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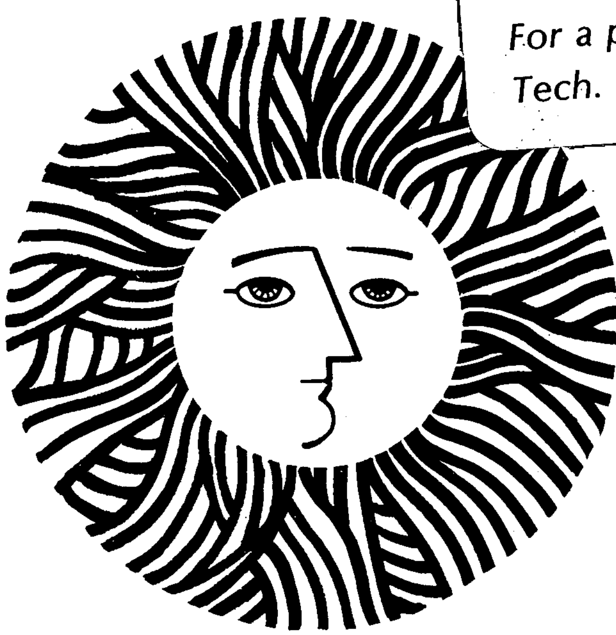

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TECHNICAL ISSUES FOR BUILDING ENERGY USE LABELS*

Who Certifies the Accuracy?
Who Validates the Tools?
Who Licenses the Auditors?

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ABSTRACT

Current market practice in building energy efficiency lags 15-30 years behind current cost-effective conservation practice, in part due to lack of credible information about home energy efficiency. We show that building energy efficiency labels are an attractive tool for providing this information, and that they can influence the value of a home by ±$2500. We discuss the requirements for label accuracy, some technical issues involved in designing a label, and suggest a certification process for labelling tools and users.

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I. INTRODUCTION

A. The Lag in Market Response The history of US residential building practice reveals a dismal track record in energy conservation. Ribot et. al.[1] have shown that, despite the fuel price increases of the last decade, the trend in current construction lags 15 to 30 years behind 1980 cost-effective construction. Fig. 1, illustrating their results, shows that current cost-effective construction can reduce the thermal intensity of buildings by as much as 75% relative to 1980 practice. Clearly, price signals alone have not overcome a variety of existing market failures, which include: lack of information, average fuel pricing (which disguises future prices), and lack of life-cycle costing. In this paper, we discuss building energy efficiency labels as a tool to overcome some of these problems, show that the potential impact on market value of efficient homes is substantial, and address the technical issues associated with developing and certifying credible labels.

B. Standards, "Pass/Fail" Labels, and "Real" Labels In the remainder of this introduction, we review briefly the advent of energy use standards and labels for automobiles, appliances, and homes, and suggest that standards and labels nicely complement one another, although either one alone is useful.

For autos, of course, the U.S. has already adopted both mandatory CAFE standards (CAFE = Corporate Automobile Fuel Economy) and individual EPA mpg stickers. The CAFE standards probably did some good, because they guaranteed a market for more efficient cars (and hence induced the manufacturers to start early to invest in new assembly lines), but it has been largely the individual stickers which have bestowed a high value on efficient cars, both in the new and used car markets.

For appliances, California has a successful program of both mandatory standards and labels; the Reagan Administration opposes both Federal and State standards but accepts the existing mandatory labels.

For buildings, the U.S. (with many other countries) has followed a different (we think inefficient) path leading to standards only. This is probably because until recently we had little faith that we could predict the energy use of a home or commercial building, and did not realize that labels would be popular and credible with purchasers of new and existing homes and buildings.

In 1977, the Edison Electric Institute initiated the NEW (National Energy Watch), a pioneering labelling program which, unfortunately, in the spirit of Gold Medallion homes, settled for Pass/Fail criteria, i.e., a new electrically-heated home could qualify for certification as "energy efficient" by achieving a minimum point score, but there was no motivation for the builder to exceed the threshold, or for the buyer to pay for "extras." And, of course, EEI wasn't about to push extra credit for gas heat or gas appliances, although individual participating utilities could (and did) choose to do so (see Fig.2). NEW has now been adopted by 170 utilities, but for most of them we believe it is still a Pass/Fail program.

Wisconsin, Florida, several other states, counties/cities, and trade organizations have also adopted Pass/Fail Labels, but as far as we know none has had the self-confidence to emphasize quantitative, comprehensive labels which permit a buyer to predict next year's energy bills and which successfully involve primary and secondary lenders, permitting market prices to respond to the present value of energy savings*.[2] The new French Agency for Energy Management is seriously committed to labels for both new and existing residences. For more information see Appendix A or the paper by Paul Hendrickson presented to this conference.

II. THE CASE FOR GRADUATED LABELS: PG&E'S ECH PROGRAM

We at LBL are proud of collaborating in 1979 with the Pacific Gas and Electric Company in designing the first quantitative, comprehensive "ECH" (Energy Conservation Home) Labelling Program, aimed precisely at motivating builders and buyers in Northern California to "beat" the California mandatory building standards, called "Title 24." (See the paper by Richardson and Haddow of PG&E, submitted to this conference.)

Mandatory standards for new homes tend to limit their coverage to items which will be expensive to upgrade and which will last for a large fraction of the 50-100 year life of a home--insulation, windows, thermal mass, etc. But the home-buyer is interested not only in utility bills 50 years hence, but also those next month. If gas is cheaper than electricity for heating space and water, cooking, and drying clothes, he wants to be told how much cheaper and then permitted to bid more for these features. And he wants to consider the efficiency of major

*Visalia, CA, and others have adopted voluntary, graduated labels, but ratings are still given in units of "stars", points, or category rather than energy. Others have adopted audit programs which include estimates of heating bills, but without a labelling component in absolute energy or dollar units. Two experimental rating programs involving primary and secondary lenders are beginning, one in the Pacific Northwest, and one in Massachusetts (see proceedings of this conference).

appliances (furnace, water heater, air conditioner, refrigerator, freezer, heat exchanger), lighting, shower heads, insulating shutters, and the like.

