Marginal	Average	Per Meas.	Total	(millions)	No.
1	Solid-state color TV	0	0	599.1	599	0	68
2	Solid-state black-and-white TV	0	0	322.3	921	0	67
3	CEC standard refrigerator	0	0	728.0	1,649	0	78
4	CEC standard room A/C	0	0	152.1	1,802	0	94
5	CEC standard central A/C	0	0	168.0	1,970	0	90
6	Water heater temp. setback	0	0	186.2	2,156	0	62
7	Cold-water laundry	0	0	407.4	2,563	0	61
8	Low-flow showerhead	.2	0	496.6	3,060	8	63
9	Night setback of 10°F	.6	.1	153.1	3,213	20	46
10	Pool filter savings from cover	.8	.1	287.0	3,500	24	70
11	Buy most eff. refrigerator	.9	.3	1,092.0	4,592	102	65
12	Refrigerator package "A"	1.1	.5	1,466.4	6,058	227	79
13	Buy most eff. freezer	1.4	.5	305.8	6,364	259	66
14	Water heater insul. blanket	1.5	.6	240.6	6,605	275	64
15	3-Way bulb to high efficiency	1.7	.6	110.6	6,715	283	83
16	Seal attic bypasses	2.1	.6	92.5	6,808	307	47
17	Freezer package	2.6	.7	327.6	7,135	373	85
18	Kitchen fluorescent	2.9	.9	608.9	7,744	511	69
19	Install R-19 in ceiling	3.7	.9	9.9	7,754	515	48
20	Divert elec. clothes dryer vent	3.8	.9	105.4	7,860	546	18
21	Switch to gas clothes dryer	4.6	1.3	766.7	8,626	821	45
22	Exterior fluorescent	4.7	1.4	239.0	8,865	909	71
23	100 W bulb to fluorescent (1)	5.0	1.5	334.5	9,200	1,039	73
24	Storm windows	5.7	1.6	258.4	9,458	1,224	51
25	Central A/C wall insulation	6.2	1.7	308.7	9,767	1,462	89

Average cost ≈ 6¢/kwh

Table continued

*1 TWh (Terawatt-hour) = one billion kilowatt-hours.
1 GWh (Gigawatt-hour) = one million kilowatt-hours.

Table 3-2 continued

	Measure*	Cost of Conserved Energy (cents/kWh) Marginal	Average	Energy Supplied (GWh/y) Per Meas.	Total	Total Dollars Invested (millions)	Meas. No.
26	Buy most efficient central A/C	6.4	1.9	252.0	10,019	1,630	59
27	Manual refrig. improvement	6.5	2.0	208.0	10,227	1,734	81
28	Buy most efficient elec. dryer	6.5	2.0	62.0	10,289	1,765	57
29	Fireplace damper	6.5	2.0	13.4	10,302	1,772	14
30	100 W bulb to fluorescent (2)	6.6	2.1	290.3	10,593	1,920	97
31	Install R-11 in walls	7.4	2.1	8.8	10,601	1,928	49
32	3-way bulb to fluorescent	7.6	2.3	305.3	10,907	2,108	72
33	Caulking	8.9	2.3	102.1	11,009	2,178	50
34	Switch to gas range	9.3	2.5	274.2	11,283	2,374	43
35	Window shading for central A/C	9.5	2.6	94.5	11,377	2,443	91
36	Refrigerator package "B"	10.0	2.8	405.6	11,783	2,755	80
37	100 W bulb to fluorescent (3)	10.1	2.9	191.2	11,974	2,904	98
38	Buy most efficient room A/C	10.2	2.9	24.3	11,999	2,926	60
39	75 W bulb to fluorescent	12.4	3.1	155.8	12,154	3,074	74
40	Weatherize apartments	12.8	3.2	204.0	12,358	3,346	10
41	Additional R-19 in ceiling	14.0	3.3	68.9	12,427	3,466	52
42	Weatherstrip	30.8	3.4	47.9	12,475	3,530	53

*The conservation measures are listed in the order they appear in the supply curve, i.e., according to cost of conserved energy. The measure number (last column) is the number used throughout the report to identify the measure.

of the space-heating measures are expensive because in our analysis they are done to every home rather than just to those of the high users. We do not recommend applying these measures to every home, but we lack the data to estimate costs and energy savings for a more focused program.

