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TWO YEAR ANALYSIS OF ELECTRICITY USE AND SAVINGS FOR THE HOOD RIVER CONSERVATION PROJECT

Final Report

By
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Prepared for
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Executive Summary

The Hood River Conservation Project (the Project) was intended to test the reasonable upper limits of a residential retrofit program. It was proposed by the Natural Resources Defense Council, funded by the Bonneville Power Administration, and operated by Pacific Power & Light Company (Pacific) in cooperation with the Hood River Electric Cooperative (HREC) in the community of Hood River, Oregon. These two utilities served the Project area -- Pacific, an investor-owned utility, and the HREC, a public utility.

This three-year, $21 million research and demonstration project installed as many program retrofit measures in as many electrically heated homes in Hood River as possible. These changes were analogous to building a "conservation power plant" within the community. The retrofits were aimed at the building shell to reduce electricity use for space heating and water-heating; no heating or water-heating equipment was replaced.

This report discusses actual electricity use and savings produced by the Project in the second year following retrofit. In particular, it addresses savings "takebacks", or customers opting for increased comfort rather than lower electricity usage. Monthly billing data was used to estimate weather-adjusted (normalized) annual electricity use. The weather-adjustment method used is the Princeton Scorekeeping Method (PRISM). PRISM is applied to data from individual households.

The major findings are:

o **Energy savings remained stable during the second year after retrofit.** There was no statistically significant reduction in savings, or "takeback" effect, during the second year following Project completion. The savings remained constant regardless of utility area or dwelling type examined.

o **Hood River Electric Cooperative customers continued to use more energy on average than their Pacific counterparts during the second year after retrofits were installed.** HREC customers consumed more electricity, both pre- and postretrofit, than did Pacific customers. Savings were also higher for customers in the HREC service area, and their ratios of savings to preprogram usage were higher. This was true for single-family homes only as well as the combined housing type sample.

1. Background

The Hood River Conservation Project

The Hood River Conservation Project (the Project) was a major residential retrofit demonstration project, initially suggested by the Natural Resources Defense Council, operated by Pacific Power & Light Company (Pacific) in cooperation with the Hood River Electric Cooperative (HREC), and funded by the Bonneville Power Administration (Bonneville). The Project sought to install as many cost-justified retrofit measures in as many electrically heated homes as possible in Hood River, Oregon. The retrofits were aimed at the building shell to reduce electricity use for space-heating and water-heating; no heating or water-heating equipment was replaced. Energy audits were conducted and retrofit measures were installed by the Project between fall 1983 and the end of 1985. Data collection and analysis began in spring 1983 and continued through 1987.

The $21 million Project involved higher levels of conventional retrofit measures than generally offered in weatherization programs in the Pacific Northwest [e.g., R-49 ceiling insulation rather than the R-38 generally recommended in the Bonneville Residential Weatherization Program, RWP; see Bonneville (1982)]. In addition, Bonneville paid for installation of these measures up to a limit of $1.15/first-year estimated kWh saved,[1] almost four times the limit in Bonneville's RWP. Thus, the Project offered the chance to examine retrofit installation and subsequent energy savings when cost to the household and prior weatherization activities were largely removed as barriers.

Information on the purposes, design, and operation of the Project can be found in Pacific (1982 and 1983), Schoch (1987), and French et al. (1985). First-year savings are reported in Hirst et al. (1987) and summarized in Hirst (1987).

Study Objectives

The purpose of this report is to examine actual electricity use and savings in the second year following the completion of retrofits. These results are compared to usage and savings estimates for the preceeding year

[1] This corresponds to 5.2¢/kWh/year, levelized over 35 years at a three percent real discount rate.

to determine whether savings remain constant, increase, or decrease. A decrease in realized savings, or "takeback", could be caused by changes in resident behavior patterns.

A downward trend in residential consumption which began several years prior to Project implementation has been observed. It was possible that customers would decide to forego lower electricity bills in favor of increased comfort -- reversing this trend once they realized the extent of their homes' energy efficiency. Some savings takeback had already been observed during the first postretrofit year -- manifested as increased indoor temperatures (see Dinan 1987) and reduced usage of wood for space heating (see Hirst et al. 1987, and Tonn and White 1987). Large takebacks in the second postretrofit year would indicate that first-year savings were nonstable and likely to be reduced through customer activity. This would have implications for the reliability of the conservation power plant.

The first-year savings analysis also noted apparent differences in energy-use patterns among various participant subgroups. This study further investigated and segregated subgroup energy usage patterns.

Electricity use and savings were examined for the five years from 1982/83 through 1986/87. 1982/83 was the preretrofit year, 1983/84 and 1984/85 were implementation years, and 1985/86 and 1986/87 were the first and second postretrofit years. Homes analyzed were those eligible (i.e., electrically heated) for the Project: those which received Project-financed retrofits, and those which were eligible but did not participate in the retrofits.

The analysis looks at two different measures of program performance: gross and net electricity savings. Gross savings are the reduction in annual electricity use achieved by Project participants. Net savings are that portion of the total that can be directly attributed to the Project. Thus, net savings are the difference between total savings and the savings that Project participants would have achieved on their own had the Project not existed. Data from the two comparison communities are used to infer the background savings for participants.

Gross and net savings were calculated using weather-normalized consumption (kWh) to eliminate the effect of variations in weather on year-to-year energy use. Gross savings were evaluated for "takeback" effects, or reduction in savings due to customer actions, and were calculated by subtracting 1986/87 usage from 1982/83 usage. Mean gross savings were calculated for

Hood River participants and nonparticipants and for a random sample of customers in the comparison communities.

Net savings are defined as the savings for which the Project is directly responsible. These were calculated by subtracting the average gross savings of the comparison groups from participant gross savings. Gross and net savings calculations were segregated by utility due to the notable differences in energy consumption behavior found between customers of public and private utilities.

How these results are viewed depends on an assessment of the reversibility of savings attained against the background decline in energy use in the Pacific Northwest. Savings generated by behavioral changes are generally thought to be more easily reversible than savings associated with physical upgrading of dwellings (cf: Hirst 1987: 33-38, 41-42). The decline associated with Project intervention results substantially from physical upgrading of dwelling units rather than from occupant behavior.