PG&E's 1979 ECH Program covered all of the above. Figure 2 shows an ECH agreement filled out with some recommendations by John Hailey, who was in charge of the program. Hailey has recommended a total of 125 points (saving 375 therms/ year of resource energy, worth about $200/year). Note that only 50 of the 125 points have anything to do with the hard-to-modify shell of the house. The majority (75) of the points save money by paying attention to fuel choices and to transient, flexible items: lighting, thermostats, even low-flow shower heads and a clogged filter indicator. Of the items that cost enough to write down, the shell upgrade costs $200 for caulking and rated only 35 points ($6/point); the rest cost $155 and rated 70 points ($2/point), so the "comprehensive" options are three times more lucrative than the shell upgrade.

Notice that even the PG&E/ECH Program lacked the confidence to label homes directly in kWh, Therms, and dollars. PG&E was apprehensive that thousands of customers would complain that their labels underpredicted, so they invented "points" (1 point = 3 Therms or 30 kWh or 2000 gallons of cold water). Each point is worth about $1.50 of fuel or electricity per year. The subterfuge was pretty mild, since points are defined on page 1 of the Agreement, and it seems to have staved off irate phone calls; so for then, but <u>not for the future</u>, it was perhaps a good idea.

Instead of using an absolute rating scale, as we recommend today, PG&E made comparisons with Title 24, awarding points only for beating it, and setting a threshold of 50 points for certification. For a year or so they also paid builders an incentive of $2 per point beyond the 50-point threshold, but eventually dropped this as unnecessary as the program became a roaring success*.[3] Figure 3 is a "symbolic" plot of the history of the PG&E ECH program.**

As you might guess, the virtue of basing the points on Title 24 was very transient, since Title 24 is updated every few years. To us it is now clear that the only reliable reference point is zero, i.e., that building labels should look like auto fuel economy labels (which read in absolute mpg, not mpg compared with comparable models) or appliance labels, which give the absolute energy use. Of course, as for appliances, we advocate helping the purchaser by comparing the house with the best and worst in the same category.

III. LABELS FOR EXISTING HOMES -- UPDATING LABELS

A. Relation to RCS Audits So far, we have discussed only labels for new homes. They came about first because it was easier for a utility representative to look at the plans for a new home than it was for him to estimate the R-value of the insulation in the walls of an existing home. But the slow evolution of labelling systems did not anticipate the creation of the RCS (Residential Conservation Service) Program, in which utilities were to be required to offer audits for most of the

*The percentage of newly connected homes which qualified as ECHomes shot from 6% in 1976 to 66% in 1981, see reference above.

**We term this figure "symbolic" because, although basic trends appear, the units are mixed resource and site energy, unnormalized for floor area or climate.

existing homes in the U.S. So we now have blundered into an inconsistency, in which millions of homes are to be audited and millions of retrofit recommendations are to be made to home-owners, yet we have not planned to leave in place a voluntary label to document all of this effort and expense.

B. Labelling at Time of Sale In California, at least 11 counties/cities (comprising about 17% of the state's population) now require an inspection of existing houses, usually at time of sale, to certify presence of significant conservation measures, and/or installation of missing items.[4] We suggest that addition of a comprehensive, quantitative, and credible label would be an attractive addition to such inspections. This brings us to a final summary point about the difference between a building standard and a label, and why a label is more effective. A new building standard is a one-shot affair and governs mainly the shell. A label is comprehensive and can be updated every time that the building is sold, and, in fact, every time that the owner invests in an improvement. As a result it becomes part of our lives and experience and will be more influential and credible than any standard.

IV. THE MARKET VALUE OF A LABEL

A. New Homes Referring back to Fig. 1, we see that average new homes in 1980 consumed about 60 MBtu less for heating than existing stock, which is equivalent to roughly a $360 annual savings for the average new U.S. house.* Recalling from PG&E's checklist that further savings from efficient appliances were about 225 therm/y (\$135/y), we add these to the heating savings for a total of about \$500/y. In a footnote**,[5,6] we discuss the difficulties of measuring the market value of an annual \$500 stream of savings, but for this paper, we will guess a present value multiplier of 10:1, which means that new 1980 houses were worth, on the average, \$5000 more than average existing stock.

B. Existing Homes Wall et. al., in a paper presented at this conference[7] found from a survey of retrofits in existing buildings a median savings of 22%. Under the assumptions of the previous paragraphs, and including appliance savings, this implies a median savings over existing stock of \$270/year, or an increased value of \$2700 for a retrofitted and

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*The calculation from Fig. 1 proceeds as follows:

$$\begin{aligned}\text{Savings} &= (\text{Fuel use})_{\text{stock}} - (\text{Fuel use})_{\text{new}} \\ &= (\text{thermal load/ft}^2)_{\text{stock}}\ (\text{floor area})_{\text{stock}}\ (1/\text{furnace efficiency})_{\text{stock}} \\ &\quad - (\text{thermal load/ft}^2)_{\text{new}}\ (\text{floor area})_{\text{new}}\ (1/\text{furnace efficiency})_{\text{new}} \\ &= (50\ \text{kBtu/ft}^2)(1300\ \text{ft}^2)(1/.65) - (20\ \text{kBtu/ft}^2)(1500\ \text{ft}^2)(1/.80) \\ &= 100\ \text{MBtu} - 38\ \text{MBtu} = 62\ \text{MBtu}\end{aligned}$$

**The market value of an investment which yields a stream of annual savings will be affected by many factors which are difficult both to measure and to predict (e.g. interest and discount rates, amortization periods, inflation). However, we note that typical bank loans for autos and home improvements are made at a real rate of 10%, that is, an investment by the bank of \$100 yields an annual return of \$10, or a 10:1 multiplier. We further note that for the ECHomes, which yielded an average \$150 of energy savings a year, homeowners surveyed by PG&E estimated an increased value of their homes of about \$1200 (1982\$) - consistent with an approximate 10:1 multiplier, although homeowner estimates of fuel savings were unclear, and may have been higher than \$150/year, thereby reducing the multiplier. Finally, we note that in another PG&E survey, the median additional amount that customers claimed they were willing to pay for a home with "the latest conservation features" was \$5000 (see references, above).

