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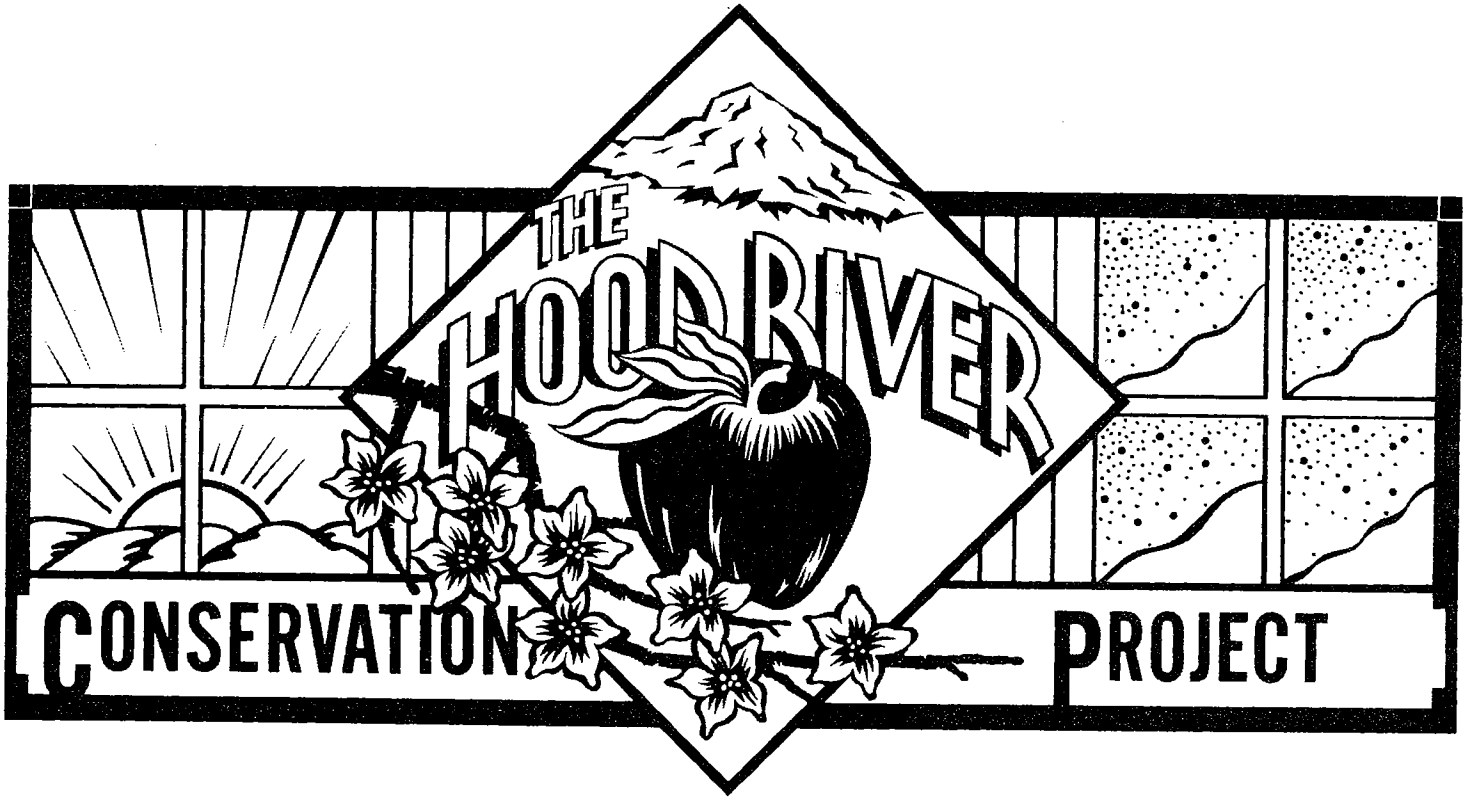
Residential Retrofit Measures: Recommendations, Installations and Barriers

