DESIGN CRITERIA FOR A CONSUMER ENERGY REPORT: A PILOT FIELD STUDY*

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ABSTRACT

A pilot study designed and tested an annual energy report providing house-specific consumption information to residential utility customers. The study combined methods of physics and statistics (to produce reliable measures of energy consumption) with methods of behavioral science and anthropology (to evaluate the appropriateness of the report for ordinary consumers). The project followed an iterative design-interview-redesign procedure. This procedure forced revision of several original concepts, resulting in a report better matched to the information needs and processing abilities of residential energy consumers. The revised test report included a two-year summary of monthly energy use and cost, annual totals, and a comparison of weather-adjusted annual totals. The report also estimated the cost of each customer's space heating versus other energy uses, and compared the customer's own use with their neighborhood and state averages. Such information provides essential background for customer energy conservation decisions, but is not now readily available. This paper discusses the tradeoffs involved in designing such a report, the advantages and disadvantages of alternative designs, and consumer response to our test report. Highlights of the findings include: 1) For customer acceptance, a report must include monthly data rather than just annual totals, 2) the concept of weather-adjusted consumption is considerably more difficult to communicate than other quantities, and 3) consumers already make many more uses of energy data than is commonly reported in the literature.

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1. INTRODUCTION

Economic theory predicts energy conservation in response to higher energy prices, based on the assumption that consumers know the investment cost and savings associated with energy conservation, and will behave as rational investors in making energy conservation decisions. These assumptions may sometimes be true for large firms, but when energy behavior has been studied in residences it has been found that consumers generally underestimate the energy savings of capital improvements (Ibler 1983; Kempton & Montgomery 1982; Mettler-Meibom and Wichmann 1982). This and other factors act against energy efficiency relative to other investments, as measured by implied discount rates for energy efficiency as high as 200% (Ruderman, Levine, and McMahon 1986; Gately 1980). One way to help consumers estimate energy costs and savings would be to provide individual households with weather-adjusted energy consumption reports based on utility billing information (Fels and Kempton 1984). The research reported here is a first empirical test of whether such reports are feasible.

Our research had four objectives: 1) to understand the current information environment in which residential energy consumers make energy decisions; 2) to decide how the weather-adjustment methods now used by energy analysts need to be adapted so that they could be automated and sent to a large population of households without intervention by a researcher; 3) to determine the appropriate numbers and explanatory text to make such a report comprehensible and useful to consumers; and 4) to test a prototype report on a sample of consumers (both in person and by mail) to see whether or not they understand it and whether they expect it to be useful.[1] This paper, the first of several reports on the project, focuses on tradeoffs in the design of new consumer energy reports, and how we evaluated test reports to determine their fit with existing consumer methods and needs. This paper deals only briefly with the consumer's current information environment and the weather-adjustment procedures, topics which will be covered in more detail in subsequent reports.

The motivation for weather-adjustment in consumer reports derives from our research experience in many U.S. energy conservation programs. In such programs, the energy savings from conservation is often similar in size to the annual fluctuations in energy use due to weather. Therefore, one cannot evaluate the success of a conservation program without adjusting energy use for weather. The same principle would apply to individual households evaluating the return on conservation investments. We have used PRISM (the Princeton Scorekeeping Method, Fels 1986) for weather-adjustment but our findings would apply to other methods of weather adjustment as well.

There are many pitfalls in moving from a researcher's technically correct information to making that information understandable and useful to energy consumers. From our prior analysis of conservation programs, we knew how to measure weather-independent changes in energy use. But our attempt to provide this information to consumers constituted some stern reality testing. For example, we initially provided only weather-adjusted annual consumption, which we saw as the most meaningful information. As we will illustrate, this approach was ill-informed as to the information environment

[1] A fifth step would be to test whether such an information form actually resulted in energy savings. Based on the findings of the current pilot study, this would be a logical follow-up project.

in which consumers are already operating; it was confusing to them and did not take advantage of the mental computing resources they were already using.

The paper begins with a summary of the previous research on "feedback" to energy consumers. While it is the only major body of energy research closely related to the issues with which we deal here, we will argue that it is biased toward short time horizons. We next overview our data collection procedures, then describe the information report developed for this study. The most comprehensive sections discuss design issues for any energy-use information program, treating problems which arose in the pretesting of our energy report and the reactions of consumers to it. The design sections are the focus of this paper and are intended to provide some guidance for others designing energy information programs. Finally, we discuss how a regularly-mailed energy report would interact with existing energy information programs and the conservation marketplace. Subsequent papers address our findings on how consumers process energy information to make decisions, and our adaption of weather-adjustment methods for this project.

2. FEEDBACK LITERATURE

There is by now a considerable literature on studies of energy "feedback" to consumers, including four good surveys of this literature (Winkler and Winett 1982; Stern & Aronson 1984:87-89; Seligman 1985; Katzev & Johnson 1987:54-67). In these studies, consumers are given "feedback" (some type of energy-use information which improves on bill information), often in conjunction with other experimental manipulations, and the consumers' energy use is monitored to establish whether it dropped as a result. The motivation is that improved feedback "can demonstrate to the homeowner that his actions to reduce energy consumption do in fact succeed ... it is enormously difficult for the homeowner to recover this information from his utility bills" (Seligman, Darley & Becker 1978:252). The number of studies is in itself tangible evidence that many behavioral scientists share this negative assessment of the information value of present utility bills.

Feedback has often been found effective, especially in conjunction with other treatments. The 19 feedback studies surveyed by Winkler and Winett showed a range of energy savings from 0% to 20%, with a mean of 10%. In most studies these are total savings, due to the combination of feedback with other measures such as rewards, commendation, training on efficient use, asking the consumer to make a commitment to conserve, etc. Controlled comparisons typically show that feedback increases the effectiveness of the other treatments (Becker 1978). Two mechanisms by which feedback works may be 1) by allowing the respondent to assess the success of the conservation actions they have already been motivated to attempt; or 2) by showing that the amount of conservation achieved so far is less than the consumer's conservation goal (Seligman, Becker & Darley 1981).

Katzev & Johnson (1987) argue that feedback will have no effect without some form of motivation such as commendation or payment. Several studies have in fact shown an effect without experimental addition of motivation, which we attribute to the motivation of price which exists without experimental intervention. One striking example of price motivation in feedback studies comes from a meta-analysis by Winkler & Winett (1982). They found the percentage energy savings from feedback to be significantly correlated with the cost of energy as a proportion of income ($r=.62$, $p < .01$). We interpret this as follows: People who pay a larger proportion of their income on energy are already motivated and tend to benefit more from a feedback program, even if no additional experimental motivation is provided.

Some individual studies argue that feedback is most effective when provided frequently, either daily or weekly. However, a review of many feedback studies (Stern & Aronson 1984:88) suggests that frequent feedback is most important when the energy-saving behaviors require conscious maintenance (e.g. closing blinds daily, night thermostat setback). We argue here that the frequent feedback prevalent in these studies is due to a bias in the feedback literature. Most experiments have tried to influence behavioral or management conservation rather than retrofit or investment conservation (Geller et al 1982). Daily, weekly or monthly feedback makes sense for certain energy management behavior. But we attribute the near-exclusivity of it in energy feedback research to a bias towards behavior rather than retrofit because the work has been conducted by behavioral scientists, not economists or engineers.

Because of this emphasis on management behavior rather than investment changes, there have been few studies of feedback at one-month or longer intervals. A notable exception is Hayes and Cone (1981), who tested monthly feedback. Their motivation for testing monthly feedback was the economic impracticality of daily feedback rather than a theory about longer-term feedback for retrofit investments.

The Hayes and Cone study tested the impact of a one-page mailed form which compared the current month with the same month of the two previous years. Change was expressed both as a percentage of energy use and as a dollar comparison at current prices. Treatment and control groups were geographically matched and randomly drawn from the utility's records. Subjects were not asked to agree to participate; the treatment consisted of sending the form for four months (February through May) and monitoring their energy use during that period. Those receiving the form used 7% less electricity during the treatment period than the matched control group. We find this 7% savings high in the absence of experimentally-added motivation, and we attribute it to the study being done in 1976, a time of heightened public awareness of energy problems. This external motivation may have caused the form to have a greater effect.

A number of utilities today use a similar comparison of "same month last-year," and Hayes and Cone's study is the best evaluation we have seen of this type of information. We have reviewed a few unpublished utility evaluations of new bill formats, but none have set up systematic experiments with control groups. Hayes and Cone's findings support our thesis that the current monthly bills, which after all are an existing form of feedback, are ineffective not because they are infrequent, but because the information is not translated into a readily usable form.