In the electricity supply curve the main sources of the saved energy are more diverse: refrigerators, lighting, and water heating (about 38%, 17%, and 12%, respectively). Moreover, with a 20-year time horizon, electricity savings are about 50% greater than with the 10-year time horizon we used. In particular, absolute energy savings from refrigerators and freezers double. Thus, it is crucial to introduce more efficient refrigerators and freezers as soon as possible (an inefficient refrigerator bought today will still be in operation in the year 2000). Had our model included growth, refrigerator energy use would have been even more important. Air conditioners will undergo major improvements because of new CEC standards, but the conserved power is far more valuable than the conserved electricity. Even stricter standards based on peak power needs might defer huge capital outlays for new power plants.

Beyond a certain point the supply curves rise sharply, which is misleading since this suggests that the reserves of cheap conserved energy are limited. First, in the case of the electric supply curve, we underestimated the number of potentially economic measures. Conserving electricity proved cheaper than we anticipated; we could have considered additional measures. Second, the curves reflect the fact that Californians have never confronted the high energy prices we now face and therefore have not developed suitable conservation techniques. In this study we have applied commonly available conservation measures and avoided speculating on new solutions (even though the efficiencies of our appliances and homes are far from the maxima set by the second law of thermodynamics). (See Appendix A.) Although the cost of conserved energy <u>based on current technologies</u> rises sharply beyond a certain point, new technologies, ingenuity, and changes in patterns of energy use will probably temper the curves' steep rise.

Supply curves of conserved energy need careful analysis of current energy demand by end use. Such a breakdown is shown as pie charts in Figure 3-3. (See also Tables B-1 and B-2.) The charts also depict the sources of the conserved energy available at costs below $6 per MBtu and 8 cents per kWh.

Why do such large cheap reserves of conserved energy exist at all? Much of it is a consequence of market failures. Poor (or worse, contradictory) consumer information, rapidly rising energy prices, and landlord-tenant impasses are just a few market failures that have created the greatest part of the cheap reserves. Also, new technologies, such as solid-state controls, flue dampers, and electronic ignition devices, will obviously take time to penetrate the market. To exploit these reserves will require diverse policies. Energy performance standards, utility rate structures, and utility financing schemes are just a few of the ways the state might tap these enormous reserves of conserved energy.

In this report we have described the technical potentials for energy conservation. There remains one final step: to transform these potentials into realistic goals. For this one must examine the feasibility of each measure. This requires another set of assumptions concerning penetration rates, effectiveness of information campaigns, and utility participation, etc. The reader may have his or her own thoughts on these matters; however, we leave that discussion to a companion paper.

We have constructed supply curves only for California's residential sector, which uses a third of the natural gas and electricity consumed in the state. Obviously all sectors should be studied in order to ascertain the overall potential for conservation. However, for policy purposes, a sectoral approach with each end use considered separately is most useful.