Final Report

U.S. Department of Energy
Bonneville Power Administration

June 1986



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RESIDENTIAL RETROFIT MEASURES: RECOMMENDATIONS, INSTALLATIONS AND BARRIERS

Final Report

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Contents

List of Acronyms

AAHX	air-to-air heat exchanger
Bonneville	Bonneville Power Administration
Council	Northwest Power Planning Council
HRCP	Hood River Conservation Project
HREC	Hood River Electric Cooperative
NCE	not cost-effective
NRDC	Natural Resources Defense Council
NWPPA	Northwest Public Power Association
ORNL	Oak Ridge National Laboratory
PNUCC	Pacific Northwest Utilities Conference Committee
Pacific	Pacific Power & Light Company
RWP	Residential Weatherization Program

Executive Summary

The Hood River Conservation Project (HRCP) is a major residential retrofit demonstration project. HRCP is funded by the Bonneville Power Administration and run by Pacific Power & Light in cooperation with the Hood River Electric Cooperative. The Project was conducted in the community of Hood River, Oregon, will cost $21 million, and last for three years (mid-1983 through 1986). Installation of applicable retrofit measures was completed by the end of 1985; data collection and analysis will continue through 1986. The project sought to install as many cost-effective retrofit measures in as many electrically-heated homes in Hood River as possible. HRCP planning, implementation, and analysis are guided by a Research Advisory Group, whose members represent the major organizations involved with HRCP.

HRCP offered a package of "super" retrofit measures. The Project paid for installation of these measures up to a cost-effectiveness limit of $1.15/first year estimated kWh saved, roughly four times the limit in other residential retrofit programs. Thus, HRCP will identify levels of installation when cost to the household and prior retrofit activities are largely eliminated as barriers. This will help define the maximum reasonable market penetration of residential retrofit as an energy resource in the Pacific Northwest.

This report documents the extent to which measures included in the Project were recommended and installed in participant homes. The report also examines the reasons for noninstallation of measures, the barriers between potential and practice. These analyses are based on data from the 3,249 homes that had some contact with HRCP (of which 3,189 received home energy audits). This represents more than 90% of the eligible electrically-heated homes in Hood River.

The major findings from this study are:

1. Conservation potential can be defined in several ways. For example, the potential could hypothetically assume that every retrofit measure can be installed in every home. Alternatively, the potential could include only those measures recommended during an energy audit as compatible with the structure and its heating system, physically feasible, and cost-effective.

Consider the first definition of potential. Averaged over all the measures and homes in this analysis, 46% of the 15 measures theoretically available in the HRCP package were installed by HRCP, 45% of the measures were neither recommended nor installed, and 9% were recommended but not installed (see Figure S-1).