Our work goes beyond that of Hayes and Cone by proposing a report which includes weather adjustment and distinguishes when a change is too small to be statistically nonzero. We feel that this is a more responsible report to consumers, and is less likely to mislead consumers or cause them to distrust the information. Our study also differs from that of Hayes and Cone in using intensive ethnographic interviews to determine what the preexisting interpretive context is and how this new information fits into it. Finally, our report provided annual (not just monthly) feedback data, figures which are better for evaluating long-term changes. We assert that annual feedback is preferable in programs which aim to affect the consumer's evaluation of prior investment of several hundred dollars on retrofits (insulation, new furnace, etc). The model here is a quarterly or annual report to investors rather than instantaneous "feedback" as in a guidance system.

3. METHODS

This section describes our data collection methods and the sample used. It then briefly summarizes two aspects of the project, how consumers use current energy bills and how we adapted weather-adjustment methods for this project; these aspects are summarized only briefly since they will be covered in separate papers.

3.1 Overview of Data Collection

There were four phases of data collection: 1) open-ended interviews to evaluate our interview protocol and our proposed designs for a prototype "Home Energy Report (HER)", 2) selection of 173 accounts from utility records to request permission to interview, resulting in 65 acceptances (of whom we completed interviews with 55), 3) in-home ethnographic interviews with 10 households, resulting in minor clarifications to our interview questions and the HER, and 4) telephone interviews with the remaining 45 households.

Prototype Development

We started with a small convenience sample of local interviews to develop and refine our interview questions and the prototype Home Energy

Report. Our goal was to choose information which would fit with the consumer's existing concerns and information processing techniques. These interviews were informal and open-ended, often presenting more than one sample information form and soliciting suggestions from informants. These and all subsequent interviews were conducted by Ph.D.-level social scientists with extensive interviewing experience.

Sample Selection

Several sampling decisions were made which simplified our study but resulted in a decidedly non-random sample. Energy data collection and sampling were facilitated by assistance from a central New Jersey electric utility, Jersey Central Power and Light (JCP&L). To reduce the complications of multiple fuels and working with more than one utility's records, we chose all-electric households. We initially selected 173 customers with complete electric consumption data for the most recent two years from JCP&L records. To simplify our use of a reliable weather-adjustment method, most of those we selected had data with a clear pattern of electric heating, but little visible energy effects of air conditioning (in fact most verbally reported at least some air conditioning in our survey). An additional group of households was selected whose energy use was sufficiently erratic that we could not reliably adjust for weather--this subset was included to test the realistic situation that some customers will receive reports lacking weather-adjusted figures. The sample also included three overlapping sub-groups identifiable by participation in utility programs: those receiving utility retrofits, those in a special program for senior citizens or those in one for low-income customers. Sample selection is discussed in more detail in the paper focusing on the weather-adjustment method (Fels and Reynolds 1988).

The utility mailed a letter to each of the 173 households, requesting their participation in a university study on energy use in the home. Interested parties returned a card to the utility giving permission to release their utility records to the university. Because of the initial low response from low-income customers (a problem common in such studies), the utility contacted some customers by telephone. A total of 64 households agreed to participate, of whom nine later asked to be dropped or were eliminated because we could not reach them by phone. Thus we conducted 55 interviews. Our survey showed the sample to be predominantly white (96%), female (59%), older (57% over 65 yrs of age), and well educated (90% had completed at least high school and 37% had completed college or beyond). Most owned their own homes (86%, including co-operatives and condominiums). Twenty-four percent of the households received senior citizen discounts from the utility, an overlapping 24% had participated in the utility's "Senior Save" retrofit program, and 9% were receiving low income assistance from the utility. Individuals are identified in this paper by the number of their report, for example, HER 22.

Ethnographic Interviews

The first phase of the survey consisted of interviews conducted in ten homes. The interviews were based on a 98 question questionnaire, consisting of both open-ended and pre-coded questions which were asked of the person who reported being responsible for paying the electricity bill in their home. The interviews were conducted by two or three researchers, with one asking the questions and all recording the responses. The interview began with general background questions concerning the household's use of existing sources of energy information, i.e., friends, bills, fliers, meters, etc. The informant was then given a copy of a Home Energy Report, made for his own energy data, and was asked to read through it, describing his reactions as he went along. In some cases, he did not spontaneously comment on individual sections and we would ask his reactions as he completed each section. This gave us an idea of the progression, as he read through the form, of the inferences he was reaching and how he connected our new information with his known world. After he had completed reading the report, the interviewer resumed with specific questions about the informant's understanding of the report, whether he considered the information useful, and finally, a series of standard demographic questions. We tried to set strong criteria for evaluation, given the limitations of evaluating only via an interview. For example, we asked if each section was "useful" -- many interviewees responded that it was "interesting" but we pressed them to say whether it would be useful. Also, we asked each informant how much he would pay for the information if there were a fee for it.

After having completed ten interviews, we noticed that people were not realizing that the figures on the second page of the report were weather-adjusted, a fact which is crucial in guiding inferences from the report. We developed several hypotheses to explain this problem and developed means for testing which of them might be contributing to the problem. Two of the hypotheses concerned our interview approach, namely, that our first ten interviews were with senior citizens and that the interviews were taking place in their homes. Our first hypothesis was that the context of a visitor and an interview might be nonconducive to a careful reading of the Home

Energy Report. Several people had said, "I will have to look at this more carefully later", or "I will really have to study this." This is in keeping with their responses to our questions concerning the reading of bills and inserts. Many said that they open their bills as soon as they come in the mail and glance at the inserts, then set them aside to read more carefully in the evening or when they are in the mood to do so. However, it also seemed possible that saying they would read the report later was a polite way of saying that they were not interested in it. A reluctance to read the report carefully while having guests in the home may be especially acute with the elderly, several of whom commented on their isolation and the importance of our visit to them.

Our second hypothesis was that elderly people, because they are less likely to make home improvements, would be less interested in the year-to-year comparison. Although a number of seniors had received retrofits to their home through JCP&L's Seniors Save program, the program was free so evaluating its effects would be of less interest.

Telephone Interviews

Both of these hypotheses were easily tested by changes in our survey methodology. We began interviewing other segments of our sample and switched to a system of two telephone interviews using a slightly revised Home Energy Report and questionnaire for the remaining 45 interviews.[2] (See Section 6.2 for discussion of the revisions to the report). The first telephone interview covered the first section of the questionnaire concerning current

[2] We also conducted telephone follow-up interviews with the ten people we had already interviewed to see whether they had, in fact, read the report again after we left and, if so, whether they had a better understanding of the weather-adjusted totals.

uses of available energy information. Each respondent was then mailed his or her Home Energy Report. About one week later, we called again and asked the questions on reactions to the Home Energy Report and household demographic information.

3.2 Current Uses of Energy Bills

Our pretesting and our interviews demonstrate that energy bills are used for at least two purposes beyond making monthly payments: checking on months with unusual bills and evaluating conservation actions. Both purposes require comparison through time; in this and our prior studies we find consumers using at least three methods for comparing energy consumption: this month vs. recent months, this month vs. same month last year, and highest this year vs. highest last year.

The most frequently reported purpose of comparing bill information was to check on expenses. As several informants reported in detail, a bill which seems unusually high can begin a process by which the bill payer asks other members of the household whether they can recall any behavioral changes which could cause a higher bill. If such a change is brought to light, a decision is made as to whether corrective action should be taken. Of course, the cost is computed simply as dollars this billing period minus dollars last billing period, which may be quite different from the cost of the imputed cause. If no such behavior can be recalled, either the matter is dropped (possibly resolving to make another check the subsequent month) or the utility company is called.

The second purpose of comparing bill information, to evaluate conservation actions, was seen less commonly. A few of the respondents who had participated in the utility weatherization program tried to use bill information to infer whether the program had been effective. Also, some of those who reported paying for their own retrofits in the prior two years used the bills to evaluate the retrofit.

How are the comparisons made? The most commonly reported method was to compare this month with recent months. Comparisons with recent months would normally be based on recall, relying on a sense of what a typical bill (in the current season) should be. When recall was uncertain, some checked by flipping back a few pages in the checkbook stub, or by finding the envelope which contained prior bills.