The background trend is due to a mix of physical improvements to dwellings and behavioral changes due at least in part to rate shock and general economic conditions as well as to the general predisposition of conservation typical of the population of the Pacific Northwest region. The background declination has a different degree of effect for public and private utility customers. Both the total yearly consumption and the rate of change vary, with public utility customers having both higher initial consumption and a higher rate of decrease. This difference shows the importance of separately analyzing the customer types in order to obtain meaningful information on net Project savings.

2. Data and Methods

Data Sources

The data used to analyze changes in electricity use are monthly household electricity bills from Pacific and HREC, and daily temperature data from the National Oceanic and Atmospheric Administration (NOAA) weather station in Hood River and the comparison areas. The data are from July 1980 through June 1987.

In addition, information was available from random samples of households in Hood River and the two comparison communities (Figure 1). Data for households in the two comparison communities were used to assess the net electricity savings produced by the Project. These communities were chosen because they are served by Pacific, pay the same electricity rates as do Pacific customers in Hood River, and are far enough from Hood River to be unaffected by knowledge of the Project (French et al. 1985).

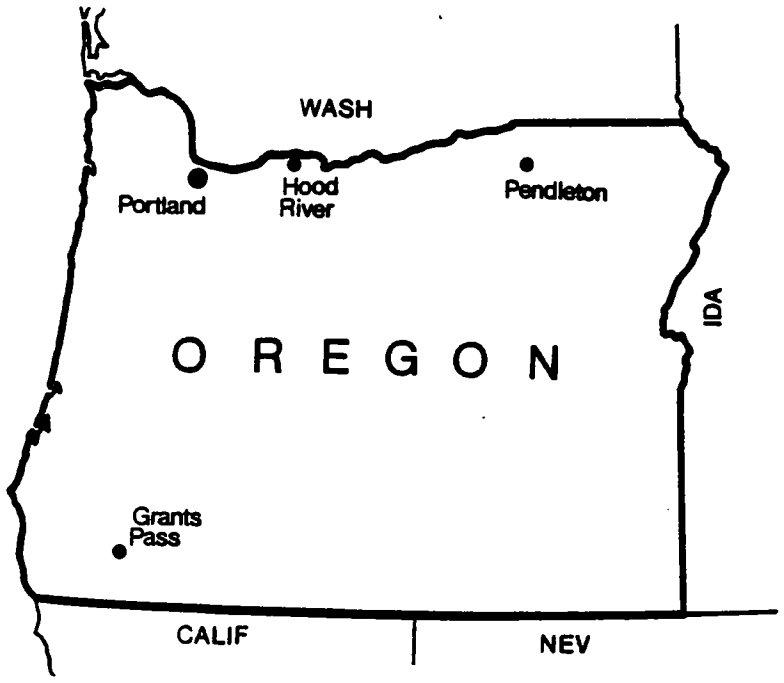

Figure 1. Map of the Pacific Northwest showing the location of Hood River and the two comparison communities (Pendleton and Grants Pass).

The primary data set (called Somefit) excluded all master-metered dwellings and included all remaining household-years of billing histories with

four or more bills that cover 270 or more days; most had 12 bills covering about 365 days. Households for which the year-to-year change in electricity use exceeded 80 percent of the prior year's consumption (6% of all homes) were considered outliers and dropped from the analysis data set. In effect, this exclusion removed dwellings which had been vacant for extended periods.

Somefit5 refers to the period 1982/83 to 1986/87, while Somefit7 refers to the period 1980/81 to 1986/87. About 60 percent of the Project households are included in Somefit7 (Table 1), while 70 percent are in Somefit5.

Table 1. Disposition of households from the Project data base

	Number of households, by group					
	Weatherized			Nonparticipant[a]		
	Pacific	HREC	Total	Pacific	HREC	Total
Total	1,806	1,181	2,987	105	74	179
Somefit5	1,281	839	2,120	72	57	129
Somefit7	1,136	732	1,868	64	51	115
Goodfit5	272	194	466	b	b	b
Goodfit7	192	115	307	b	b	b

[a] The 179 (estimated) nonparticipants are from the Nonparticipant Survey, and include households which received audits but declined to participate further.
[b] Too few cases to analyze.

The second analysis data set (called Goodfit) is a subset of Somefit. It includes only households whose electricity billing data closely fit the Princeton Scorekeeping Method (PRISM) model[2] -- R^2 greater than 0.75, daily baseload and heat slope coefficients statistically significant at the 10 percent level or better, reference temperature less than the maximum daily outdoor temperature for the entire year (from NOAA data), and a standard error in reference temperature of less than 20 ^{o}F -- for each year of analysis. Households whose billing histories met these criteria almost certainly

[2] See Fels 1986.

used electricity for most or all of their space heating needs, corresponding with little or no use of wood. This method was used to determine which homes used electrical heat in all groups (Table 2).

Table 2. Disposition of households in comparison groups

	Number of households, by community			
	Hood River Partic-ipants	Hood River Nonpar-ticipants	Grants Pass Sample	Pendleton Sample
Total	2,987	179	1,212	1,394
Somefit5	2,120	129	871	1,047
Somefit7	1,868	115		
Goodfit5	466	a	110	115
Goodfit7	307	a		

[a] Too few cases to analyze.

Attrition in second-year analysis

The number of homes available for this second postretrofit year analysis is less than in the first-year savings analysis due to the inclusion of the second posttest year, 1986/87. The requirement that all years between 1982/83 and 1986/87 meet the Somefit standard resulted in an additional attrition of 242 cases. There were 2,120 cases in the second-year analysis, compared to 2,362 somefit cases for the first-year study.

Methods

Monthly billing data was separated into analysis years, defined as July through June. Weather normalization was then performed using the PRISM model.[3] After weather normalization, participants meeting the Somefit cri-

[3] Methodology for determining pre- and postretrofit space-heat estimation

teria described above were separated by dwelling type, utility district, and participation in a previous retrofit program. Each of these subsets was analyzed, as were all participants as a group, using the Somefit5 and Goodfit5 data sets.