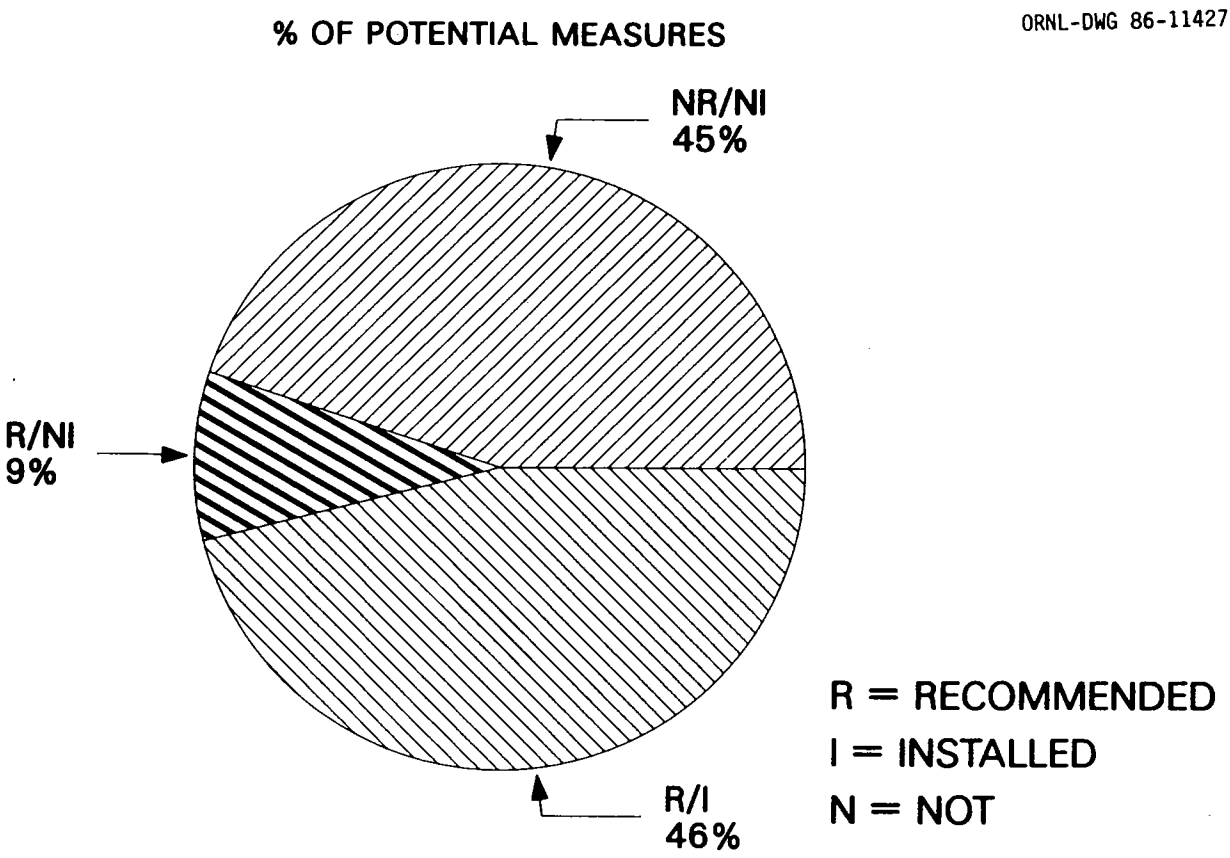

Figure S-1. Distribution of HRCP measures (15 measures times 3,249 homes), by recommendation and installation.

The second definition paints a different picture. Eighty-three percent of the measures recommended in the energy audits were installed by HRCP. These installed measures yielded an estimated saving of 6,140 kWh/year (93% of the estimated saving for all the recommended measures). Although 17% of the recommended measures were not installed, only 7% of the estimated electricity savings were not realized.

2. Only 8% of the homes had no major measures installed by the Project, which explains some of the difference in potential realized, noted

above. The barrier identified most frequently (in 56% of these 261 homes) was lack of cost-effectiveness. This suggests that these homes had installed applicable retrofit measures prior to HRCP, either on their own or through participation in earlier conservation programs. For example, 25% of these homes had participated in prior utility retrofit programs; only 8% of the other HRCP participants had participated in these programs.

3. The cost-effectiveness limit for HRCP installation of retrofit measures was $1.15/first-year estimated kWh saving. However, the total HRCP cost, averaged across the completed homes that had at least one major retrofit measure installed, was only 69¢/kWh, which suggests that most of the savings were achieved at much less than the maximum allowable cost.

4. The average cost of HRCP-installed retrofit measures was $3,760, of which HRCP paid 99%. Only 10% of the households paid anything for HRCP-installed measures; their average payment was $430.

5. Single-family homes accounted for 60% of the HRCP participants. Because these dwelling units are substantially larger than multi-family units and mobile homes, their estimated energy savings and retrofit costs were much higher. The estimated savings per unit floor area were much higher for single- and multi-family units than for mobile homes; apparently, only limited opportunities exist to retrofit mobile homes.