A second comparison is to use similar months from the previous year. This provides a crude form of folk weather-adjustment, in that the same month last year may have had more similar weather than the most recent two or three months. This method has become common in the service areas of utilities which print a comparison of this month with the same month last year on their bill.

The third comparative method is the "highest bill comparison" method. As reported in Kempton & Montgomery (1982: 818), consumers who were asked about the efficacy of heating retrofits often made comparisons like: "this year we didn't have any $100 gas bills, did we? ...we used to have $100 gas bills". The reported amount is a maximum bill, which is more memorable and normally corresponds to the months of most extreme weather.

3.3 Weather-Adjustment Method

For weather-adjustment we used PRISM, a statistical procedure for calculating changes in individual-house energy consumption over time (Fels

1986). Although PRISM was originally designed to provide a standardized methodology for determining savings achieved from residential energy conservation programs, we found that consumers will use the resulting figures in non-conservation contexts as well. The main feature of PRISM is a reliable weather-normalized index of consumption, called NAC (Normalized Annual Consumption). NAC is the amount of energy which would be used in a year of average weather. Thus, energy use can be compared across years without the confounding effect of weather fluctuations.

A physically based model, PRISM differs from other weather-normalization procedures in its treatment of the house's break-even temperature as a variable, rather than a constant such as 65°F. PRISM also differs from other methods in its emphasis on reliability, particularly of the NAC index, which is usually very well determined (typical standard error is 3-4%). Required input for PRISM includes: 1) consumption data, including exact meter readings and reading dates, for approximately one year in each period of interest; 2) average daily temperature data for the periods of interest, from a nearby weather station; and 3) long-term degree-days (computed from about 10 years of daily temperatures) to provide an "average" year. Using an iterative procedure to regress consumption against heating degree-days, PRISM determines the parameters of the line that best fits the data, and, in addition, the standard errors of all the parameters. From these parameters, PRISM produces NAC as the estimate of the house's weather-normalized consumption, and other estimates, such as heating and non-heating use. Although PRISM software is currently in use by many conservation groups, incorporating it (or any weather-adjustment software) into a software package that produces a Home Energy Report from billing data would require additional software development to handle utility-specific data preprocessing and report generation.

An estimate of weather-adjusted consumption (NAC), or a change in that consumption, is not valid unless one knows how reliable the estimate is. Previously, NAC has been used for program evaluation, where occasional spurious estimates would average out. In this study, for the first time, we had to consider the reliability of estimates for each individual house. We used PRISM's standard-error statistics to develop selection criteria to determine whether or not to include each estimate in each consumer's report. For example, what would be the largest standard error of a change in NAC for which we would report the change to the customer? The variables affected by these selection criteria were the NAC's for each year, the difference in NAC from this year to last year, and the space-heating portion of NAC. A thorough discussion of the PRISM analysis and selection criteria for the estimates presented in the Home Energy Report will be reported in a separate paper.

Using PRISM with customized post-processing software, we generated Home Energy Reports for all 64 customers who originally agreed to participate in the study. We used the prior 24 months of billing data, split into two 12 month periods to compare differences in consumption from one year to the next. For the subsample of customers who had recently participated in a utility weatherization program we split the two years at the retrofit date to measure more clearly the effects of the retrofit.

4. THE HOME ENERGY REPORT

The following is a copy of the Home Energy Report (in this case called the Home Electricity Report) for household 56.

HOME ELECTRICITY REPORT

HER 56
(name and address
go here)

This HOME ELECTRICITY REPORT is based on your actual utility bills and has been prepared to show you

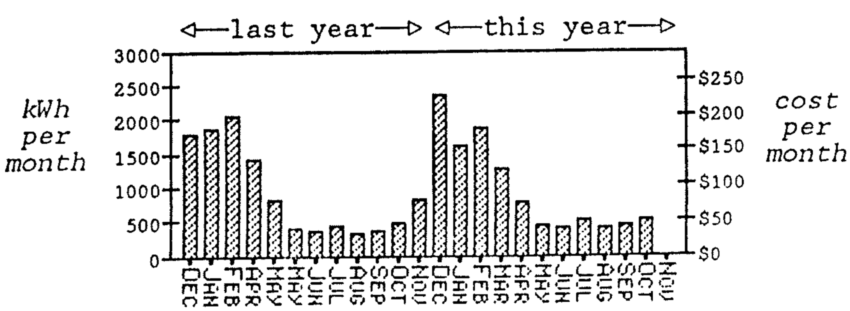
- How much electricity you used each month for the past two years
- How much it cost you
- How your cost this year compares with last year
- What you can do to reduce your electricity bills

TAKE A LOOK: Based on your actual monthly bills, we prepared the following table to show you exactly how much electricity you used in kilowatt hours and how much you were billed in dollars (including the monthly service charge and taxes).

Your Electricity Use During The Previous 24 Months

	LAST YEAR			THIS YEAR	
	kWh	cost		kWh	cost
Dec 84	1,810	$181.54	Dec 85	2,370	$229.71
Jan 85	1,900	$189.55	Jan 86	1,620	$163.62
Feb 85	2,070	$204.69	Feb 86	1,900	$188.29
Apr 85	1,460	$150.38	Mar 86	1,290	$124.26
May 85	850	$94.14	Apr 86	820	$83.69
May 85	440	$51.05	May 86	460	$49.03
Jun 85	380	$46.52	Jun 86	420	$46.71
Jul 85	450	$54.22	Jul 86	530	$54.89
Aug 85	340	$42.13	Aug 86	430	$45.43
Sep 85	410	$49.82	Sep 86	460	$48.26
Oct 85	490	$56.31	Oct 86	530	$52.45
Nov 85	840	$92.69	Nov 86	n.a.	n.a.

The bar chart below covers the same period so that you can see graphically your high and low months.



ADJUSTING FOR THE WEATHER

The weather affects how much electricity you use, so this has to be taken into account in comparing years. Our computer has totaled your yearly electricity use, the ACTUAL USE shown below. Then it adjusted for any weather differences to give your ADJUSTED USE and also computed the cost at today's electricity rates, your ADJUSTED COST.

	Last Year	This Year	Change in Adjusted
ACTUAL USE (kWh)	11,440	10,830	
ADJUSTED USE (kWh)	12,200	11,720	480 less
ADJUSTED COST (today's rates)	$1,210	$1,160	$46 less

This year you used less electricity than last year (discounting differences resulting from the temperature) and the difference would have cost you $46 less.

How to use these adjusted figures: The adjusted totals are the ones to look at if you are interested in reducing your electricity bills. Actual bills cannot be accurately compared because they reflect weather conditions and electricity rates in addition to your personal activities and the tightness of your house. The weather you have no control over, utility rates you have only indirect control over, but the rest is up to you. If you make changes in your house or the way you use it, the adjusted yearly totals will show whether your changes increase or decrease your electricity use.

WHERE ELECTRICITY GOES IN YOUR HOUSE

Our computer compared your electricity usage in the winter months with the usage for the rest of the year, and estimated that this year you used approximately 6,340 kWh ($630 at today's prices) for heating and 5,380 kWh ($530 at today's prices) for all other electricity uses (an additional $57 was for service charges). By comparison, the average for electrically heated houses in New Jersey this year was 4,850 kWh ($470) for heating and 8,790 kWh ($860) for other electricity uses.

Targeting areas to lower your electric costs: The comparison of heating with other electricity costs can help you target areas of high use. In most houses winter heating is the largest single energy use. To reduce the heating portion of your bill you may want to concentrate on measures such as insulation, storm windows, thermostat settings, and caulking and weatherstripping. To reduce the non-heating portion of your bill, you may want to consider low-flow shower heads, insulation wrap for your water heater, or replacing your refrigerator or freezer with a more efficient model.

YOUR HOUSEHOLD IN COMPARISON WITH THE AVERAGE

The chart below gives the weather-adjusted electricity use for your home and the average for electrically-heated homes in New Jersey and in your area over the last four years. An "n.a." indicates that information is not available.

Adjusted Electricity Use for the Past Four Years

	1983	1984	1985	1986	Total Change (1983-1986)
Your Adjusted Use	n.a.	n.a.	12,200	11,720	n.a.
Study Group Average	n.a.	n.a.	14,280	14,370	n.a.
New Jersey Average	14,290	14,250	13,430	13,640	4.5% less

Since the energy crisis in the 1970s, Americans have been using less electricity in their homes. In New Jersey, the average electrically-heated home has dropped from 19,360 kWh in 1972 to 13,640 kWh in 1986 (a savings of $570 per year at today's electricity rates). For the most recent four years shown in the table, New Jersey electric use has dropped 4.5%. During the period for which we have records on your house, you have decreased your electricity use by 4%.