Calculated first- and second-year saved kWh were compared for each group to determine whether statistically significant differences were present. Savings were said to be stable if the difference between years was not statistically significant.[4] These comparisons were then performed using the Goodfit5 data set.

Participants were next divided by utility service area, and usage and savings compared for each year. Statistically significant differences would indicate that behavior patterns differ between Pacific and HREC customers. These comparisons were done using both the Somefit5 and Goodfit5 data sets.

Changes in usage between 1982/83 and the two postretrofit years were calculated for the comparison samples from Pendleton and Grants Pass. This reduction in kWh was then subtracted from the amount of energy saved by Project participants to determine net Project savings for Pacific participants.

The comparison communities of Pendleton and Grants Pass, Oregon, both totally served by Pacific, were used to calculate net savings for Pacific's Project participants. The comparison group for HREC particpants was a sample of customers eligible for Bonneville's Residential Weatherization Program but who did not participate.[5]

To determine whether the choice of base year affects estimated savings, an exploratory analysis was performed using the average of 1980/81, 1981/82, and 1982/83 annual consumption. Results from this method were then compared to results using the actual base year, 1982/83. This analysis used the Somefit7 and Goodfit7 data sets. Data were separated by dwelling type and utility. Estimated preretrofit usage and postretrofit savings were compared for each group. This analysis appears in Appendix C.

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correlations is under development at Oak Ridge National Laboratory.

[4] The statistical significance level criterion chosen for this test was alpha = 0.05.

[5] Data obtained from Goeltz et al. (1986) and Horowitz et al. (1987).

3. Results of Second-year Analysis

Stability of Savings

All participants

PRISM results (Table 3) show that second-year kWh savings were similar to first-year savings for all housing types in both utilities.

Table 3. All participants (Somefit) -- Total kWh, savings, and space heat consumption, 1982/83, 1985/86, and 1986/87

	(n)	Savings 82/86	Savings 82/87	Change in Savings	% Change Savings[c]	Statistical Significance Level
All participants						
Combined	(2,120)	2,600[a]	2,700	+100	0.5	NS
Pacific	(1,281)	1,800	1,900	+100	0.6	NS
HREC	(839)	3,900	4,000	+100	0.4	NS
Single-family						
Combined	(1,431)	2,800	2,800	0	0.0	NS
Pacific	(804)	1,900	1,900	0	0.0	NS
HREC	(627)	3,900	3,900	0	0.0	NS
Mobile homes						
Combined	(382)	2,500	2,800	+300	1.5	NS
Pacific	(200)	1,600	1,700	+100	0.6	NS
HREC	(182)	3,500	3,900	+400	1.8	NS

[a] All estimates have been rounded to the nearest 100 kWh.
[b] NS = Not significant at alpha = 0.05.
[c] Calculated as: (1982/87 Savings - 1982/86 Savings)/(1982/83 Total kWh).

Savings between the two postretrofit years varied less than one percent for all groups except HREC mobile homes. For that group, the difference was less than two percent. For single-family homes and nonparticipants, the overall percentage difference was zero. In those subgroups which did register differences in savings between the two years, the differences were all very small. None of these differences were statistically significant.[6]

[6] The power to detect a significant difference should it exist ranged between six and thirty percent.

Primarily electric participants

For the subset of homes which heat primarily with electricity (Table 4), some differences were evident, but none were found to be of practical importance, being well within the range of normal statistical fluctuations at the 95 percent confidence level.[7] These savings were all negative, indicating slightly less savings, and as might be expected, varied slightly more for the primarily electric homes than for all participants.

With the above caveat, these differences may be indicative of a small takeback effect for these homes. For HREC customers, the difference was about three percent, compared to about one percent for Pacific customers. Mobile home customers again had the larger percentage difference.

Table 4. Primary electric participants (Goodfit) -- Total kWh, savings, and space heat consumption, 1982/83, 1985/86, and 1986/87

(n)	Savings 82/86	Savings 82/87	Change in Savings	% Change Savings[c]	Statistical Significance Level
All participants					
Combined (466)	3,100[a]	2,700	-400	-1.8	NS
Pacific (272)	2,000	1,900	-100	-0.6	NS
HREC (194)	4,500	3,800	-700	-2.5	NS
Single-family					
Combined (285)	3,900	3,500	-400	-1.6	NS
Pacific (149)	2,800	2,600	-200	-0.9	NS
HREC (136)	5,200	4,400	-800	-2.8	NS
Mobile homes					
Combined (111)	1,700	1,100	-600	-2.9	NS
Pacific (56)	900	400	-500	-2.8	NS
HREC (55)	2,500	1,700	-800	-3.3	NS

[a] All estimates have been rounded to the nearest 100 kWh.
[b] NS = Not significant at alpha = 0.05.
[c] Calculated as: (1982/87 Savings - 1982/86 Savings)/(1982/83 Total kWh).

[7] The power to detect a significant difference should it exist ranged between five and twelve percent.

Customer takebacks

Hirst (1987) found a 300 kWh takeback effect due to increased indoor temperatures and an additional 300 kWh takeback effect due to decreased use of wood for space heating. Both of these effects were averaged over all participants, including non-wood users. These effects were identified through analysis of end-use submetered data; not derived from comparisons of annual consumption estimates.

Therefore, although Table 4 shows an indication that additional customer takeback is occurring among primary electric customers, this effect has not been verified, and is not statistically significant. It is possible, however, that these results represent the beginning of a shift in consumption behavior which cannot be measured at this time.

Net Energy Savings

Pacific customers

Combined housing types

Preprogram usage in the comparison communities of Pendleton and Grants Pass was about 4,000 kWh lower than in Hood River, averaging 14,500 kWh in 1982/83 compared to Hood River's 18,600 kWh. Residents in these communities decreased their annual consumption by an average of 900 kWh in 1985/86 and 1,000 kWh in 1986/87. Net Project savings for the private utility customers are thus 900 kWh for both the first and second postretrofit years.

Primary electric heat users in the comparison communities decreased annual consumption by a smaller amount -- 700 kWh in 1985/86 and 200 kWh in 1986/87. The net Project savings for these homes are 1,300 kWh first year and 1,700 kWh second year.