labelled existing house, if the results extend to average stock.*

C. All Homes The division above is a bit artificial, since new homes quickly turn into existing homes, but we have seen that the efficiency of new US houses is worth \$5000 above that of existing stock. We further note that we have so far considered only average new and existing homes; cost-effective 1980 construction would reduce heating costs up to another \$120, worth another \$1200. Furthermore, existing stock includes some houses which are below average - therefore the total spread in operating costs will be larger than we calculated for the average. In the rest of this paper we shall then frequently say that a label should easily influence the value of a typical house by "plus or minus" \$2500, recognizing that this is a conservative figure that may underestimate the range of building energy efficiency. After a few years of demonstration programs, if interest rates remain stable enough to run experiments, we can hope for data rather than conjectures on this point (refer to the previous footnote on market value of a stream of energy savings).

D. An Example By way of a concrete example, we refer to our sample label in Fig. 3, calculated on Lawrence Berkeley Laboratory's Computerized, Instrumented, Residential Audit (CIRA) for a real house in Walnut Creek, California. The label is designed to offer the homeowner a

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*The calculation follows that of the previous footnote:

$$\text{Heating savings} = (.22)(50\ \text{kBtu/ft}^2)(1300\ \text{ft}^2)(1/.65) = 22\ \text{MBtu}$$

$$\text{Total savings} = (22\ \text{MBtu})(\$6/\text{MBtu}) + (\text{appliance savings}) = (\$132) + (\$135) = \$267$$

variety of "target" ratings available to him, and the energy savings resulting from improvements he might choose to make, compared to his current rating. In this case, the house costs $200/year more to operate than a new house built to California standards, a difference in present value somewhat less than that between practice in 1960, the year the house was built (estimated from the dashed 1950-73 "trend" in Fig. 1) and 1980 practice (about $350/year, or a present value of $3500). We also see a $500/year, or $5000 present value difference between the house in its present state and after a $3000 retrofit, a figure consistent with $5000 difference between average stock and new practice in 1980.

V. THE "STANDARD" OR "REFERENCE" HOUSE

Every label relies on a test procedure: for autos there is the standard urban driving cycle and the standard highway cycle; for refrigerators there must be a standard number of door openings, and so on. There is nothing very tricky about defining the standard use of a home, but we must not confuse the home-buyer by having New York City base its standard on a thermostat setting of 72°F, and having New Jersey adopt 68°F. So it seems easiest to have national or regional standards suggested by DOE/HUD, with appropriate advice from professional societies.

There is a minor debate as to whether the standard house should be of a standard size, or whether a large house should indeed have a larger energy use label, just as an eight-passenger wagon is rated at fewer miles per gallon (i.e., more gallons per mile) than a Honda Civic. We strongly prefer not correcting for size, and argue that we have taken care of this point on our suggested label (Fig. 4), where we give for comparison the energy use of the house, calculated for the same size and shape, but uninsulated at the bad end and sensibly retrofit at the good end. And real quality buffs can always divide by the floor area if they so desire.

Some further adjustments, not shown in Fig. 4, should be made for the number of occupants and the appliance use, on the grounds that larger houses (with more people) will use more lights and hot water and run the dryer more often. Since occupancy and appliance use will not necessarily scale linearly with floor area, standard curves for each should be developed from local census and survey data.

There is also the question of how to handle appliances that have a saturation of less than 100%, like freezers and air conditioners. To avoid penalizing the home-owner who has just purchased a super-efficient freezer, or giving apparent credit to a home which has no air-conditioning, the label can have each appliance weighted by its regional saturation for the "standard" houses, and include the actual appliance inventory for the point labelled "You are Here" in Fig. 4, and for the retrofit points. (Compare to the case in the preceeding paragraph, in which all points represented the same, area-adjusted occupancy since occupancy, unlike major appliance saturation, is family- rather than building-dependent.)

We conclude by noting that the standard house may be a poor predictor of actual energy use by elderly people, who spend most of their time at home and prefer warmer-than-average temperatures, or for families with many children and grandparents. We therefore suggest that a service, called "The Rating-Game", be offered by enthusiastic utilities, in which, for an annual fee, the owner of a labelled house can inform the utility of a few personal points about his home--occupancy, thermostat schedules, and use of non-standard items like a pool or a spa. The utility could then easily calculate the family's probable use at the end of each month, taking into account last month's weather and these individual preferences. The home-owner could then compare these tailored predictions with his actual bills and decide whether he should check on his furnace efficiency, boast at cocktail parties, and/or nag at the kids to keep the doors closed and take shorter showers.

VI. ACCURACY OF LABELS

We showed above that a label can be expected to modify the value of the house by $\pm$\$2500 or more, *if* the buyer believes that the label is sufficiently accurate, that is, that the predicted energy is sufficiently close to the energy use that would be actually measured under standard operating conditions. A reasonable estimate of what constitutes "sufficient" accuracy can be based on two observations: 1) The label has been defined to predict energy use for the house under standard reference conditions, which are typical of local occupancy and weather patterns, and which should yield predictions close to the actual local average use; 2) Variations in energy consumption* due to

*Sonderegger and Wilson, in independent studies, have compared energy use in structurally identical buildings and have each found a 2:1 variation in energy use between the 10% of households with the lowest and the 10% with the highest consumptions. In Wilson's work, some variation might have been attributable to presence or absence of basement insulation (building characteristic); however, since presence correlated with the practice of basement heating (occupancy), this is arguably occupant-linked (see references, above).

differences in occupancy alone have been shown to contribute to as much as a 2:1 variation in energy consumption,[8,9] with a standard deviation ranging from 15-25% (see Fig. 5).