6. HRCP retrofit costs and estimated savings increased with house age. For example, the savings and retrofit costs were roughly three times higher for homes constructed before 1945 than for homes built during the 1980s. Improvements in construction practices, stimulated by higher fuel prices and by new construction standards, reduced the potential for retrofits in newer homes.

7. There was substantial variation across measures in the frequency of recommendation and installation. Ceiling insulation, storm windows, caulking, door weatherstripping, and outlet gaskets were installed in more than two-thirds of the homes. On the other hand, duct insulation and thermal doors were installed in less than 15% of the homes.

8. The four insulation measures (ceiling, wall, floor, heating ducts) accounted for 57% of the total estimated savings and 48% of the total

retrofit cost. Thus, these measures dominated energy savings and were relatively cost-effective. The three window and door measures, however, were relatively expensive, accounting for only 27% of the estimated savings but 47% of the cost. The eight infiltration reduction, water heating, and clock thermostat measures were both inexpensive and small energy savers.

9. The reasons that HRCP measures were not installed were grouped into a few categories (see Figure S-2). Almost half (45%) of the barriers that prevented installation arose because the measure was already partially or fully in place, which rendered further installation cost-ineffective. Physical barriers accounted for 31% of the noninstallations, noncompatible conditions for 19%, customer concerns for 4%, and other barriers for the remaining 2%.

10. The vast majority (81%) of the barriers were identified during the energy audit. Small fractions were uncovered later, during the contractor bid, installation, or inspection phases of the Project. Thus, the energy auditors did a careful job of identifying barriers to installation of retrofit measures.