Single-family homes

The Pacific combined comparison community sample averaged 1,000 kWh first-year savings and 1,200 kWh second-year savings. Net Project savings for all Pacific single-family homes are therefore 900 kWh first-year and 700 kWh second-year, slightly less than for combined housing types.

For primarily electric single-family homes, however, the results are quite different, based upon the available data (n=47). First-year comparison group savings are 600 kWh, but second-year savings are negative -- this sample increased usage by 300 kWh over the 1982/83 base year. Net Project savings are 2,200 kWh first year and 2,900 kWh second year, sixty percent higher than savings for combined housing types.

Mobile homes

Comparison group mobile homes saved 200 kWh the first-year and 600 kWh the second year, yielding net Project savings of 1,400 kWh first year and 1,100 kWh second year for this group. There were too few primarily electric mobile homes in the comparision sample (n=16) to allow calculation of net Project savings.

HREC customers

Single-family homes

Available data on yearly energy consumption for public utility customers is limited to single-family residences -- data was consistently collected only for those homes eligible for Bonneville's Regional Weatherization Program. Data for a sample of eligible homes which did not participate is available for the years 1982/83 through 1984/85 (Goeltz et al. 1986). Approximately 80 percent of this dataset consists of public utility customers. HREC single-family customers had very similar consumption to this regional sample in 1982/83 -- 23,500 kWh compared to 24,000 kWh.

A different, larger sample was available for the years 1984/85 and 1985/86 (Horowitz et al. 1987). Data for 1986/87 is not available at this time. This sample is comprised entirely of public utility customers, but was not separately analyzed for primary electric heat customers. This sample had the same average consumption, 22,100 kWh,[8] in both 1984/85 and 1985/86 -- 200 kWh lower than the first sample's 1984/85 mean consumption.

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[8] This was calculated using the unadjusted sample. If the sample was weighted to reflect actual participation in Bonneville's program, the 1985/86 usage increases 800 kWh, which would yield even higher net savings for the Project's public utility customers.

From this, we estimated that the 1985/86 consumption for the first sample would show no change from the 1984/85 usage, yielding an energy decrease of 1,700 kWh for the period 1982/83 to 1985/86. Net first-year Project savings for HREC single-family homes are therefore 2,300 kWh.

For primary electric homes, under the assumption that usage did not change between 1984/85 and 1985/86, the decrease was also 1,700 kWh. We estimate net first-year Project savings for these homes to be 3,400 kWh.

Differences Between Utility Areas in Hood River

All participants

Participants varied greatly in their electricity consumption behavior between the two utility areas. Overall, HREC customers used significantly more electricity than did Pacific customers -- both before and after the program.

HREC participants used an average of over 23,000 kWh in 1982/83 -- very close to what Project planners had anticipated, based on previous regional studies (cf: Hirst 1987:33). In contrast, Pacific participants used an average of less than 17,000 kWh (Table 5).

For single-family homes, the results are very similar, although Pacific single-family homes used more electricity than the average for all Pacific participants, while HREC single-family homes virtually matched the HREC participant average. Pacific's mobile home residents also used more than the overall average, while HREC mobile home residents used a bit less.

In both of the postretrofit years, HREC customers used considerably more electricity overall than did Pacific customers. This pattern was consistent for the single-family and mobile home residents. Savings were significantly higher for HREC participants, no doubt because of their higher pre-Project usage. Savings as a percent of preprogram usage were significantly different, with HREC homes saving six percent more electricity overall and for single-family homes, and nine percent more electricity for mobile homes.

Table 5. Differences between utility areas -- Somefit

	Pacific	HREC	Difference	Statistical Significance Level
All Dwelling Types				
1986/87 electricity use	14,900	19,400	4,500	0.01
1985/86 electricity use	15,000	19,500	4,500	0.01
1982/83 electricity use	16,800	23,400	6,600	0.01
Percent preprogram kWh saved	7.9	13.9	6.0	0.01
1982/83 - 1986/87 savings	1,900	4,000	2,100	0.01
Number of households	1,281	839		
Single-family Households				
1986/87 electricity use	16,700	19,600	2,900	0.01
1985/86 electricity use	16,700	19,500	2,800	0.01
1982/83 electricity use	18,600	23,500	4,900	0.01
Percent preprogram kWh saved	7.0	13.4	6.4	0.01
1982/83 - 1986/87 savings	1,900	3,900	2,000	0.01
Number of households	804	627		
Mobile Homes				
1986/87 electricity use	15,700	18,100	2,400	0.01
1985/86 electricity use	15,800	18,500	2,700	0.01
1982/83 electricity use	17,500	21,900	4,400	0.01
Percent preprogram kWh saved	5.8	14.8	9.0	0.01
1982/83 - 1986/87 savings	1,700	3,900	2,200	0.01
Number of households	200	182		

Goodfit participants

Among customers using little or no wood for space heat (Table 6), the differences in total consumption and savings between utilities were similar to the differences between all participants. Only 15 percent of the total participants (n=466) met the Goodfit5 criteria.

HREC homes overall continued to have savings twice those of Pacific homes. This difference was particularly noticeable for mobile homes -- savings were almost four times higher than for Pacific mobile homes, 1,700 kWh vs. 400 kWh. Savings for these homes were much lower than for single-family homes, however, and the difference for single-family homes was more significant.

Savings as a percent of preprogram usage were again significantly higher for HREC customers, but these differences were not as large. HREC saved four and a half percent more electricity overall and for single-family homes, and five and a half percent more for mobile homes.

Table 6. Differences between utility areas -- Goodfit

	Pacific	HREC	Difference	Statistical Significance Level
All Dwelling Types				
1986/87 electricity use	16,200	24,000	7,800	0.01
1985/86 electricity use	16,100	23,300	7,200	0.01
1982/83 electricity use	18,100	27,800	9,700	0.01
Percent preprogram kWh saved	8.0	12.5	4.5	0.01
1982/83 - 1986/87 savings	1,900	3,800	1,900	0.01
Number of households	272	194		
Single-family Households				
1986/87 electricity use	19,100	24,600	5,500	0.01
1985/86 electricity use	19,000	23,900	4,900	0.01
1982/83 electricity use	21,800	29,000	7,200	0.01
Percent preprogram kWh saved	9.7	14.3	4.6	0.04
1982/83 - 1986/87 savings	2,600	4,400	1,800	0.01
Number of households	149	136		
Mobile Homes				
1986/87 electricity use	17,600	22,200	4,600	0.01
1985/86 electricity use	17,200	21,400	4,200	0.01
1982/83 electricity use	18,100	23,900	5,800	0.01
Percent preprogram kWh saved	1.1	6.8	5.7	0.05
1982/83 - 1986/87 savings	400	1,700	1,300	0.05
Number of households	56	55		

4. Conclusions and Discussion

No Additional Takeback Effect Found

The primary goal of this analysis was to determine whether customers would change their behavior to reduce, or "take back" retrofit-induced savings. This effect was not found, either in aggregate or in various customer subsets which were examined. Savings were stable two years after retrofit completion.