Since the energy use of individual houses will vary due to occupancy, it seems reasonable that the label, which predicts an energy use close to the average, should predict consumption to within the range of variations induced by occupancy. Therefore, a reasonable requirement appears to be $\pm$ 15%, that is, predicted and actual use, normalized to standard conditions, should agree within 15%. Certainly a label with less accuracy should so state; likewise, a label with greater accuracy could also so state, in order to encourage development of increasingly accurate labelling systems.

As we have noted elsewhere,[10] in calculating building energy consumption, the accuracy of the output of course depends on the accuracy of the following inputs and algorithms:

1. Weather
2. Occupancy: i.e. schedules for thermostats, appliances, window management, venting, and water use
3. Input data that describe a house: U-values, dimensions, infiltration, etc.,
4. Algorithms used in energy analysis, and microclimatic corrections to weather data.

Since, for a label, Weather and Occupancy are specified, the remaining sources of error are Input and Algorithms. This suggests three basic steps in developing a labelling system to meet required accuracy.

Certification of Labelling Tools and Users

We propose a certification system which will accomodate a variety of tools and labellers.* The general approach is similar to that used to certify operation of airlines. First, the aircraft itself must pass tests of safety and performance, and then the pilot must demonstrate competency. Finally, after initial certification, the aircraft and the pilot undergo continuing monitoring, servicing of the aircraft and further training of the pilot as appropriate, and, if necessary, delicensing. The same process, applied to certification of labels, allows a great deal of flexibility in the design and use of labelling tools, as long as desired accuracy is maintained. We suggest the following certification process:

1. Validation of the labelling tool. In this step the accuracy of the algorithms are tested by experts comparing predicted to measured energy use in well-monitored houses. Through intensive monitoring or control of weather and occupancy and by expert preparation of input, errors from sources 1,2, and 4 above are minimized. Remaining error is a measure of the accuracy of the algorithms alone. For such validation, accurate data from a few well monitored houses, representing the range of housing types and climate to be labelled, are far more valuable than sketchy data, of unknown or poor accuracy, from thousands of houses. Some data are now available on algorithm validation.[11]

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*We use "certification" to mean validation and certification of the computer programs or other tools used to calculate labels, as well as the testing, licensing (and delicensing) of "labellers" - who of course will include auditors, appraisers, and consulting engineers.

1a. User friendliness. In order for the users other than the program developers to successfully predict energy use, the tool must be not only accurate, but comprehensible with a reasonable amount of training.

2. Certification of Auditors or Appraisers. Once the tool is validated and made user friendly, users must be sufficiently trained and competent to use it, i.e., to make accurate measurements, to identify building characteristics correctly, and to correctly input measured data to the program. The first step in certification is testing the user's ability to audit the house, e.g. to make measurements and to distinguish correctly between R-7 and R-11 insulation or between light-reflecting and heat-absorbing window films. Some labelling tools allow discretion or ingenuity in inputs, e.g. simulation of party walls in apartments by an input of "infinite" insulation. This sort of "trick" will vary between labelling tools. Therefore, the second step in user certification should test the user's ability to obtain correct predictions using a specific labelling tool (much as pilots are certified to operate a specific aircraft).

4. Monitoring of labelled houses. As a labelling system is implemented on a large scale, the actual energy use of labelled houses should be continuously monitored to detect:

o large overall deviations (e.g. > 15%) from predicted energy use;

o changes or trends away from the average operation used for the label reference;

o major inaccuracies for particular housing types or regions;

o inaccuracies due to implementation of new construction technologies not previously modelled by the labelling tool.

Program validation and auditor licensing establish the overall accuracy of the labelling system; to assure the buyer that the accuracy is within 15%, this certification should be performed by a responsible entity such as a state government or industry trade group. By establishing a "performance" criterion (accuracy) rather than a "prescriptive" criterion (acceptable methodology), certification is available to a large number and variety of potential labelling tools and auditors (e.g. private entrepreneurs, utilities, non-profit organizations).

The credibility of the certification process is supported by the ongoing monitoring process of Step 3 above. Monitoring fulfills several important functions: 1) Detection of problems, as outlined above; 2) Early resolution of problems, before complaints become widespread and the credibility of the label is damaged; 3) Provision of a mechanism for resolving complaints, when they are received; 4) Providing a basis for de-certification of labelling tools or auditors, where necessary.

CONCLUSIONS

We have outlined the need for building energy efficiency labels, offered evidence that their chances for success are good; suggested a criterion for the accuracy of labelling tools and auditors; and sketched a process for certification and ongoing monitoring. We have found elsewhere that the requirements for labelling tool accuracy <u>can</u> be met (though are not necessarily met by <u>all</u> tools).[12] We are aware of extensive, but undocumented, utility experience with training and testing of auditors. We believe that the next step should be a pilot project to further test tool and auditor abilities, and further, to design and test a full scale certification and monitoring process.