KEEPING COSTS DOWN: New sources of electricity are expensive for the utility companies to develop. By using electricity more efficiently, both the utility's expenses and your bills are kept lower. For additional information on how to keep your electricity costs down, your utility provides this toll free number: 1-800-982-0141.

THIS IS NOT A BILL. This information is provided to you to help you understand your electricity consumption. No payment is necessary.

5. GENERAL DESIGN ISSUES

A series of prototype Home Energy Reports were tested via pilot interviews in a design-interview-redesign-reinterview strategy. Numerous unanticipated problems were uncovered, and in the process we have built up a much clearer picture of the issues which must be addressed in designing energy reports for consumers. This section describes the design tradeoffs we have identified, many of which are applicable to any type of consumer energy information. We describe them here in the hope that they may help others in program design.

The optimal design of any energy report will depend on the audience. Possible alternative audiences include: households that have made conservation investments, households with high energy use, households which request such information, or all customers in a service area. Since this research was intended to inform the design of programs for any of these audiences, we included sections of the report and topics on the questionnaire intended for each of them. If an actual utility program were trying to reach only one audience, its report might be reorganized and shortened appropriately.

This section discusses general design issues which affect many types of energy reports. The subsequent section discusses specific tradeoffs which we weighed in designing our prototype report.

5.1 Frequency of Feedback.

As discussed in the literature review, high-frequency feedback is unnecessary, and perhaps excessive, for evaluating the effects of long-term changes such as weatherization or altered management habits. For utility-provided feedback, the expense of more frequent meter reading probably sets the month as a lower bound on intervals. The argument for a longer period, such as quarterly or annually would be that consumers would not want to be bothered with reevaluating major conservation changes every month. While our prototype home energy report is oriented toward annual reporting, it could be used in conjunction with a mini-report added to the monthly bill. Both annual and monthly reports offer some advantages.

The advantage of monthly reports is that they would be directly related to the monthly checking procedures noted above. Consumers, unlike energy analysts, know what happened in the house each month. Thus they can see the energy effects of holidays, visitors, or a month when an appliance was broken. One of the surprising findings of this research was that the consumer's knowledge of the times of household events makes monthly data far more useful to consumers than it normally can be to energy analysts.

A yearly report creates a new form of information from the utility that fits better with accounting for taxes and annual budgeting. In addition, a yearly accounting provides a better fit with how consumers seem to evaluate conservation investments. In this and previous research, when consumers mentioned payback, they described it by counting years, not months. Yearly figures also provide a better fit with the Federal appliance labelling program, which always translates energy units into dollars per year operating cost, and with many of the proposed "home energy rating systems" which also use annual rather than monthly figures.

The optimum frequency depends upon the purpose for which the numbers are used. Monthly reporting is needed to monitor short-term changes; yearly reporting is better for larger and lasting changes such as changes in family structure, a major retrofit or deliberate changes in management. A report with both would enable people to make the largest number of inferences.

5.2 Actual versus Adjusted Figures

We began designing the Home Energy Report with the conviction that weather- and cost-adjusted figures could help consumers sort out weather fluctuations and rate changes--aspects which affect their bills but over which they have little or no control--from aspects such as weatherization or behavioral changes which they do control. Because we feel that weather-adjusted energy usage permits eminently better comparisons, our initial design provided only adjusted figures.

However, our pre-pilot testing indicated that 1) although people had their own bills and could make a table of monthly usage and expenditure and compute their unadjusted annual totals, only a minority had done so, and 2) people were suspicious of and/or did not grasp the concept of annual weather-adjusted figures when presented without the corresponding actual annual figures. People wanted to see a record of the actual figures from which we were making adjustments. For example, one comment was "Oh, the utility's playing with numbers to show that they're not really charging you as much as it seems--maybe I think that because it says 'we adjusted your energy use' but does not explain 'adjustment'". A problem with giving actual totals with adjusted totals is that consumers might use the actual totals for comparison because they are more familiar. Nevertheless, we feel it is desirable to give both actual and weather-adjusted figures.

5.3 Energy Units versus Dollars.

Today's conventional wisdom in energy conservation is that consumers understand dollars, not energy units. This observation has been thoroughly documented in Kempton and Montgomery (1982). The primary problem with energy units is that most consumers lack a sense of the scale--is 100 kWh a lot or just a few cents worth? A contributing problem is that energy units like kWh and CCF are more abstract than measures such as gallon and pound which can be seen, felt, and approximated without instruments. A final factor, which we would judge to be less important, is that unknown energy units seem intimidating, confusing or otherwise bothersome to some consumers.

Some practitioners have interpreted this problem to mean that any mention of energy units should be excluded from public information. This interpretation won the day in the Federal appliance labelling program, and most of today's labels provide dollar comparisons without any mention of energy units. We oppose dollar-only labels both on general principles and for a practical reason. The general principles are: 1) we find some people recognize and use the energy units, 2) we would expect more to use them as energy prices increase, and 3) we feel it is good policy to facilitate the use of energy units.

The practical reason concerns comparison. This problem is seen in appliance labels: since energy prices are continuously changing, dollar-only labels must be changed every year or two, thus confounding comparison of old models with new. The multi-year comparison problem would be even worse if a home energy report used dollars only. As discussed previously, consumers currently use dollar totals to assess the energy effects of changes (whether retrofits, behavioral conservation, or non-energy motivated changes in lifestyle or equipment). Evaluation which shows a savings may be used to justify taking subsequent conservation actions, or recommending the same action to neighbors. Conversely, an evaluation which shows no savings will discourage further conservation. Since these comparisons may be multi-year, it is even more important to use energy units rather than dollars alone, since rates can change greatly over time.

The approach taken in our Home Energy Report is to give kWh first, and translate that into dollars. Since all dollar totals are based on the current prices at the time the report is sent out, multi-year comparisons are meaningful (the monthly dollar figures are actual billed dollars, to facilitate checking with customer bills). We have simplified the calculation of cost by not including in our study customers with blocked rate schedules (where the first few kWh are at a different rate from subsequent ones) or time-of-day rates (in which the rate is higher during peak hours of the day). Such rate schedules can be accommodated by first applying weather-adjustment to the energy units, then computing the cost. However, the resulting dollar figures may be more difficult to understand.

5.4 <u>How Much Explanation to Provide?</u>

A natural tension exists between providing enough explanation so that the consumer knows what the numbers mean, and giving unwanted text which wastes the reader's time and causes him or her to stop reading. There is no perfect balance because readers differ greatly--some would rather just be told what to do with the numbers ("use these numbers for comparing years"), while others will be skeptical if they are not told, at least approximately, how the numbers were computed.

There are several ways of stratifying additional explanatory information: it can be printed in smaller type on the computer-generated form, produced in a separate preprinted flyer, or made available by calling a telephone number that contacts a utility service person.

A separate preprinted pamphlet offers several advantages to printing on the energy report form itself. It shortens the form, which makes it faster to read and cheaper to produce. It makes a clear distinction between house-specific information and general information sent to everyone. As we watched consumers in our study read the form, we noticed that they paid more attention to information specific to their own house, and read more quickly the general information which applies to everyone.

While we feel that a separate pamphlet is an excellent choice for a real program, we did not use it in our experiment because of the particular needs of the research project. We needed to evaluate consumer's reaction to information. In order to compare across people, we wanted them to read the same information. Had they been switching between the numbers on the form and background information on a brochure, we would have had less control over exactly what they read and when they read it. To make our interpretation of their answers simpler, the format of the experimental energy report is a single form combining the numbers with the explanations.

5.5 Just Consumption History or Add Conservation Suggestions?

Another related issue concerns the provision of suggestions for conservation action. Some respondents in our pilot tests requested conservation suggestions. Thus a reader, having learned that his or her bills were high, would know what could be done to reduce energy costs. We initially added a section of conservation information at the end of the report, then in the final report integrated this information in with each relevant section. For example, in conjunction with the heating/non-heating section we mentioned specific conservation measures people might want to take depending on whether or not heating was their largest energy use. A frequent response to this section was to read out loud our list, saying "I've already done that" after each measure. If there was something that they had not done, they explained why it did not seem practical for them, for example "I'd like to get storm windows but can't afford them", or "I would add insulation but I'm not sure how long I'll be staying here" often concluding that there is nothing more they could do. Respondents did not comment on which measures would affect their area of largest use (heating or nonheating). The problem with adding conservation suggestions is that the report is highly house-specific, but without an audit the conservation suggestions cannot be house-specific. Based on these data, we cannot make a strong argument for including conservation suggestions on a home energy report. Perhaps a better approach would be to provide a number to call for an audit or for conservation information.