Private utility customers

For Pacific customers, gross savings are 1,800 kWh first year and 1,900 kWh second year overall, and 1,900 kWh both years for single-family homes. Net savings overall are 900 kWh both years for all homes, 900 kWh first year and 700 kWh second year for single-family homes.

Primarily electric customers saved 2,000 kWh gross first year and 1,900 kWh second year, with 2,800 kWh and 2,600 kWh respectively for single family homes. Net savings were much higher -- 1,300 kWh first year and 1,700 kWh for all homes; 2,200 kWh first year and 2,900 kWh for single family homes, but were calculated from a small single-family home sample.

Public utility customers

For HREC customers, gross savings are 3,900 kWh first year and 4,000 kWh second year; single-family homes saved 3,900 kWh both years. Net savings could be calculated only for first-year single-family homes due to data limitations, these savings are 2,300 kWh. For primarily electric single-family homes, first year savings are estimated to be 3,400 kWh.

Difference in Conservation Potential Between Utility Areas

Customer groups from the two utilities showed quite different energy using behaviors over time. HREC customers used much more electricity. In all categories, HREC customers also showed a significantly higher ratio of savings compared to preprogram usage. Savings were also higher for customers in the HREC service area. Both groups of customers showed declining trends

in consumption prior to the Project, however the downward trend begins much earlier for Pacific customers.

Pacific nonparticipants consistently used less energy than participants, even ten years before the Project began. It can be inferred from this that these residents had already taken steps to reduce their energy usage, probably by installation of retrofit measures (Kaplon and Engels 1986). It is doubtful that the Project could have helped many of these homes -- many were already energy efficient.

Pacific nonparticipants did not alter their behavior over the Project time frame. HREC nonparticipants, however, reduced their annual electricity usage by almost 2,600 kWh. This parallels a trend which occurred between 1977 and 1982 among Pacific's customers, with total usage dropping about 3,000 kWh.

Synopsis

These results show that retrofit savings are stable two years following weatherization. In addition, the amount of savings appears to be dependent upon prevailing electricity rates prior to Project implementation. Since the HREC had a historical record of lower rates, higher average consumption for these customers was expected, and found.

Acknowledgements

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Appendix A: Hood River Area Nonparticipants

Because the number of identified eligible customers who did not participate in the Project was so low (n=179) and because this group self-selected rather than being randomly drawn, it is difficult to draw firm conclusions about their behavior, but customers not participating and living in the Pacific service area did not appear to change their behavior as a result of the Project (Table A-1). Their total electricity consumption was a bit less than the average for Pacific participants during the preretrofit year, and remained at that level following the Project.

Table A-1. Differences between utility areas -- Nonparticipants

	Pacific	HREC	Statistical Significance Level
1986/87 electricity use	15,700	18,600	0.03
1985/86 electricity use	15,700	18,700	0.02
1982/83 electricity use	15,800	21,200	0.01
1982/83 - 1986/87 savings	100	2,600	0.02
Savings as % of 1982/83 usage	<5.5>	7.3	0.02
Number of households	72	57	

Among the HREC customers that did not participate in the Project, in contrast to Pacific customers, consumption did change over the course of the Project. Initial total consumption was about 21,000 kWh, 3,000 kWh less than the HREC participant average. Postretrofit consumption was almost 19,000 kWh -- very close to participant preretrofit average consumption. These households saved almost 2,600 kWh.

HREC nonparticipants also showed a significantly higher proportion of savings over preprogram usage; in fact, while Pacific noparticipants did decrease usage slightly overall, the majority actually increased usage, as shown by a negative ratio of savings over preprogram usage.

This decrease in usage is very similar to that observed for Pacific's customers a few years prior to the Project (Schoch et al. 1986). Pacific's Hood River customers used relatively stable amounts of electricity between

1973 and 1976, with only a slight decline from year to year.[9] In 1977, however, usage began to steadily decline, resulting in an estimated annual reduction of 3,000 kWh by 1982 (see Figures A-1 and A-2).

This decline is correlated with increasing prices for electricity -- the late 1970s were a period of frequent rate hikes by Pacific (Schoch et al. 1986). HREC, however, did not raise their rates as frequently during this period (see Appendix B). Perhaps as a result, these customers started their downward trend later than Pacific customers. In 1986/87, HREC customers in single-family homes used about the same amount of electricity as Pacific single-family home participants used in 1980/81.

The overall average 900 kWh reduction found in Pacific's comparison communities is a more drastic change than that of Pacific area Project non-participants, who decreased their annual usage by only 100 kwh. This compares to a decrease of 1,700 kWh in the public utility comparison group and a 2,600 kWh decrease by HREC nonparticipants. However, these nonparticipants are not representative of the region as they consist mainly of higher income families with higher levels of education, and who elected not to participate in the Project.

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[9] Data prior to 1979 are not available for HREC customers.