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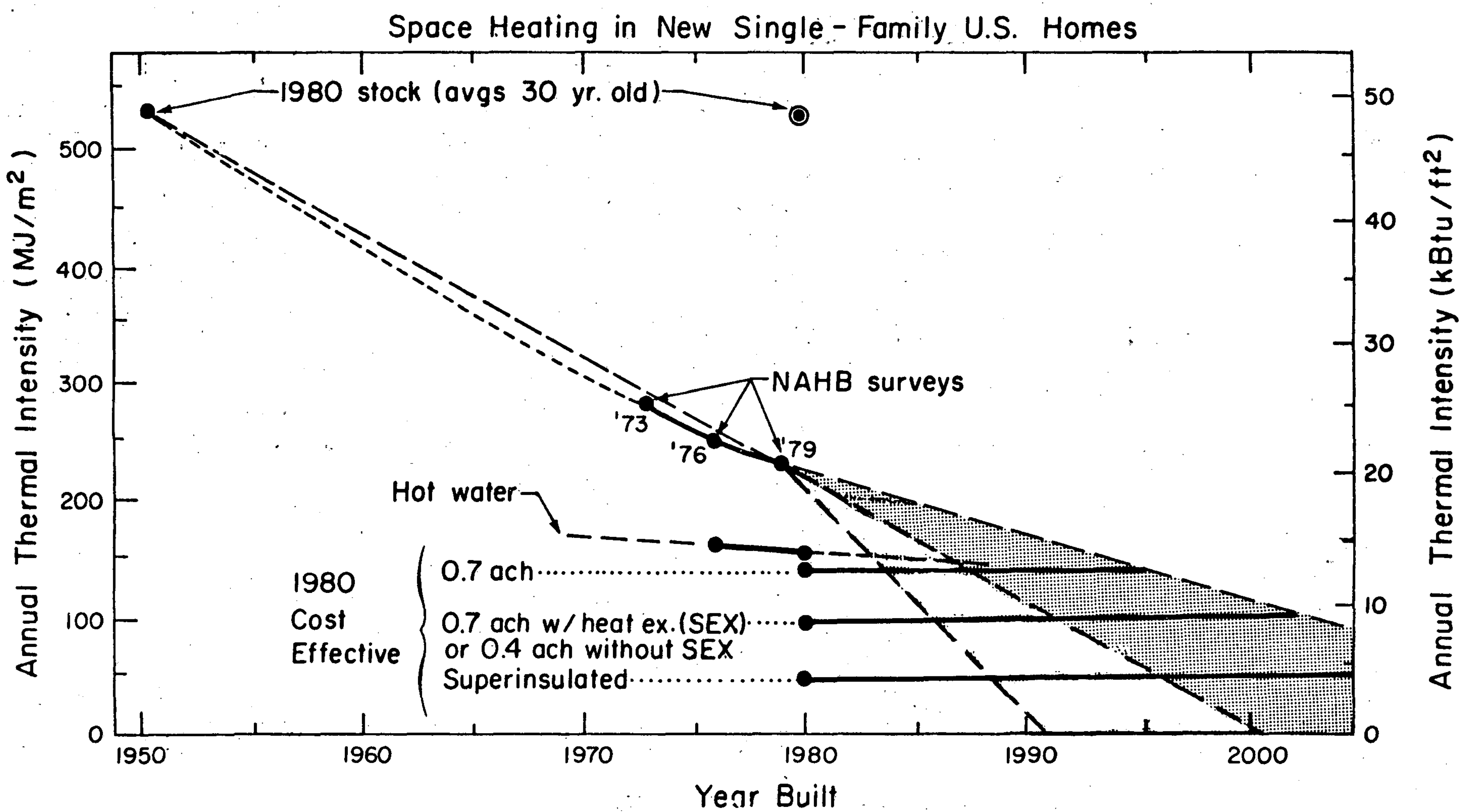

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Figure 1. Lag in Market Response.

Item	Points Allowed	Score	Incremental cost ($)
(1) Major Appliances:			
Gas Range	13	13	-
Oven with light and window	1		
Microwave oven	10		
Dishwasher with switch controllable drying cycle	5		
Gas dryer outlet	10	10	25
(2) Space Heating/Cooling			
Set-back or programmable thermostat (not for use with heat pump)	16	16	60
Clogged filter indicator	8	8	20
Used with air conditioning	10		
Air conditioning - 1 point per 0.1 increment in EER exceeding state requirements. Points will only be awarded in areas where air conditioning is required as defined in PGandE Schedule D-1.			
Solar Assisted Space Heating System: One point will be awarded for each 2 square feet of properly located (orientation and tilt) collector			
(3) Water Heating:			
Insulation blanket	5	5	25
Solar Assisted Water Heating System. One point will be awarded for each square foot of properly located (orientation and tilt) collector			
Insulated hot water piping first four feet from water heating unit	2	2	15
Insulated hot water piping throughout	5		
Showerheads with flow-control devices rated at 2½ GPM or less	4	4	10
(4) Weatherization:			
Caulking (per 1,000 sq. ft. of floor area) (Assume a 1,500 sq ft house)			
– Exterior sole plate only	7		
– Seal all plug outlets only	4		
– Total exterior (doors, windows, electrical/plumbing penetrations, sole plate, top plate, plug outlets)	23	35	200
Ceiling R-30 (per 1,000 sq. ft. of floor area)			
Heating benefit	5		
• Cooling benefit	2		
Walls R-19 (per 1,000 sq. ft. of wall area)			
Heating benefit	7		
• Cooling benefit	4		
Perimeter insulation for slab on-grade floors with moisture barrier (per inch of insulation thickness exceeding state standards)	12		
Conventional floors (per 1,000 square feet)			
– R-19 instead of R-11	2		
– R-11	10		
Double glazing (per 25 sq. ft. window area)			
Heating benefit	3		
• Cooling benefit	1		
Thermal drapes, moveable insulating shutters, blinds, roller shades, integral louvered screens or other glazing insulation features (per 25 sq. ft. window area)			
Heating benefit	2		
• Cooling benefit	1		
Reflective glass or film on east or west facing glazing (per 25 sq. ft.)			
• Cooling benefit	4		
Subtotal		93	$355

•Points awarded only in areas where A/C required – see (2).