5.6 Incomplete Report versus No Report.

Another tradeoff in design was whether to send incomplete reports to people for whom we could not reliably calculate the figures or not to send a report at all. We decided to test the incomplete reports for two reasons: 1) some types of consumer information programs might be compelled to send every participant something, and 2) we suspected that even a partial report would provide some new information. We deliberately included houses in our sample for which NAC could not be reliably computed: fifteen houses received forms missing either one or both years' NAC or the heating/nonheating breakdown.[3] The overall reaction of this subset was only slightly less positive than those who received a complete form, 30% thought it told them something new about their household energy use (versus 40% in the total sample), and 70% rated the information useful enough to read the whole report (versus 82% in the total). These findings suggest that sending partial information would be a reasonable program strategy.

6. DESIGN TRADEOFFS IN THE PROTOTYPE REPORT

This section discusses design tradeoffs which had to be faced in designing our prototype report. We will refer to specific parts of the final Home Energy Report used in the interviews, which was presented in Section 4 of this paper.

6.1 Table versus Bar Chart

If one has decided to add monthly figures rather than a single yearly sum, one is faced with having to present many more numbers. As shown on our prototype report, we drew on the two methods already in use by utilities, 1) a table of billed kWh and dollars, and 2) a bar chart of kWh. Here we consider the relative merits of these two formats.

Most bar charts on existing utility bills show consumption for the current month and the prior twelve to fifteen months. Kilowatthours are given either as the total kWh used that month or as the average kWh per day.

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[3] Diverse combinations are possible: Two houses did not receive either the NAC section or the heating/nonheating section; 5 households received the NAC for one year only and 4 of these received no heating section; and 8 households received everything but the heating/nonheating section. For those who did not receive NACs, the section comparing their use to the neighborhood and state was also incomplete.

If comparative dollar figures are given at all, they are given in an adjacent section as the average daily cost for the current bill, and sometimes the daily average cost for the previous 12 months is also given for comparison (for example, this is done by Niagara Mohawk, and Orange and Rockland). We began with some information on preferences for format of utility data. In a customer opinion survey of Jersey Central Power & Light's redesigned bill (Auch 1986) customers were told that the utility was considering using a graph to describe annual energy consumption once a year and were asked to state a preference for different kinds of graphs (vertical bar chart, horizontal bar chart, line graph) or to state if they do not like graphs. The largest number preferred a vertical bar (37%).

We presented a two-year vertical bar chart of monthly kWh usage. By labelling the right side of the vertical axis in dollars we presented the cost per month at today's prices. In both the length of time represented and the inclusion of cost our chart differed from those currently in use by utilities. Both of these innovations entailed some design challenges. One problem was in the best wording to distinguish the two years: "this year", "last year", or "previous twelve months", "last twelve months", especially when the two years do not necessarily begin with January. Another problem was that the use of two types of units (kWh and dollars) on the vertical axis was an unfamiliar graphic form. It was also inconsistent with the NAC section in that cost was de facto adjusted to current prices whereas usage was not adjusted for weather.

As noted previously, our pilot tests of the energy report indicated that the adjusted annual figures were less credible without unadjusted actual use and dollar figures which could be cross-checked with bills. As a result, we added the two-year table showing use in kWh and cost in dollars taken from their bills. Our initial Home Energy Report totaled these amounts for both years. Although many people keep their old bills, few take the time to calculate annual totals on a regular basis. While some responded to the monthly table with comments like "I've seen this before", others had enthusiastic reactions like "this is the first time I have looked at the whole year or whole season and can see where to cut down". We might have expected those who were on the budget plan (making an equal payment each month) to find both the monthly table and bar chart of monthly bills less useful, since JCP&L budget plan customers already receive similar data on their monthly bill. This pattern was consistent with the data: only 23% of budget plan customers found the table of monthly bills "very useful" compared with 37% of those with normal billing, and the bar chart showed a similar pattern (However, we could determine billing status for only 37 respondents, 13 of whom were on the budget plan).

Both the table and the bar chart were drawn from billing information and were labelled with the month of the meter reading date. As seen on the sample report, this meant that a month name (in this case, May 1985) might appear twice or not at all if the meter was read at the beginning and end of the same month. This was confusing, and some adjustment should be used for any real program.

We had expected a split between people who preferred this information in the form of a table and those who preferred it as a bar chart. This expectation was based on a few of the pilot interviews and on information from utilities. In the process of choosing a new bill format, two utilities have reported internal debates as to whether most customers can understand bar charts. The JCP&L study showed that 17% of sampled customers said they did not like graphs, while 56% preferred a monthly energy consumption table to a bar chart (Auch 1986). The stronger pattern in our data (see Table I) is a split between people who either like both the table and bar chart or neither. About half (24) rank both exactly the same, while only five rated one form very useful and the other not useful.

TABLE I. Cross tabulation of consumer ranking of bar chart and table.

		TABLE OF MONTHLY BILLS		
		very useful	somewhat useful	not useful
BAR CHART	very useful	10	3	4
	somewhat useful	6	7	4
	not useful	1	7	7

Comments made during the interviews showed that some people either do not understand or do not like graphs, or want to see exact figures, and thus prefer the table. Others feel that "pictorial images are always bett :r" because they show the overall pattern of seasonal change and the high or low months. We conclude that it is desirable to have both if space permits. If space is at a premium, the designer would have to weigh the advantages and disadvantages of each, as discussed above. Since they are constructed from actual consumption, neither the table nor bar chart is appropriate for year-to-year comparison because neither is weather-adjusted.

6.2 Annual Weather-Adjusted Consumption.

Our initial design of this section was not successful. When our hypothesis that the problem was due to interview methodology was not confirmed, we revised the presentation of the weather-adjusted totals.

On our original test report, the weather-adjusted figures were preceded with a lengthy textual explanation under the heading "COMPARING THIS YEAR WITH LAST YEAR". This heading seemed logical to us, since the report's introduction said that the weather-adjusted figures were for comparison. However, this heading was a nonsequitor to most respondents because they had just finished comparing the years in detail by interpreting their monthly actual use for two years in the table and bar chart. Observation of people reading the report in their homes indicated that people tended to skip the long introductory paragraph explaining NAC, glance at the numbers, then read the rest of the page. Our revised section reduced the amount of text preceding the adjusted figures and changed the heading to "ADJUSTING FOR THE WEATHER" to alert people to the difference between the actual monthly figures on page 1 of the report and the weather-adjusted figures on page 2. The original and revised versions are shown in Figure 1. Other alternatives we considered included using graphic images, i.e., a sun for weather-adjustment, dollar sign for price adjustments, to represent what kind of adjustment was being made. We considered the idea of eliminating the actual monthly figures to force people to compare only adjusted figures, but rejected this idea for the reasons discussed above in the monthly/annual discussion. Instead of eliminating the actual figures altogether, we removed the annual actual totals from the first page and placed them next to the annual adjusted totals as seen in Figure 1.

Figure 1

Old Report

COMPARING THIS YEAR WITH LAST YEAR

Your electricity costs from month to month depend on your own personal activities, variations in how many people are home, and the "tightness" of your house. They also depend on weather conditions and electricity rates set by the state and utility company. The weather you have no control over, utility rates you have only indirect control over, but the rest is entirely up to you. To see the effects of the part you do control, you need to look at your electric usage independent of outdoor temperature and changes in the utility's rates. And now--again using your actual bills--our computer has calculated your electricity use and cost, adjusted for temperature and rate changes. We call these adjusted figures your "electricity index" and your "cost index".

Weather and cost adjusted

	Last Year	This Year	Difference
Electricity Index (kWh)	20,610	21,460	not significant
Cost Index (today's prices)	$2,050	$2,130	

The small change in your electricity use is not statistically significant.

New Report

ADJUSTING FOR THE WEATHER

The weather affects how much electricity you use, so this has to be taken into account in comparing years. Our computer has totaled your yearly electricity use, the ACTUAL USE shown below. Then it adjusted for any weather differences to give your ADJUSTED USE and also computed the cost at today's electricity rates, your ADJUSTED COST.