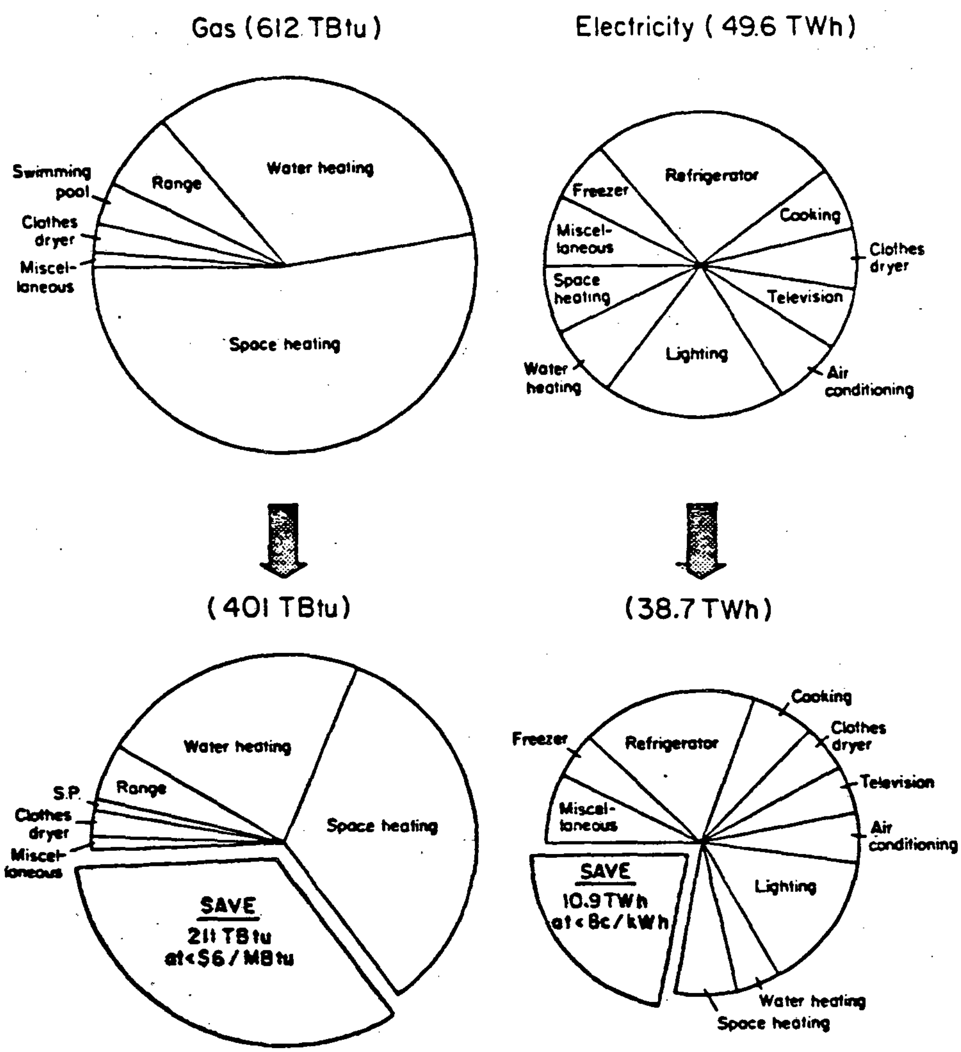


Figure 3-3. Residential energy by end use in California in 1978 (above), and the potential energy savings for a ten-year time horizon. The "saved" gas and electricity is based on a 5% real discount rate. (The areas of the pies are proportional to the energy in resource units.)

ATTACHMENT 5

From the Energy Efficient Buildings Chapter of the LBL Annual Report for 1980.

"House Doctor" Demonstration, Training, and Retrofit Monitoring Project

Researchers at LBL are currently conducting a cooperative project with Pacific Gas and Electric Company (PG&E) to determine the energy savings resulting from "house doctor" retrofitting of single-family residences in Walnut Creek, CA. The standard house-doctor visit is designed to increase the effectiveness of residential audits by including instrumentation and ~2 person-days of retrofitting. House doctoring also has potential as a contractor type business similar to, or combined with, insulation installation.

The procedure emphasizes use of a "blower door," a device which can both pressurize and depressurize a house to facilitate the measurement of infiltration levels and permit quick identification of air leaks. An infrared scanner is used in conjunction with the blower door to detect leaks in the attic and to check the quality of wall insulation.

From the audit portion of the visit, a series of recommendations are made to the homeowner, as in other audit procedures. The principal feature of the retrofit portion is that the auditor, at the time of the visit, will implement simple energy-saving measures while the house is pressurized. The convenience to homeowners is that the work is not only done immediately (and correctly) but also at low materials cost.

Thirty houses were included in our study. Ten of the houses were "active controls" which received house-doctor audits only (no retrofit). Ten received a standard house-doctor visit, and ten received an "extended retrofit," which is a house-doctor visit plus additional retrofit to be performed by contractors. In our experiment, the house-doctor audit is essentially the PG&E Enercom computerized audit with the addition of an infiltration measurement and a few extra items on the audit form/prescription. Our retrofits included installation of electronic ignition devices on the furnace--not always considered part of house doctoring. The contractor retrofits will be installed in Spring 1981, selected on the basis of economic attractiveness from a list that includes: increased insulation in attics, walls, and floors; installation of storm windows; taping and insulating furnace ducts; further house-doctor-type leak plugging; and replacement of incandescent with fluorescent light fixtures.

The energy use of each house will be monitored for at least one year after the retrofitting occurs. Consumption by furnace, water heater, pool heater (if any), and air conditioner will be recorded weekly. A regression of energy use with respect to temperature data from a nearby site, done before and after the retrofits, will allow calculation of energy savings in an average year.

Several useful materials have been developed as part of this project. One is a comprehensive House Doctor Manual which describes the on-site audit and retrofit procedure. Another is a complete list of the equipment, tools, and retrofit materials needed for a house-doctor visit. In addition, a curriculum for training house doctors was developed and used in a two-week intensive training course for seven PG&E "weatherization specialists." These trained PG&E house doctors completed the twenty partial retrofits and thirty audits during November and early December of FY 1980.