Item	Points Allowed	Score	Incremental cost ($)
Insulated exterior doors (per door)			
– 2" wood, solid core	1		
– 1¾" with solid polystyrene core and thermal break	1		
– 1¾" with solid urethane foam core and thermal break	3		
Attic ventilation (• cooling benefit only)			
– Eave vents with continuous ridge vent	4		
– Eave vents with gable vents	2		
(5) Chimney (fireplace):			
Positive damper, without gas outlet	3	3	-
Fireplace – Glass doors	5		
– With heat exchanger	6		
– Connected to central space heating ducts	5		
– With outside combustion air supply (dampered or used w/glass doors)	2		
Free-standing model	10		
Air tight wood burning stove	20		
(6) Lighting:			
All incandescent and fluorescent fixtures surface mounted	2	2	-
Fluorescent Application:			
– Exterior - Porch/Patio	3		
– Kitchen area	5	5	-
– Laundry area	1		
– Bathrooms (all)	7	7	20
– Bathrooms (full only)	5		
– Recreation or family room	3		
– Shop or garage	1		
(7) *Passive Solar Design Features:*			
Heating Benefit:			
House to lot orientation (minor axis within 25° of true south)	15	15	-*
South facing glass in excess of 25% of total glazing area (per 3 sq. ft.) (Where glazing exceeds 22% of floor area of room being passively heated, room must be protected from excessive heat gain)	2		
Evergreen trees providing protection from prevailing winter winds on north, northeast or northwest exposure (per tree, 15 gal. minimum if newly planted)	1		
Cooling Benefit:			
Deciduous trees providing summer shade on west, east, or south facades (per tree, 15 gal. minimum if newly planted)	2		
Roof overhang or operable exterior awnings on south exposure for each 2 inches exceeding 12 inch horizontal overhang (maximum 32" overhang)	1		
(8) *Active Solar Design Features (for future adaptation):*			
Increased slope on south-facing roof (minimum unobstructed roof surface 8 ft. x 8 ft. with required structure to support future solar panels) (per each 5° over 25° slope, 40° maximum)	2		
Rough plumbing for future solar hot water retrofit (must include 2' x 2' minimum space and stubbed control valves for future hot water storage tank)	5		
(9) Other			
TOTAL POINTS		125	$375

* Can account for extra costs due to site constraints or poor planning

Figure 2. ECHome Rating Sheet Filled out with 125 Points.

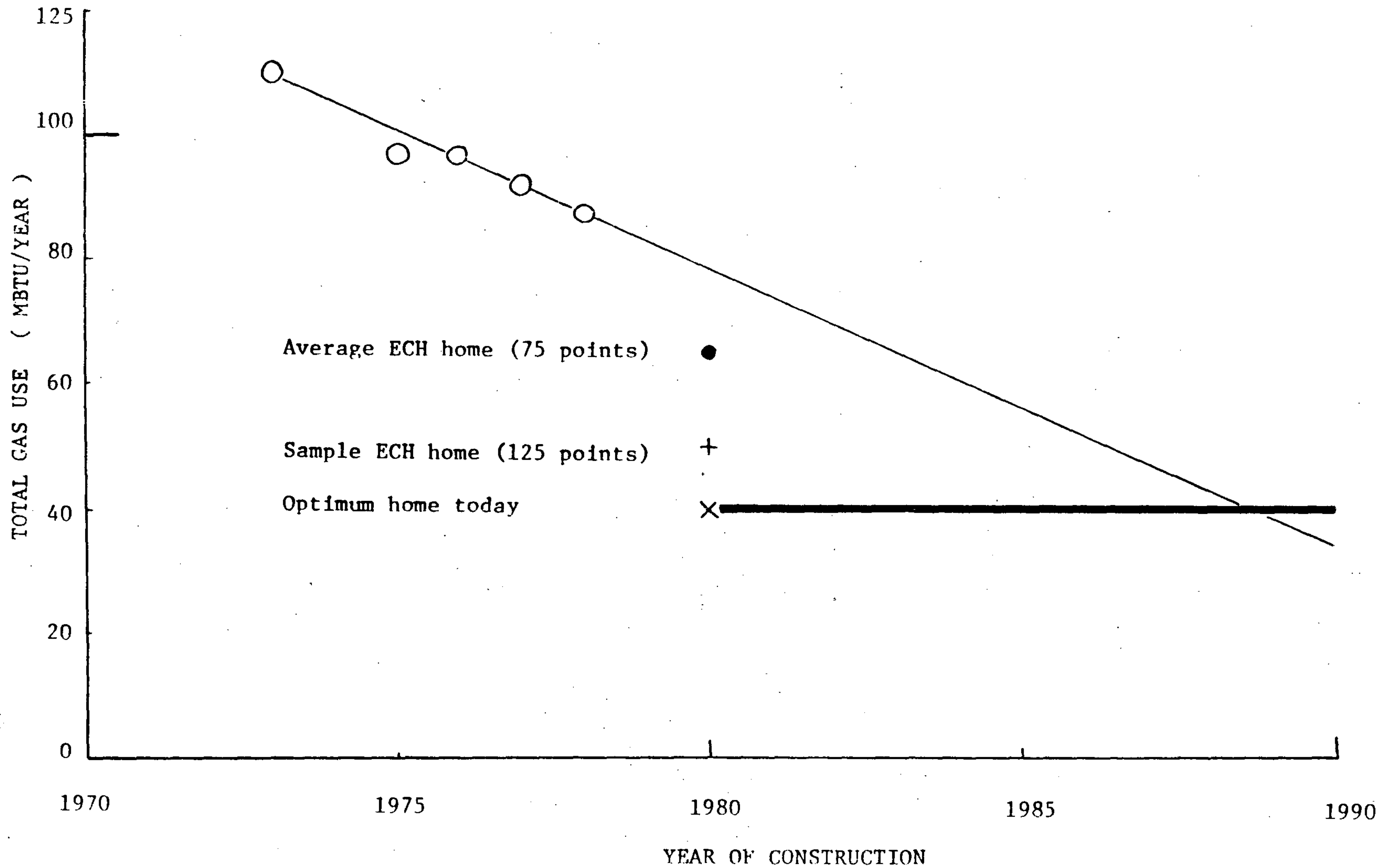

Figure 3. "Symbolic" Plot of ECHome Program Results.