	Last Year	This Year	Change in Adjusted
ACTUAL USE (kWh)	19,310	19,300	
ADJUSTED USE (kWh)	20,610	21,460	**
ADJUSTED COST (today's rates)	$2,050	$2,130	**

** The change from these two years is so small that it may be due only to random fluctuations.

We initially decided to call the Normalized Annual Consumption (NAC) by what we thought was a simpler name, "the energy index". We hoped that people would learn to use an energy index in a way similar to their use of miles per gallon (mpg) in making decisions about which car to buy. However, comments during the first interviews showed that the word "index" introduced a concept that needed to be explained rather than drawing on a familiar concept. Thus, on our revised form we dropped the use of "index" and substituted "adjusted use" for "energy index" and "adjusted cost" for "cost index". Our impression is that this change reduced the confusion, but we do not have a specific measure to validate this impression.

In the process of interviewing and redesign, we also realized that a major problem with the table of NAC figures is that it combines three analytic steps: 1) adds up yearly totals, 2) adjusts the yearly totals for temperature and rate changes, and 3) compares one year's adjusted totals with the next. One of our earlier prototypes took people through the process step by step. We gave them a table of their monthly actual consumption and costs for two years on the first page, then using the same format, presented those figures after having adjusted for temperatures on the second page, and finally showed each month adjusted for both temperature and cost on the third page. This prototype, although it made the analytical steps much clearer, resulted in a five-page report which we felt was too long to hold the consumer's attention. Another problem with presenting the material in this way is that it requires performing weather-adjustment at monthly intervals rather than annual (A subsequent section discusses this problem).

One additional hypothesis as to why people were not paying attention to the section on NAC is that the change in NAC between the two years often was not statistically significant. Two-thirds of our total sample (42 of 64) did not show significant changes in their NAC for two years.[4] Thus, when they glanced at the table and read "not significant", several made comments suggesting they thought that it was not worth reading such a long passage. In a mass mailing or a random sample, presumably most people would not show a significant change in NAC because in any single year most people have not changed their behavior or house drastically. On the other hand, if the report were mailed to participants in an effective conservation program, a higher percentage would show significant changes. Although this is a program design issue, not just a problem of presentation, we tried to improve readability to in our revised report by eliminating the words "not significant" and replacing them with asterisks defined after the table (as shown previously in Figure 1).

The NAC also appears to be less important on our test forms because the difference between actual and weather-adjusted totals happened to be small for the years covered by our study. As mentioned in the introduction, the amount of weather adjustment in two successive years is often small in proportion to total energy consumption but it can be large in proportion to the savings achieved by a conservation retrofit in any one year.

To test whether people were grasping the concept of weather-adjusted

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[4] It is interesting that 8 of the 13 retrofits for which we have a two-year comparison do not show a significant change in NAC from one year to the next. (Four show significant decreases in NAC and the comparison is not available for one house.) The percent of houses with significant decreases is about the same for the retrofit sample as for the sample as a whole, 31% compared with 34%

figures, two questions were added to the interview. We referred the respondent to the figures for the ACTUAL TOTALS and the WEATHER-ADJUSTED TOTALS on the second page, then asked two questions: 1) "If last year had been colder than it really was, do you think the actual total for the year would be any different?" (the correct answer is "yes"); and 2) "If last year had been colder than it really was, do you think the weather-adjusted total for the year would be any different?" (the correct answer is "no").

Question 1 tested whether respondents understood that weather affects yearly energy use and question 2 tested their understanding that our adjusted figures neutralized this weather effect. Of the 36 respondents asked these questions, an impressive 92% answered the first question correctly, but only 17% answered the second one correctly (58% answered incorrectly and 22% said they did not know the answer).[5]

The low level of correct responses to the question on weather adjustment was a surprise. Part of the problem may lie in the fact that indices and adjusted figures are concepts used mostly by analysts and academics.[6] This does not necessarily mean that they should be eliminated. People can use the NAC figures for appropriate purposes without fully understanding them. When asked which totals they would use to see if their

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[5] In reviewing this paper, several energy analysts have suggested that the correct answer to question two is "yes" because the weather-adjusted methods are imperfect. We are fairly confident this does not explain our low proportion of answers because we encouraged (and got) comments and qualifications when such factors affected answers. We did not hear such comments on this question.

[6] All of the six who correctly answered the question about weather-adjustment had college or graduate degrees. However, it should be noted that a college education does not automatically guarantee an understanding of these concepts--eleven respondents with the same level of education answered the question incorrectly.

energy use had gone up or down as a result of any changes they had made, 59% said they would use the adjusted totals either alone (27%) or in combination with the actual totals (32%).

6.3 Heating Compared with Nonheating Uses.

The space heating fuel is typically used for additional purposes (water heating, cooking, etc). Though usually not metered separately, space heating can be analytically separated from other uses by correlating the total monthly fuel consumption with the outdoor temperatures for the month (Fels 1986). As part of our experiment, we distinguished space heating from all other uses on the report as a piece of additional information. Our rationale was that it would help consumers identify what was contributing most to their total bill, in part because this might be the first place to look for conservation possibilities. We also felt it would provide general information on their house and their habits. The method used (PRISM) provided a measure of the statistical reliability of this separation.

One problem is that, whereas the weather-adjusted annual total is very reliable statistically, the heating/nonheating division is not as reliable. Nevertheless, we included the heating/nonheating breakdown based on the logic that our procedure for separating them out was probably more reliable than whatever consumers are now using. Unfortunately the unreliability and consequent yearly fluctuations would make it misleading to present a heating/nonheating division for comparison between years, as useful as this might be. If it were more reliable, a two-year comparison could show, for example, that a consumer's heating part went down but the nonheating part did not. Instead, we showed only the second year's heating portion and provided the heating portion of the New Jersey aggregate data for comparison.

With the heating/nonheating division, more than any other numbers on the Home Energy Report, we found that people reacted with skepticism and even some suspicion, making comments such as "How could you compute that?" and "How do you know what we did inside our own house?" Two separate issues were involved: First, they did not understand how we could know this number, since there is only one utility meter. Second, some gave reactions that we interpreted as a feeling that their privacy was being invaded. A few reacted negatively to our computation, as if the utility's right-to-know stopped at the meter. Even when the interviewer explained our method of computing the heating/nonheating uses, a credibility problem was indicated by comments such as "its a ballpark figure" or "You just guess". One woman dismissed our analysis with: "that's ridiculous because in addition to changes in heating in the winter and summer, people's other uses change. They cook more in the winter: stews, soups and more baking whereas in the summer they barbecue and eat more salads and cold cuts". Some of these comments demonstrate rather insightful criticism of any analytical separation of heating from other energy uses.

The heating/nonheating breakdown was a first attempt towards the ideal of providing customers with a personalized breakdown of all individual energy uses in their home.[5] We feel that the problems we encountered could be solved with a better explanation of the computation and with an assurance that the figures were only for the resident's own use. Nevertheless, the

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[5] A more complete breakdown of appliances has been proposed by EPRI (McCarthy, Barnes and Harris 1984). But such methods must either use very expensive submetering or use an analytic separation much less reliable than the heating/nonheating breakdown used here.

experience was interesting in providing examples of both technical and cultural constraints to be overcome in presenting analytic breakdowns of energy use.

6.4 Comparing Self with Neighborhood and State.

The final section of the report showed the individual's NACs for the past two years in comparison with the study group's average NAC for the same periods and the New Jersey average over the last four years. The text placed these comparisons in the context of the general pattern of residential energy use in the United States since the oil crisis. Although we had only the previous two years' data for this study, in a long-term program the table could be completed to show the individual's performance over four years or more. Also, the "study group average" is intended to be a neighborhood average. We were able to provide a neighborhood average for one community which was well represented in our sample, and respondents found this more useful. Of those with the neighborhood average, 38% found the comparison very useful (and 38% found it somewhat useful) compared with 26% of the total sample who found it very useful (and 33% somewhat useful).

We had assumed that consumers could use the neighborhood and state averages either as a gross diagnostic tool of the relative efficiency of their home or in the spirit of competitiveness to gauge their place relative to others. However, we found that the spirit of individuality was equally strong. Respondents were evenly split between those who liked this section and those who did not. Their responses seemed to be related to whether their energy use was higher or lower than average. Those whose NAC was above the NJ average were polarized in their reaction to the NJ comparison (44% found it very useful, 36% not useful, and only 16% somewhat useful).