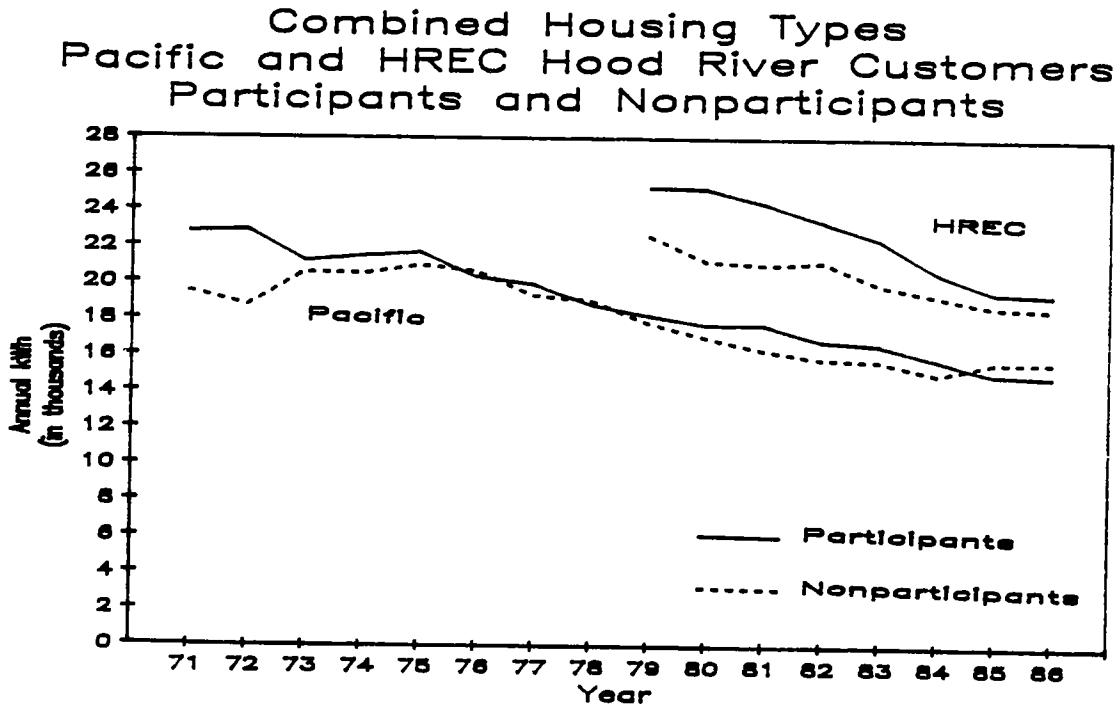

Figure A-1. Annual normalized consumption for participants and nonparticipant Pacific and HREC customers -- Combined housing types.

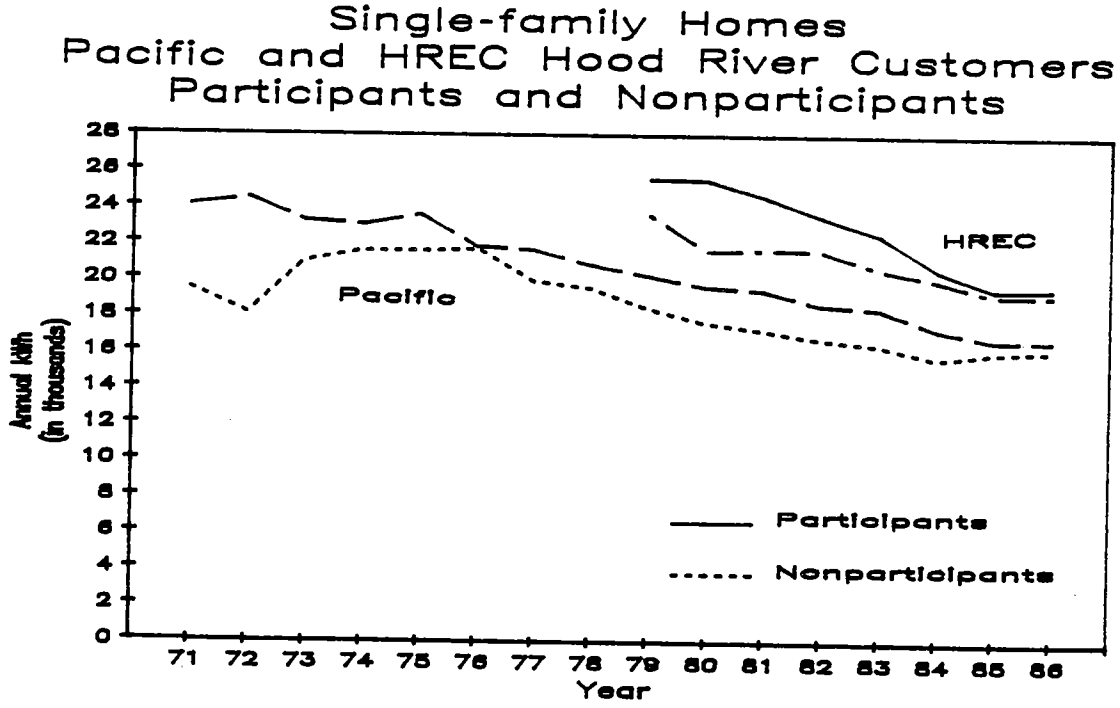

Figure A-2. Annual normalized consumption for participants and nonparticipant Pacific and HREC customers -- Single-family dwellings.

Appendix B: Utility Rate Schedules

Table B-1 shows the marginal prices charged by Pacific and the HREC as of January 1 for each year, normalized by the Consumer Price Index for Portland and Seattle. HREC's monthly customer charge increased sharply during this period, from $3.10 in 1980, to $4.16 in 1981, to $5.10 in 1982, $7.30 in 1983, and $8.00 afterwards (cf: Hirst et al (1987):24). Pacific's monthly charge remained constant at $3.00 during this period. Pacific's prices apply to the comparison communities of Pendleton and Grants Pass as well as Hood River, average prices were not available for the regional sample of private utility customers.

Table B-1. Electricity prices from 1980

	HREC	Pacific
Electricity prices (1982-¢/kWh)		
1980	1.8	3.3
1981	2.2	3.9
1982	2.5	4.7
1983	2.4	4.8
1984	2.3	4.8
1985	2.2	4.7
1986	2.2	4.7

Appendix C: Effect of Base Year on Estimated Savings

Savings calculations were significantly higher for single-family homes when calculated using the average of 1980/81, 1981/82, and 1982/83 base year consumption rather than 1982/83 consumption. Other types of dwellings did not show a significant difference, either in savings or base year, between the two methods.