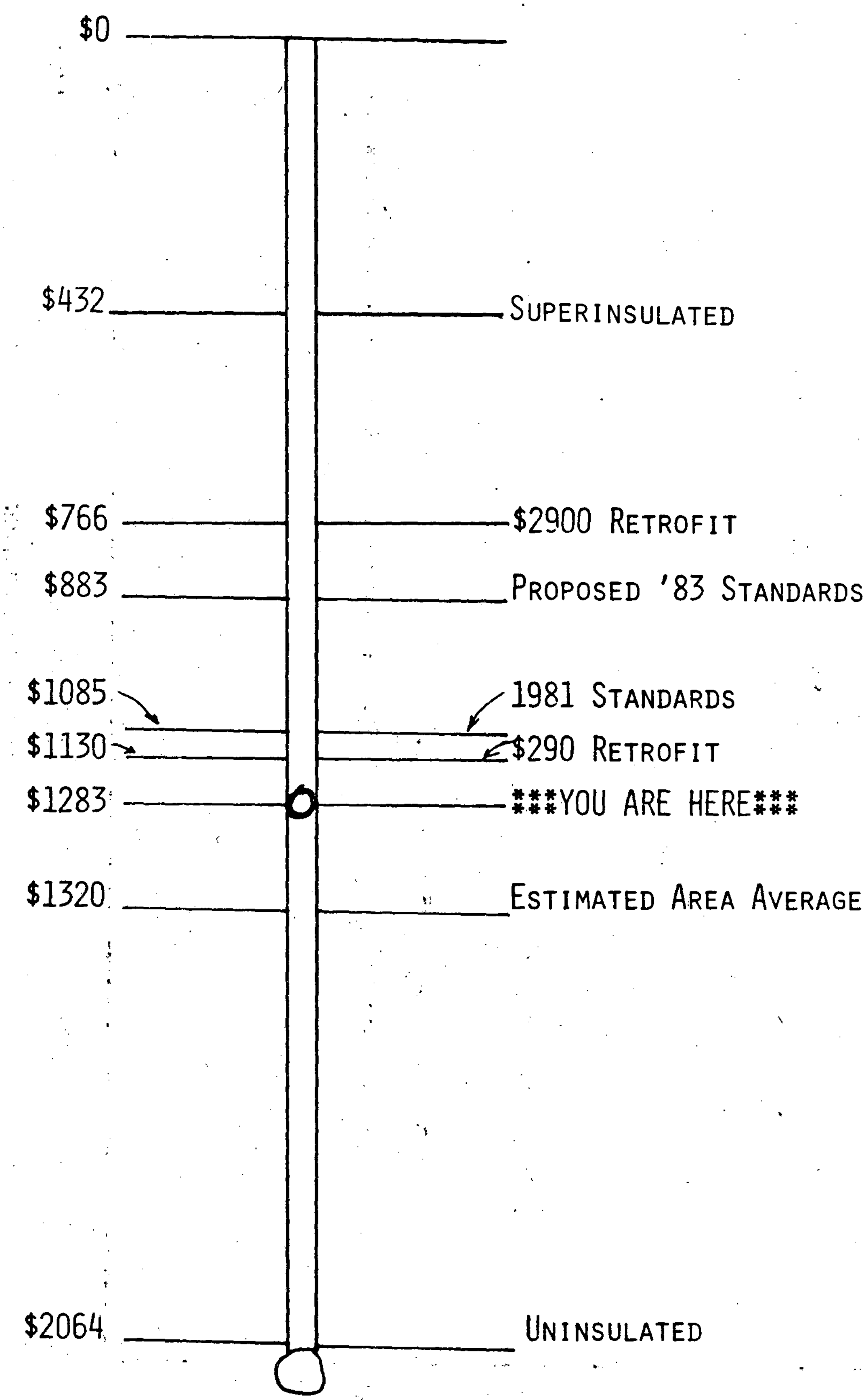

Figure 4. Yearly Total Utility Bill for 1939 Cherrytree Lane, Walnut Creek, under Standard Operating Conditions and in 1982 Dollars.

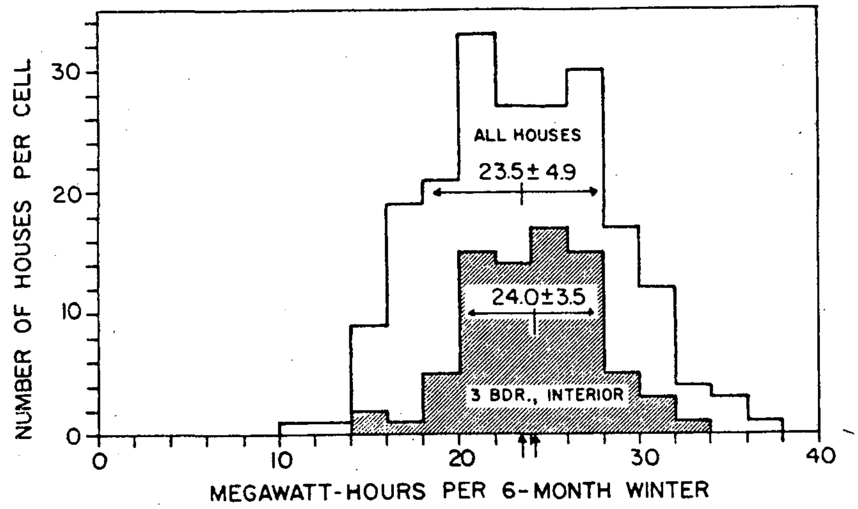

Figure 5a. Occupancy Effects at Twin Rivers. (Source: Sonderegger, Movers and Stayers.)