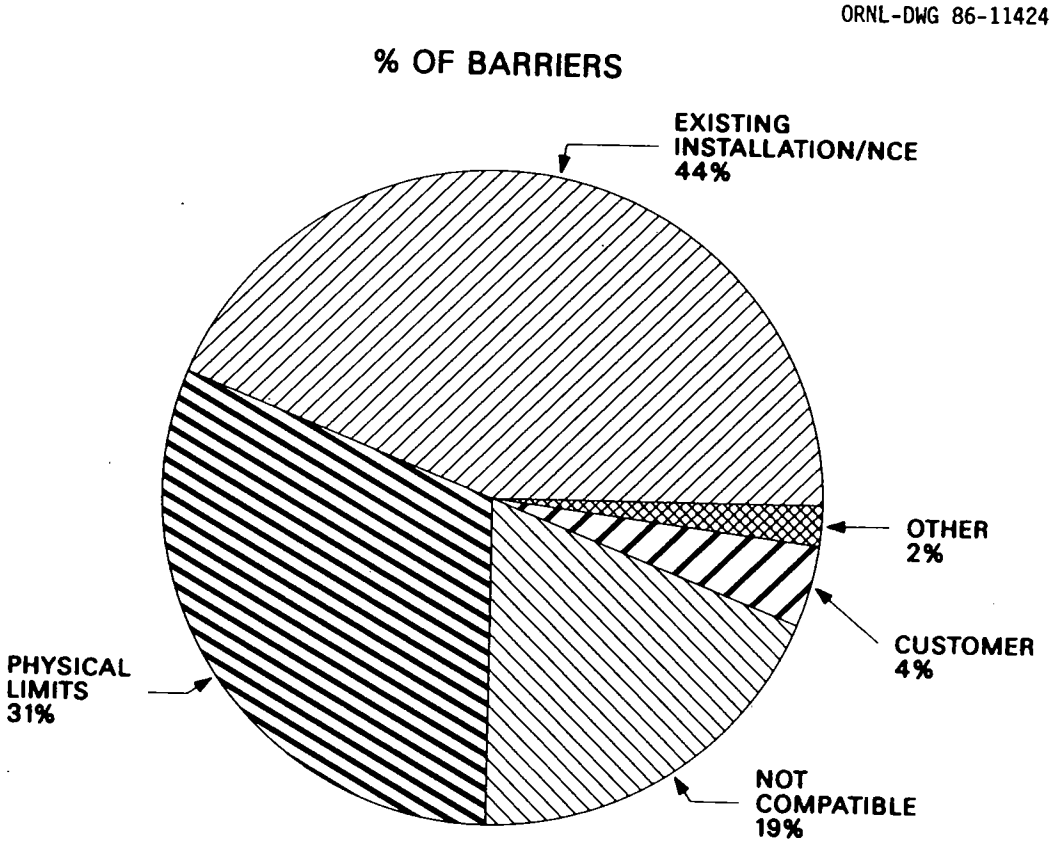

Figure S-2. Distribution of barriers for HRCP measures not installed, by type of barrier. (NCE is not cost effective.)

Chapter 1: Introduction

The ultimate success of a conservation program depends on the fraction of eligible customers who participate in the program, the fraction of recommended conservation actions adopted by these participants, and the actual energy savings achieved by the adopted measures and practices. Because program effectiveness is a multiplicative (rather than additive) function of these three factors, the actual performance of government and utility conservation programs is generally very much less than their potential.

A successful program, for example, might reach 50% of its potential market and induce these participants to adopt 50% of the recommended actions. If these actions yield energy savings that average 75% of the engineering predictions, then the overall program savings are only 19% (0.50 x 0.50 x 0.75) of its estimated potential.

In practice, many eligible customers choose not to participate in a particular program: they may not know about the program, they may lack funds to pay for the recommended actions, they may believe that their building is already energy-efficient, they may plan to move soon, they may not own their home, or they may be too busy to take time for conservation actions.

Several reasons cause customers who participate in a program not to adopt recommended actions: the building may already contain some of the measures offered by the program, some measures may not be applicable to the particular home, the cost of some measures may be too high, the customer may believe that estimated savings will not be achieved, or the customer may not like the measures.

The actual energy savings realized after adoption of recommended actions might be less than anticipated for several reasons: poor quality of measures, poor workmanship during installation, interactions among various conservation measures, and operational changes that offset some of the energy savings (e.g., reduced use of wood for space heating or increased indoor temperatures in winter after retrofit).

The Hood River Conservation Project (HRCP) affords a unique opportunity to examine the differences between potential and practice for each of these three factors. HRCP is an experimental residential retrofit project, operated by Pacific Power & Light Company (Pacific) and funded by the Bonneville

Power Administration (Bonneville). The project sought to install as many cost-effective retrofits as possible in all electrically heated homes in the community of Hood River, Oregon.

The program offered a comprehensive package of 15 retrofit measures at very high levels of installation [e.g., R-49 ceiling insulation rather than the R-38 that is recommended in Bonneville's Residential Weatherization Program (RWP)]. HRCP paid for installation of these measures up to a cost-effectiveness limit ($1.15/first-year estimated kWh saving; Pacific 1982) that is almost four times the limit in Bonneville's RWP. The free installation and high level of retrofit measures provide the opportunity to examine levels of implementation when cost to the household and existing levels of conservation measures are largely removed as obstacles. Thus, HRCP will help determine the maximum reasonable market penetration of residential weatherization as an energy conservation resource in the Pacific Northwest.

The purpose of this report is to document the extent to which measures included in the Project were recommended and installed in participant homes. In addition, we examine the reasons for noninstallation of measures, the barriers between potential and practice. As far as we know, HRCP is the first project to collect data on the reasons that measures were not recommended and not installed.

It is important to recognize that many definitions of "potential" and "barrier" are possible. The most inclusive definition of potential refers to installation of the maximum amount of every measure in every house. This unrealistic definition assumes that existing homes presently have no energy-conserving devices in them. Barriers then explain why the measures actually installed fall short of this ultimate (and unrealistic) potential.