Conversely, of all those in the sample who found the section very useful, 61% had an NAC higher than the average. Apparently the high users found the comparison diagnostically useful. Those who said they did not find the comparison useful were strident in their assertion of the fallibility and even unfairness of making such comparisons. One woman said of the New Jersey average, "You are comparing us with those mansions in Princeton". Another woman whose usage was lower than the neighborhood average objected to being compared with others in her housing development. She pointed out that not all the units in the development were one bedroom and went on to say, "I don't have a washer and dryer. I go to my daughter's to do my laundry".

We feel that the merit of helping people to understand how their house and habits fall in relation to the average, and the enthusiasm of those who like getting this information weighs more strongly than the perceived "unfairness" of those who did not like it. Nevertheless, this strong minority reaction argues that the comparisons should be confidential, made available only to the residents themselves. Some potential problems could also be averted by judicious selection of the text interpreting the comparison tables.

7. HOW THE HOME ENERGY REPORT ENHANCES EXISTING INFORMATION

As we have shown, a Home Energy Report would be entering into an information environment which already contains many other sources. The HER would not be believed if it contradicted existing credible information, and it would not be worth doing if it simply duplicated what is already available. In this section we show how the HER enhances the energy computations consumers are now doing.

Our interviews showed that consumers now exploit a remarkable diversity of tools for understanding energy consumption, including their current bill and stored old bills, neighbors' or friends' experiences, fliers and pamphlets included with their bills, the utility's toll free information number, the electricity meter, and their own knowledge and beliefs about how the weather and their behavior affect their energy use. Of these sources, the monthly bill is the most extensively used. The Home Energy Report differs from existing bills in having: 1) annual total with monthly breakdown, 2) rate-adjusted dollar figures, 3) weather-adjusted consumption rather than daily average temperatures or degree days, 4) usage breakdown and 5) comparison with averages. This section describes how each of these new types of information fits with the existing information environment.

<u>Annual Total and Monthly Breakdown</u>. Our test report differs from current utility billing information in providing annual consumption figures for two years, and a complete table of monthly figures. We reviewed existing bills using a national compendium (AGA and EEI 1984), and with additional inquiries to about 15 gas and electric utilities. The only utility we encountered which provides an annual figure is Atlantic Electric, which gives unadjusted kWh and dollar totals for the year.

A number of utilities today print on each monthly bill a comparison of the current month with "this month last year". The most common type gives only the energy unit comparisons. An interesting variant of this is the new Public Service Gas & Electric bill which shows consumption (ccf and kWh) for the last three months in comparison with the same three months for the previous year. Thus, a single odd month stands out more clearly. A few current bills provide temperature information to allow the customer to do his or her own crude weather adjustment. For example, at least two utilities provide the average daily outdoor energy usage for the current month and the same month the previous year along with the average daily temperature for both months (Philadelphia Electric Company and Northeast Utilities). Less frequently dollar figures are also included. Portland General Electric presents a similar kWh comparison with temperature this month and the same month last year, but includes the average cost per day only for the current month, presumably to avoid the issue of adjusting for rate changes. South Jersey Gas actually provides heating degree-days (base 65) which is an improvement over temperature in being a scale proportional to heating energy needs.

As mentioned above, in addition to making monthly payments, bills are also used for checking on unusual months and evaluating conservation actions. Each of these can be seen more clearly when the current month is presented with the remainder of the year, as in our table and bar chart of actual bills.

Of our sample, 37% reported having computed an annual energy total on their own at least once in the past [6]. Several of those who had calculated the annual sum reported that a home energy report would save them the trouble of doing this themselves. It also adds more valuable comparative information than the unadjusted dollar totals, which is the only quantity most of them now compute.

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[6] Some total annual cost only while some total both kWh and cost. Several people reported making an annual total around tax time every year. Others had totaled their costs at particular decision making points in their lives, for example, when trying to determine when they could afford to retire, or when trying to decide whether to move to another home.

Since some of those who do an annual summary do so for the calendar year, and do it around tax time, this would argue for sending an annual report out to all customers between January and March, based on the prior calendar year. The fact that some consumers use this kind of information at decision points in their lives suggests that it should also be made available on request.

Rate Adjustment. The fliers and pamphlets that the utilities send with monthly bills include, in addition to conservation tips, information on rate changes. Although several people mentioned saving the fliers with this information, only one person mentioned actually making calculations with it. The one who did use it was a low-income woman who had her neighbor read her meter, and calculated how much her next bill would be based on the meter reading (from which she subtracted the previous reading) and the current rate on the utility fliers. By contrast, one man, even though he was interested enough to keep his energy records on his personal computer, did not feel he could adjust for rate changes when comparing years.

Weather Adjustment. Another important element in consumer calculations of home energy is the weather. Nearly everyone in our sample (89%) acknowledges the important effect weather has on their utility bills, for heating and cooling. However, many people engage in seemingly circular reasoning in this matter. For example, several people attributed higher bills to colder weather, but when asked how they determine that it is colder they said their heating bills were higher.[7] Other ways people reported

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[7] For example, HER 6 answered "This winter was colder from what I can gather from the bills", and HER 41 said she did not know whether this winter was warmer or colder than last winter because her old bills were up in the attic.

determining if the weather was colder one winter than another include the number of days that snow had to be shoveled, the length of time winter clothing was needed, the frequency with which the heater switched on, hearing a daily weather report which declared that day the "coldest (or warmest) on record," and simply how cold it "felt".

These crude coldness estimates are too imprecise to judge expected fuel use, and may obscure (or exaggerate) conservation savings. For example, one couple who had participated in the utility's retrofit program for seniors had lower bills in the following year (their HER showed a weather-adjusted savings of $410). The woman of the house concluded "The insulation saves us plenty of money when it's cold" whereas the husband concluded that the drop was due to the second winter being warmer.

An energy report that accounted for weather fluctuations and rate changes could enable people to feel more confident of savings which result from their conservation efforts. However, even after fluctuations in the weather and rates have been taken into account, the consumer will need to continue to use house-specific information such as vacations or special activities to interpret fluctuations in some individual monthly bills.

There are several conceptual challenges to successfully communicating the annual weather-adjusted consumption figures to a lay audience. Although people are already making adjustments when interpreting their energy consumption (one of the things we learned from this study), our weather-adjustment is unfamiliar to them, a problem made worse by the fact that we did not tell people to what quantity we were adjusting (twelve years of average temperatures). Several respondents specifically asked whether we were using degree days. In fact, an average of twelve years of temperatures is probably easier to grasp than degree days. Another problem was pointed out by consumers when we explained the method in a few of the open-ended interviews: several people felt that our temperature adjustment was incomplete since it did not take into account other weather components such as wind, solar input, or humidity.

Some respondents apparently would find monthly weather-adjustment more relevant. Eighty-nine percent of our sample responded that weather has a "very important" effect on electricity consumption.[8] However, in response to the seemingly identical question of whether their bills change much from one winter to the next depending on the weather, a smaller 64% agreed (29% said "no" and 7% did not know). Some of those who said "no" explained that although one or two months might be unusually cold, overall the winter evened itself out. It is in fact correct that months vary more than the entire winter, but as mentioned earlier, remaining year-to-year variation is often sufficient to cancel or exaggerate the effects of energy conservation.

Usage Breakdown. HER differs from any existing information in its analytical separation of space heating from other energy uses. Many consumers are already doing an approximation of this method: they have a sense of the average (non-air-conditioning) summer month, which they subtract from each winter month to compute the amount they are paying for heating. We have not conducted an analysis of how accurate this generally is, nor do we know precisely what proportion of consumers do it. The advantage of the consumer method is that it is straightforward and easy to understand. The advantage of our PRISM-based method is that it is almost

[8] Some of the few who thought that weather was not important to electric bills were people who had switched to non-electric heating systems.

certainly more accurate and provides a measure of the reliability of the estimate.

As mentioned previously, a finer breakdown distinguishing among more appliances would be desirable, and would be more parallel to other services such as telephone billing or retail purchases. Current metering devices do not permit this to be done cheaply for every consumer, and the occasionally skeptical reactions to our analytic heating/nonheating breakdown bodes poorly for an (much less statistically reliable) analytic breakdown of non-space-conditioning appliances. A few respondents reported making rough relative estimates by looking at their meter while another family member switches an appliance on and off, and a few reported using brochures which give the typical usage of several appliances.