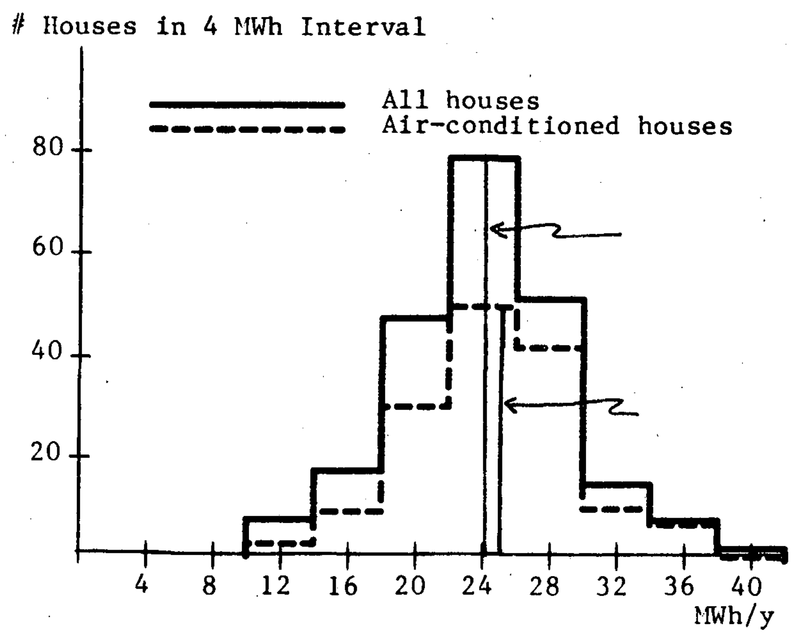

Figure 5b. Occupancy Effects in Houses in Windsor, Canada. (Source: N.W. Wilson, Energex '82.)

NOTE: For complete references for figures 5a and 5b, see Section VII in this paper.

APPENDIX A.

Building Energy Labels- A Preliminary Literature Review

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There is a well-established tradition, within the utility and building industries, of labeling and advertising energy-related features of a home. For example, over a decade ago when the marginal cost of electricity was less than the average cost, and electric utilities were actively soliciting new customers, labels were used on houses to persuade buyers of the advantages of all-electric houses. The slogan "Live Better Electrically" was employed, and the label was called a "Gold Medallion." Gas utilities countered this campaign with their "Blue Star" and "Balanced Power" homes. Efficiency was only one of the characteristics emphasized by both electric and gas utilities; others included low cost, safety, and reliability.

Recently the cost of electricity has risen, and consumers have become increasingly aware of the cost advantages of energy-conserving homes (11, 18). In addition, the marginal cost of new generating capacity is in general now greater than the average cost. Utilities, as well as industry groups and government agencies, are now promoting more efficient energy use, and the advertising and promotional programs have now become "Energy Efficient Home" awards. Unlike building standards, energy efficiency labels leave to the consumer the choice of whether or not to buy an energy efficient house.

Given the past experience of the utilities, and their present interest in reducing growth of residential energy demand, it is not surprising that a large number of them now have labeling systems designed to reduce domestic electric use. Beginning in 1975, Pacific Gas and Electric Co. introduced a pilot scheme of "Energy Conservation Homes," a program which was expanded system-wide in May 1976 (6). Florida's Gulf Power Co. introduced their "Good ¢ents Home" program in February 1976, and in April 1977 added a "Good ¢ents Home Improvements" program for the retrofit of existing homes.

In 1977, the Edison Electric Institute developed the "National Energy Watch" program for use by its member utilities. The program was designed to improve the thermal integrity of buildings, encourage installation of more efficient appliances and equipment, and promote the adoption of "better everyday energy use habits." This program has been adopted, in various forms, by 170 utilities across the U.S.

All these programs use a point system for rating houses (7). Points are awarded for a range of energy conservation measures, such as attic insulation, wall insulation, weatherstripping, efficient air conditioners, solar water heaters, and setback thermostats. A minimum number of points must be achieved to qualify as an efficient house. The precise format and number of points varies from one utility to another. In most cases, though, the points are used only to determine eligibility for the program; no provision is made for a more precise quantitative comparison among homes (the PG&E program is an exception).

Other energy rating schemes have been devised by non-utility organizations. One example is the ECH$_2$ONERGY Energy Efficiency Rating system, a joint program of the Denver Board of Water Commissioners, the Public Service

Company of Colorado, and the Colorado Home Builders Association. It is designed as an aid to both home buyers and home mortgage institutions. The rating takes into account both water use and electricity use.

In several instances, industry and professional associations of realtors, lenders, and appraisers have taken an interest in techniques for simply and reliably comparing the energy performance of different homes (4, 10, 17).

Another organization with an energy rating scheme is the city of Visalia, California, which started its rating system in October, 1981 (3). The rating system used is adapted from the Pacific Gas & Electric criteria, and applies to both new and existing houses.

Evidence of the growing interest around the country in building energy labels was provided at recent hearings in the subject, convened by Congressman Ottinger's Subcommittee on Energy and Power (16). Generally supportive testimony was offered at these hearings by representatives of the Federal Home loan Mortgage Corporation, the U.S. League of Savings and Loan Associations, the Society of Real Estate Appraisers, the National Institute for Building Sciences, the American Consulting Engineers Council, Gulf Power Company, and the Hart Construction Company (a builder of "super-insulated" homes).

There are a number of rating and labeling schemes in existence. However, the accuracy, adequacy, and usefulness of these systems have not been thoroughly examined.

There are a variety of ways to produce an energy label for a house, depending on the exact purpose and desired level of accuracy. The energy rating and label might be based on an energy audit of the house, with the energy consumption of the house calculated either by hand or by a computer program such as CIRA (15), DOE-2, or a proprietary model. Another way would be to make use of a pre-calculated point system, in which the energy-saving effects of various conservation measures have already been calculated, and the net effect, based on the set of characteristics for that house, need only be looked up in a table (8, 9).

There are already a number of rating systems, produced by the Edison Electric Institute, Pacific Gas & Electric Company, Gulf States Power Company, Lawrence Berkeley Laboratory, Owens Corning Fiberglas, the State of Florida Bureau of Codes and Standards, and the State of California Energy Commission, to name but a few (1,3,5,7,8,13). More data will hopefully become available as these competing systems are tested and refined in various parts of the country.

In spite of the efforts on labeling systems to date, a number of critical issues need to be understood and resolved for energy labeling of buildings to achieve widespread acceptance. These issues involve an assessment of the effectiveness and accuracy of existing labeling systems, an understanding of how a system can be designed to achieve acceptance by affected parties, and assessments of policy vehicles to encourage the use of labeling programs. These are topics addressed in the proposal.

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