An alternative definition of potential includes only those measures that can be installed, where "can" means physically possible. This definition excludes cases where the measure is already fully installed and cases where installation is not feasible (e.g., attic insulation in a cathedral ceiling, heating duct insulation in a house with room electric space heaters). In this definition, barriers explain why these feasible (in an engineering sense) measures are not installed.

The potential could also be defined in terms of measures whose installation is both technically feasible and economical. This definition would reduce the potential further by excluding from consideration those measures

whose high installation cost and/or low expected energy savings make them not cost-effective (NCE).

In addition to the physical and economic barriers discussed above, other reasons cause measures not to be installed. A third major class of barriers relates to the household and includes aesthetics, inconvenience, perceived ineffectiveness of measures, and other customer concerns that prevent installation of recommended measures.

Finally, the potential could be defined in terms of a target level of energy efficiency. For example, a goal of X kWh/ft^2-HDD could be set for each home.

These comments suggest that the definition of "potential" is not simple. One can examine differences between potential and actual installations in many ways, depending on the definition chosen and perspective adopted. The HRCP data permit analysis from various viewpoints.

The following chapter briefly describes HRCP and the data available for evaluation purposes, with particular attention to the data used in this portion of the HRCP evaluation. Chapters 3 and 4 present results on the recommended and installed retrofit measures, and on related energy savings and retrofit costs. Chapter 3 discusses aggregate savings identified during the energy audits and reflected in the measures actually installed by the Project. Chapter 4 examines recommendations,installations, and the reasons for noninstallation on a measure-by-measure basis. The final chapter discusses results.

ORNL's responsibility for evaluation of HRCP includes answering several questions:

- What are the actual electricity savings (kWh) that can be attributed to the HRCP-installed measures and to HRCP itself?

- What are the actual electricity savings for individual measures? How do actual and estimated (audit) savings compare?

- To what extent do eligible households participate in the Project?

- To what extent are individual measures recommended and/or installed by the Project (penetration of measures)?

- What are the physical, behavioral, and economic barriers to implementation of these retrofit measures?

- What are the capacity (kW) effects due to implementation of the Project?

We plan to publish five reports this year, of which this is the first. A report examining program participation (the first of the three factors discussed on page 6) will be completed in mid-1986. Reports on actual electricity savings and on load reductions (kWh and kW effects, respectively; the third factor) will be published in Fall 1986. Finally, we will prepare a comprehensive report summarizing all ORNL and other HRCP research projects (Oliver et al. 1986).

Chapter 2: The Hood River Conservation Project and Related Data

The Project

HRCP is a major demonstration program designed to determine and document the extent to which "conservation energy resources" can be obtained from retrofits of existing homes. HRCP is intended to define the maximum limits of a utility-operated residential retrofit program, one in which cost to the household is not a barrier and in which the number and level of retrofit measures installed are beyond that usually included in such programs (Pacific 1983).

The three-year study is an outgrowth of the Pacific Northwest Electric Power Planning and Conservation Act (U.S. Congress 1980). This legislation established the Northwest Power Planning Council (Council) to develop a 20-year plan for the Pacific Northwest region's electricity demand and supply. Conservation was established, within the Act, as a cornerstone of this plan. In particular, conservation resources were given a 10% "bonus" in assessing the relative benefits and costs of conservation resources, traditional supply resources, and unconventional supply resources. Unfortunately, much of the information needed to define the appropriate types and levels of conservation programs within the region were not available. HRCP was designed, in part, to fill this information gap.

The project has other historical roots as well as the 1980 law. In particular, the Natural Resources Defense Council (NRDC) had debated with the region's utilities (including Bonneville) the relative advantages and disadvantages of aggressive utility conservation programs. NRDC saw such programs as viable and attractive alternatives to construction of conventional coal and nuclear power plants. The utilities, on the other hand, were unsure about the costs of purchasing conservation resources and the amount of these resources they could obtain. That is, the utilities felt that studies showing the enormous technical potential for improved energy efficiency failed to consider the difficulties and costs associated with realizing that potential. HRCP was intended to find out how much conservation could be purchased, at what cost, and how quickly.