Comparison with Average. HER also differs from existing information in that it compares the individual with the NJ and neighborhood averages. Only one new bill that we know of (Niagara Mohawk) provides a comparison with average use. They give the current month's usage of their average residential customer as the last bar on their bar charts of actual kWh and Therm usage.

An important existing source of comparative energy data is the experience of neighbors, colleagues or relatives. Seventy percent of our respondents reported discussing electricity bills with others. They do so because their added knowledge of their friend's and neighbor's behavior allows them to make adjustments for differences in family patterns and behavior. For instance, numerous residents in a retirement community mentioned that many of their neighbors went to Florida for the coldest months every year. They also commented on their neighbors' use of air conditioning, which they monitored by the sound of the AC units. Even more detailed comparison of behavioral patterns is possible. One woman said that she compared her energy bills regularly with those of a co-worker: "They use a lot of hot water. She has three daughters and cats and dogs and the girls are always shampooing their hair. I don't understand how they can use less than I do". In comparing with neighbors, although the weather conditions would be comparable, many felt that because of the specifics of their homes, certain exposures (Southern or Northern) or particular architectural features, the weather would affect their homes differently.

8. DATA FROM EXAMPLE CASES AND POSSIBLE EXTENSIONS OF THIS STUDY

There are several logical follow-up studies which could test hypotheses raised in this research. If a home energy report were implemented to meet energy conservation program goals, it would be useful to test whether or not it actually improves conservation. The present study was oriented toward seeing what types of information were understandable and useful to consumers, based on self-reports in open-ended and fixed-question interviews. Given our results, a study could be designed to test for effects using a much larger sample but requiring much less interview data per household. In fact, the interview could be eliminated: a utility could simply mail a Home Energy Report to a randomized subsample of their customers and measure any change in energy use over several years.

While we did not collect data on energy change caused by our report, we have some hypotheses about how a HER might affect consumption based on a few cases in which the topic was mentioned. Below, we discuss insights from several individual cases. While the data are anecdotal, they suggest possible further studies and give clues as to how a home energy report would be used by diverse consumers.

<u>Linkage to Conservation Retrofits</u>

The most important application we envisioned when designing the Home Energy Report was as an aid to people who had retrofitted their home. One example of this was a person (HER 56) who had taken a number of conservation measures including recaulking the windows inside and out, weather-stripping around the doors, replacing old, inefficient window air conditioners with ceiling fans and installing an air-tight wood stove in the living room (for "recreational" use). He was surprised and delighted to know that he had actually saved money, even though it was $46 for the year, an amount which was statistically significant but in strict economic terms would be a poor rate of return. Nevertheless, seeing a definite measured dollar savings encouraged him and he itemized several reasonable weatherization changes he is now planning as a result of getting the HER. While he is not using our information for systematic investment analysis, it seems to reinforce his previous efforts.

We assumed that renters would be less interested in the retrofit applications of the HER since renters would be less inclined to invest in improvements to their homes.[9] However, one of our respondents (HER 51) had volunteered to participate in our project because she felt the house she rented was uncomfortably cold and drafty due to poor insulation. In the last several years her family had resorted to putting plastic on the windows and using a kerosene heater. She hoped that a document like ours would prove to the landlord that the building was in need of work. In fact, her

[9] A number of studies have focused on the constraints on conservation measures for rental units (e.g. Bleviss and Gravitz 1984).

bar chart did show a more marked peak during heating season than the rest of our sample and the heating/nonheating section showed that her household was using about double the NJ average for heating.

Increased Knowledge or Consciousness of Energy

Apart from the above cases of direct links to conservation, in several cases the HER corrected energy misconceptions, provided general background information, or served as a general consciousness-raising tool. A number of people said that they were going to try and pay more attention to energy expenses in the future. Because of the time lag between preparing the reports and completing the last interviews, the records on their reports often did not include the most recent month or two. On their own, a number of people completed the table of monthly bills up to their current bill, and one man also drew in the additional bars on the bar chart. Several said that they would continue to keep such a record. Others said they had not realized how much they were spending. The HER also corrected false assumptions. One woman thought that her bills had gone up this year because of her new self-defrosting refrigerator, but the HER report showed her that her unadjusted consumption had gone down a little and that her weather-adjusted costs had not changed significantly (HER 29). (While she was correct in believing the self-defrosting feature used more energy, the effect--if any--was much smaller than she had believed from unsystematic inspection of individual monthly bills.)

In addition, for several people the report was an impetus for them to make behavioral changes to conserve energy. For example, one man said he was going to try to get his wife to use the clothes drier less. Another said that she might go on her utility's time-of-day billing program as a result. This woman said that she did not normally talk to others about electricity but that after receiving our report she talked to a few people and they had recommended the time-of-day program.

Potential Connection with Contractors

One problem with selling conservation services in the residential sector is that the buyer has a hard time seeing how much benefit has been derived for the money. This can act against an effective contractor or in favor of an inefficient one. The weather-adjusted home energy report provides a standardized evaluation of contractor services, from an independent party.

If a program were to be oriented to independent contractors, a service could be provided whereby either the customer or the contractor (with the customer's permission) requested a report on retrofit work. At the time of the request, the date of the work would be specified, and one year after the work was complete, the utility computer would send out a report comparing the year before with the year after the retrofit. This could serve several purposes. The customer would have a direct measure of the effectiveness of the contractor's work. The contractor could use it as feedback as to which methods or which crews were more effective and could use it as a much more reliable way to estimate probable future savings dependent upon house type and retrofit package (of course, this will not prevent exaggerated claims in advertising). The contractor could also use a successful report as a sales tool, either for the same person to have further work done or for their neighbors to do the same work. Its effectiveness as a sales tool is greatly enhanced by its being provided by a neutral third party (the utility).

Finally, utilities or other bodies evaluating or recommending conservation contractors would have an objective mechanism for ranking them by effectiveness.

Research on Monthly Weather-Corrected Data

One hypothesis generated by our research is that consumers would benefit from monthly rather than annual weather-adjusted consumption figures. This hypothesis deserves testing in a future study. Our study provided annual weather adjustment more as a matter of practicality than of philosophy. Even though NAC is derived from monthly data, the weather-adjusted index of consumption produced by PRISM is annual. Nevertheless, providing monthly weather adjustment, for example, in the form of an "NMC" (Normalized Monthly Consumption) index, raises problems of reliability and readability.

The annual NAC index generally has a small standard error--much smaller than those of the individual components of NAC. (This is PRISM's most important feature; see Goldberg 1984 and Fels 1986.) Thus the reliability of NAC is not strongly dependent on the reliability of the reference temperature, or the other parameters, estimated from the same data. This reliability may not hold for monthly estimates. The month's error term may be large in a month of unusual behavior (thermostat turned up for grandmother's visit, family on vacation, furnace needing repair, etc.). Yet if the monthly estimate were supplemented with the month's "error", the report would be made more complicated and difficult to read.

If inclusion of an NMC index on the Home Energy Report is for some reason impractical or undesirable, simpler feedback on the monthly data may be an alternative worth considering. For example, one might add two columns to the monthly table: percent change in actual consumption (for each month), and percent change in heating degree-days for that month. A house-specific reference temperature would make the degree-days more accurate, but might be confusing to neighbors who compare Home Energy Reports.

In short, if monthly consumption were to be weather-adjusted, further investigation would be required both to determine what monthly estimates are understandable and should be included, and to develop reliable analytic techniques and software to compute monthly adjusted figures.

9. CONCLUSIONS

By integrating interviewing into the design process, we found that our original conception of a home energy report was flawed in two ways. First, we needed to add raw monthly data, and second, we needed to allow for the fact that the majority of American consumers will not understand the most fundamental building efficiency analysis tool-- weather-adjusted consumption. The second effect is a surprisingly strong one: while 92% of our sample recognized that weather affected energy use, only 17% understood that our weather-adjusted figures controlled for this effect.

These are solvable problems. Our point is that these problems were anticipated neither by us nor by the many energy analysts with whom we shared our original proposal. We presume that these problems would not have been recognized without the intensive interviewing we conducted in parallel with design of the home energy report.

While some consumers simply pay their energy bills without further thought, our interviews show that many try to make inferences based on simple calculations. In some cases, these calculations are labor-intensive yet not very accurate. For example, 37% reported that, at some time previously, they computed an annual total by adding up all their bills. But this was not weather-adjusted and was often in dollars, rendering it of minimal use in comparing energy consumption across years. This study has demonstrated an alternative: a house-specific energy report mass-produced by computer and put in a form which is understandable and relevant to consumer energy decisions.

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