Various members of the public were invited to observe a series of retrofit demonstrations in October. This program was designed so that the observers could get a first-hand idea of the kind of retrofit procedure that becomes possible when the various instruments mentioned above are used. The houses were house-doctored by two members of our LBL staff, while a third explained the procedure to the observers.

The preliminary results from this project are summarized in Tables 3 and 4. The average reduction in infiltration (as calculated from the blower-door measurements) is 30%, with a range from 14% to 65%. The average infiltration rate for the 16 houses included in the preliminary calculations is 0.75 air changes per hour (ach) before, and 0.52 ach after house doctoring. We estimate the costs

Table 3. Infiltration reduction from house-doctor retrofits.

House	Year Constructed	Volume (m^3)	Leakage Area (cm^3)		Heating Season Average Air changes/hour		Infiltration Reduction (%)
			Before	After	Before	After	
A2	1969	430	1421	1081	.62	.47	24
A3	1955	350	1499	1282	.78	.67	14
A5	1965	370	1325	789	.68	.40	41
A6	1956	350	1126	951	.62	.52	16
A7	1969	600	1638	1319	.52	.42	19
A9	1966	420	1148	944	.68	.56	18
A10	1960	340	2010	1510	1.12	.84	25
B1	1965	490	2091	1606	1.06	.82	23
B2	1970	520	1916	1297	.70	.47	33
B4	1969	640	2712	950	1.06	.37	65
B5	1970	510	1761	1106	.67	.42	37
B6	1960	440	1437	1049	.62	.45	27
B7	1969	640	1462	1127	.57	.44	23
B8	1969	600	3164	1827	.99	.57	42
B9	1965	480	2148	1458	.85	.58	32
B10	1969	770	1230	881	.40	.28	30
Average	--	497	1756	1199	.75	.52	29

(including labor, materials, and overhead) of a standard house-doctor visit at $365, (or $556 including the cost of IID installation). This yields a cost of conserved energy, over the useful lifetime of the retrofits, of $0.22/therm.

By finding and fixing leaks which are undetectable in current (uninstrumented) audits, house doctoring not only cuts energy waste but can make other conservation measures more effective. For example, if an attic is insulated before leaks are identified and patched, two serious problems arise: some leaks will be hidden by the insulation and harder to find and fix, and (2) loss of heat through these undetected leaks will undermine the benefits of insulation (in energy and dollar savings) and discourage homeowners from investing in energy-efficient strategies. Because of the relatively low materials cost and moderate labor intensity, this audit procedure may be well suited for use by small contractors and community groups.

New homes

Use of the blower door as a diagnostic tool during construction of new homes will probably turn out to be even more effective than its use in occupied houses.

Homes at time of sale

A house-doctor visit at the time of sale is probably a good investment for the future owner. If the house is doctored while it is empty (of furniture, rugs, and material stored in the attic), far more work can be done in one day. Preliminary results indicate that house doctor techniques can save energy at costs below the current fuel prices, and far below the price of new energy supplies. As prices rise and the importance of conservation grows, the importance of testing and refining these techniques will likewise increase.

Table 4. Savings and cost of conserved energy (CCE) for house-doctored homes of Table 3, before final contractor retrofit.

House No.	Therms/year saved by infiltration Reduction[a]	Total therms/year saved[b]	Estimated Cost[c] ($)	Cost of Conserved Energy[d] ($/therm)
A2	41	121	526	.29
A3	28	108	526	.33
A5	70	189	556	.20
A6	24	143	556	.26
A7	45	125	526	.26
A9	32	112	526	.32
A10	62	101	365	.24
B1	77	77	336	.29
B2	71	151	526	.23
B4	269	349	526	.10
B5	89	208	556	.18
B6	44	44	336	.51
B7	53	172	556	.22
B8	151	190	365	.13
B9	78	158	526	.22
B10	55	94	365	.26
Average	74	146	480	.22

[a]Calculated from leakage area measurements. Assumes 65°F heating degree day base and 20% reduction in furnace steady-state efficiency due to cycling and duct losses.

[b]Includes calculated savings from water heater and/or intermittent ignition device (IID) in houses where these were installed.

[c]Includes labor, materials, and 50% overhead. For a typical visit including infiltration reduction and water heater insulation labor costs are $155 and materials costs are $75. Additional costs for IID installation are $67 (labor) and $60 (materials).

[d]CCE calculated on the basis of an amortization period equal to expected useful life of the retrofits (20 years). Real interest rate assumed to be 3%.

TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720