Interestingly, only the group of single-family homes served by Pacific showed a significant difference between the actual base year and the average base year (Table C-1). The difference was not significant for the HREC homes, but these homes also had a very high standard deviation around the mean (see Appendix E).

When only the Goodfit homes were compared, no significant differences were found either for savings or between the base years used (Table C-2). There were, however, only a small number of cases in this comparison (n=307), ten percent of all participants.

Table C-1. Weather normalized savings estimated using average and actual base years, and probabilities of significant difference -- Somefit

	Base Year			
	3-year Average	1982/83 Actual	Difference	Statistical Significance Level
All single-family	21,500	20,700	800	0.04
Pacific Single-family	19,400	18,600	800	0.05
HREC Single-family	24,400	23,500	900	NS[a]
Pacific Multifamily	10,900	10,900	0	NS
Pacific Mobile Homes	18,100	17,500	600	NS
HREC Mobile Homes	23,100	21,900	1,200	NS

	Savings			
	3-year Average	1982/83 Actual	Difference	Statistical Significance Level
All single-family	3,600	2,800	800	0.01
Pacific Single-family	2,600	1,900	700	0.02
HREC Single-family	5,000	3,900	1,100	0.01
Pacific Multifamily	1,600	1,700	<100>	NS
Pacific Mobile Homes	2,400	1,700	700	NS
HREC Mobile Homes	5,000	3,900	1,100	NS

[a] NS = Not significant at alpha = 0.05.

Table C-2. Weather normalized savings estimated using average and actual base years, and probabilities of significant difference -- Goodfit

	Base Year			
	3-year Average	1982/83 Actual	Difference	Statistical Significance Level
All single-family	25,500	25,200	300	NS[a]
Pacific Single-family	22,200	21,800	400	NS
HREC Single-family	29,400	29,000	400	NS
Pacific Multifamily	9,600	9,400	200	NS
Pacific Mobile Homes	18,300	18,100	200	NS
HREC Mobile Homes	23,900	23,900	0	NS

	Savings			
	3-year Average	1982/83 Actual	Difference	Statistical Significance Level
All single-family	3,900	3,500	400	NS
Pacific Single-family	3,000	2,600	400	NS
HREC Single-family	4,900	4,400	500	NS
Pacific Multifamily	1,500	1,200	300	NS
Pacific Mobile Homes	800	400	400	NS
HREC Mobile Homes	1,300	1,700	<400>	NS

[a] NS = Not significant at alpha = 0.05.

Appendix D: Mean NAC Estimates of Subgroups

The tables on the following pages show the breakdown of various participant subcategories and their respective normalized annual consumption (NAC) estimates. Participants are subdivided by type of dwelling, by participation in an earlier weatherization project, and by utility district. Numbers in parentheses are those obtained from the first year savings analysis.

For standard deviations and the number of observations in each group, please see Appendix E.

	1986/87 NAC	1985/86 NAC	1982/83 NAC	dNAC 1982/83-1986/87
All Participants	16,707	16,800	19,416	2,709
Single-family Primarily electric Participants	21,752	21,343	25,241	3,489
Multifamily Primarily electric Participants	8,201	8,295	9,376	1,175
Mobile Home Primarily electric Participants	19,907	19,299	20,970	1,064
All Single-Family Participants	17,959	17,956	20,740	2,781
All Nonparticipants	16,979	17,022	18,181	1,202

	1986/87 NAC	1985/86 NAC	1982/83 NAC	dNAC 1982/83-1986/87
Pacific Power Customers				
All Participants	14,930	15,040	16,812	1,882
Single-family				
Primarily electric	19,146	19,042	21,794	2,648
Primarily electric, no previous programs	20,044	20,060	23,150	3,106
Primarily electric, previous participant	18,211	17,983	20,382	2,171
Multifamily				
Primarily electric	8,201	8,295	9,376	1,175
Primarily electric, no previous programs	7,586	7,760	8,649	1,063
Primarily electric, previous participant	8,929	8,930	10,238	1,309
Mobile Home				
Primarily electric	17,639	17,221	18,075	435
Primarily electric, no previous programs	17,610	17,348	18,157	547
Primarily electric, previous participant	17,736	16,802	17,802	66
All Non-participants	15,659	15,730	15,776	117

	1986/87 NAC	1985/86 NAC	1982/83 NAC	dNAC 1982/83-1986/87
Hood River Electric Cooperative Customers				
All Participants	19,419	19,487	23,391	3,972
Single-family				
Primarily electric	24,607	23,864	29,018	4,411
Primarily electric, no previous programs	25,454	24,733	30,114	4,661
Primarily electric, previous participant	18,260	17,342	20,797	2.537
Mobile Home				
Primarily electric	22,216	21,415	23,919	1,703
Primarily electric, no previous programs	22,335	21,532	24,064	1,729
All Non-participants	18,647	18,653	21,220	2,573

Appendix E: Means, Standard Deviations, and Number of Observations

The following table contains the mean, standard deviation, and number of observations for Hood River participants and nonparticipants. This data is shown in aggregate and for several subsets -- separated by utility, by participation in previous weatherization program, by primary use of electric heat, and by dwelling type.

Group	Variable	Mean	Standard Deviation	n
Combined utilities				
All participants (mixed fuel uses)	1986/87 NAC	16,707	8,352	2,120
	1985/86 NAC	16,800	8,136	2,120
	1982/83 NAC	19,416	9,443	2,120
	1982/83-86/87 NAC	2,709	5,740	2,120
Single-family (primarily electric)	1986/87 NAC	21,752	8,457	285
	1985/86 NAC	21,343	8,244	285
	1982/83 NAC	25,241	9,639	285
	1982/83-86/87 NAC	3,489	5,226	285
Multifamily (primarily electric) (all are Pacific)	1986/87 NAC	8,201	4,018	59
	1985/86 NAC	8,295	4,414	59
	1982/83 NAC	9,376	4,749	59
	1982/83-86/87 NAC	1,175	2,156	59
Mobile home (primarily electric)	1986/87 NAC	19,907	7,787	111
	1985/86 NAC	19,299	7,090	111
	1982/83 NAC	20,970	7,691	111
	1982/83-86/87 NAC	1,064	3,288	111
All single-family (mixed fuel uses)	1986/87 NAC	17,959	8,174	1,431
	1985/86 NAC	17,956	7,957	1,431
	1982/83 NAC	20,740	9,224	1,431
	1982/83-86/87 NAC	2,781	5,943	1,431
All nonparticipants (mixed fuel uses)	1986/87 NAC	16,979	7,466	129
	1985/86 NAC	17,022	6,999	129
	1982/83 NAC	18,181	8,777	129
	1982/83-86/87 NAC	1,202	5,153	129

Group	Variable	Mean	Standard Deviation	n
Pacific customers				
All participants	1986/87 NAC	14,930	6,815	1,281
(mixed fuel uses)	1985/86 NAC	15,040	6,733	1,281
	1982/83 NAC	16,812	7,437	1,281
	1982/83-86/87 NAC	1,882	4,831	1,281
Single-family	1986/87 NAC	19,146	6,218	149
(primarily electric)	1985/86 NAC	19,042	6,404	149
	1982/83 NAC	21,794	7,299	149
	1982/83-86/87 NAC	2,648	4,370	149
Single-family	1986/87 NAC	20,044	6,316	76
(primarily electric)	1985/86 NAC	20,060	6,635	76
(no prev. programs)	1982/83 NAC	23,150	7,571	76
	1982/83-86/87 NAC	3,106	5,478	76
Single-family	1986/87 NAC	18,211	6,015	73
(primarily electric)	1985/86 NAC	17,983	6,018	73
(prev. participants)	1982/83 NAC	20,382	6,770	73
	1982/83-86/87 NAC	2,171	2,747	73
Multifamily	1986/87 NAC	8,201	4,018	59
(primarily electric)	1985/86 NAC	8,295	4,414	59
	1982/83 NAC	9,376	4,749	59
	1982/83-86/87 NAC	1,175	2,156	59
Multifamily	1986/87 NAC	7,586	3,788	32
(primarily electric)	1985/86 NAC	7,760	4,130	32
(no prev. programs)	1982/83 NAC	8,649	5,145	32
	1982/83-86/87 NAC	1,063	2,300	32
Multifamily	1986/87 NAC	8,929	4,230	27
(primarily electric)	1985/86 NAC	8,930	4,728	27
(prev. participants)	1982/83 NAC	10,382	4,163	27
	1982/83-86/87 NAC	1,309	2,007	27

Group	Variable	Mean	Standard Deviation	n
Mobile homes (primarily electric)	1986/87 NAC	17,639	4,686	56
	1985/86 NAC	17,221	4,568	56
	1982/83 NAC	18,075	4,817	56
	1982/83-86/87 NAC	435	2,897	56
Mobile homes (primarily electric) (no prev. programs)	1986/87 NAC	17,610	4,868	43
	1985/86 NAC	17,348	4,765	43
	1982/83 NAC	18,157	5,130	43
	1982/83-86/87 NAC	547	2,888	43
Mobile homes (primarily electric) (prev. participants)	1986/87 NAC	17,736	4,207	13
	1985/86 NAC	16,802	3,993	13
	1982/83 NAC	17,802	3,761	13
	1982/83-86/87 dNAC	66	3,012	13
All nonparticipants (mixed fuel uses)	1986/87 NAC	15,659	7,424	72
	1985/86 NAC	15,730	6,736	72
	1982/83 NAC	15,776	8,099	72
	1982/83-86/87 NAC	117	3,524	72
HREC customers				
All participants (mixed fuel uses)	1986/87 NAC	19,419	9,656	839
	1985/86 NAC	19,487	9,282	839
	1982/83 NAC	23,391	10,716	839
	1982/83-86/87 NAC	3,972	6,710	839
Single-family (primarily electric)	1986/87 NAC	24,607	9,610	136
	1985/86 NAC	23,864	9,261	136
	1982/83 NAC	29,018	10,468	136
	1982/83-86/87 NAC	4,411	5,906	136
Single-family (primarily electric) (no prev. programs)	1986/87 NAC	25,454	9,747	120
	1985/86 NAC	24,733	9,340	120
	1982/83 NAC	30,114	10,440	120
	1982/83-86/87 NAC	4,661	6,177	120

Group	Variable	Mean	Standard Deviation	n
Single-family	1986/87 NAC	18,260	5,367	16
(primarily electric)	1985/86 NAC	17,342	5,336	16
(prev. participants)	1982/83 NAC	20,797	6,321	16
	1982/83-86/87 dNAC	2,537	2,646	16
Mobile homes	1986/87 NAC	22,216	9,508	55
(primarily electric)	1985/86 NAC	21,415	8,492	55
	1982/83 NAC	23,919	8,905	55
	1982/83-86/87 NAC	1,703	3,558	55
Mobile homes	1986/87 NAC	22,335	9,555	54
(primarily electric)	1985/86 NAC	21,532	8,527	54
(no prev. programs)	1982/83 NAC	24,064	8,922	54
	1982/83-86/87 NAC	1,729	3,586	54
All nonparticipants	1986/87 NAC	18,647	7,241	57
(mixed fuel uses)	1985/86 NAC	18,653	7,043	57
	1982/83 NAC	21,220	8,722	57
	1982/83-86/87 NAC	2,573	6,443	57

Appendix F: KiloWatt-hour Data on Comparison Groups

Table F-1 shows the comparison group data which was used to calculate net Project savings.

Table F-1. KiloWatt-hour data

Sample	1982/83	1983/84	1984/85	1985/86	1986/87	n
Bonneville area (80% public, single-family, somefit)	24,000	23,400	22,300	[22,300][a]	NA	280
Bonneville area (80% public, single-family, goodfit)	26,200	25,700	24,500	[24,500][a]	NA	114
Bonneville area (100% public, single-family, somefit)	NA	NA	22,100	22,100	NA	1,192
Private comparison (mixed housing, somefit)	14,500	14,000	13,900	13,700	13,500	1,936
Private comparison (mixed housing, goodfit)	18,300	18,200	17,800	17,700	18,100	225
Private comparison (single-family, somefit)	15,100	14,500	14,400	14,100	13,900	519
Private comparison (single-family, goodfit)	20,800	21,000	20,700	20,200	21,100	47

[a] Estimated.