Several residential retrofit programs have operated in the Pacific Northwest during the past few years. Although evaluations of these programs provide useful information (Burnett 1982; Hannigan and King 1982; Hirst et

al. 1985; McCutcheon 1983; and Weiss 1982), they offer little insight on the maximum limits of such programs.

HRCP is funded by Bonneville and implemented by Pacific in cooperation with the Hood River Electric Cooperative (HREC). Several advisory groups helped design the project and continued to provide guidance as the Project was implemented. These groups include representatives from the local community, NRDC, the Council, the region's electric utilities (represented by the Pacific Northwest Utilities Conference Committee and the Northwest Public Power Association), Bonneville, Pacific, HREC, and others.

HRCP included a comprehensive set of measures (see Table 1) to test the reasonable limits of a residential retrofit program. The cost-effectiveness limit for HRCP is based on an assumed 35-year life for the measures and the marginal cost of a new coal-fired power plant (see Table 2 of Hirst and Goeltz 1985). Although the method of calculating the retrofit measure cost-effectiveness limit was different from that used by the Council (1983), the result is essentially the same ($1.15/kWh vs $1.12/kWh in the regional plan).

The town and county of Hood River, Oregon (plus the town of Mosier in Wasco County) were selected as the location for this experiment because the area is geographically delimited; it includes a diversified economy, population, and housing stock; the area is served by both public (HREC) and private (Pacific) utilities; and it encompasses climate zones representative of the Pacific Northwest. Hood River County has a population of about 15,000. Roughly two-thirds of the 6,200 residences are served by Pacific and the remainder by HREC. Hood River lies along the northern edge of Oregon almost 50 miles east of Portland and is bounded on the north by the Columbia River (see Figure 1). Additional information on Hood River and the reasons for its selection are in Appendix A of Pacific (1983) and French et al. (1985).

The contract between Bonneville and Pacific to initiate this $21 million demonstration was signed in May 1983. Energy audits were started in Fall 1983, and installation of retrofit measures began in January 1984 (see Figure 2). All households in the area were eligible for energy audits. However, the project pays for retrofit measures only in homes with permanently installed (before March 1983) electric space heating equipment. This eligibility requirement is based on the notion that the program is intended to purchase "conservation electricity resources." Between October 1983 and December 1985 (when the field work was completed), 3,249 eligible households

Table 1. **HRCP conservation measures.**

Measure	Target level
Home energy audit	All electrically heated homes[a]
Ceiling insulation and appropriate ventilation	R-49
Floor insulation[b]	R-38
Wall insulation	R-11 to R-19
Cold and hot water pipe insulation to water heater[c]	R-3
Dehumidifiers and air-to-air heat exchangers[d]	As required
Clock thermostats	Where applicable
Duct insulation	Crawl space R-11, attic R-30, where applicable
Storm windows and thermal replacement sash and glazing	Triple-glazing
Thermal doors and double-glazed sliding doors	Where applicable
Caulking and weatherstripping	Where applicable
Outlet and switchplate gaskets[c]	Where applicable
Heat pump conversion of existing furnace system[d]	Where appropriate conventional measures cannot be installed
Electric water heater wraps[c]	R-11
Low-flow showerheads and other hot water flow regulators[c]	As required

[a]Audits were provided to homes heated with nonelectric fuels, primarily to maintain good relations with the community.
[b]Includes insulation of hot and cold water pipes, if under the floor.
[c]These four low-cost measures are installed by the auditor, at the time of the energy audit or soon thereafter.
[d]These measures are installed only in special circumstances.

Source: Peach et al. (1984).

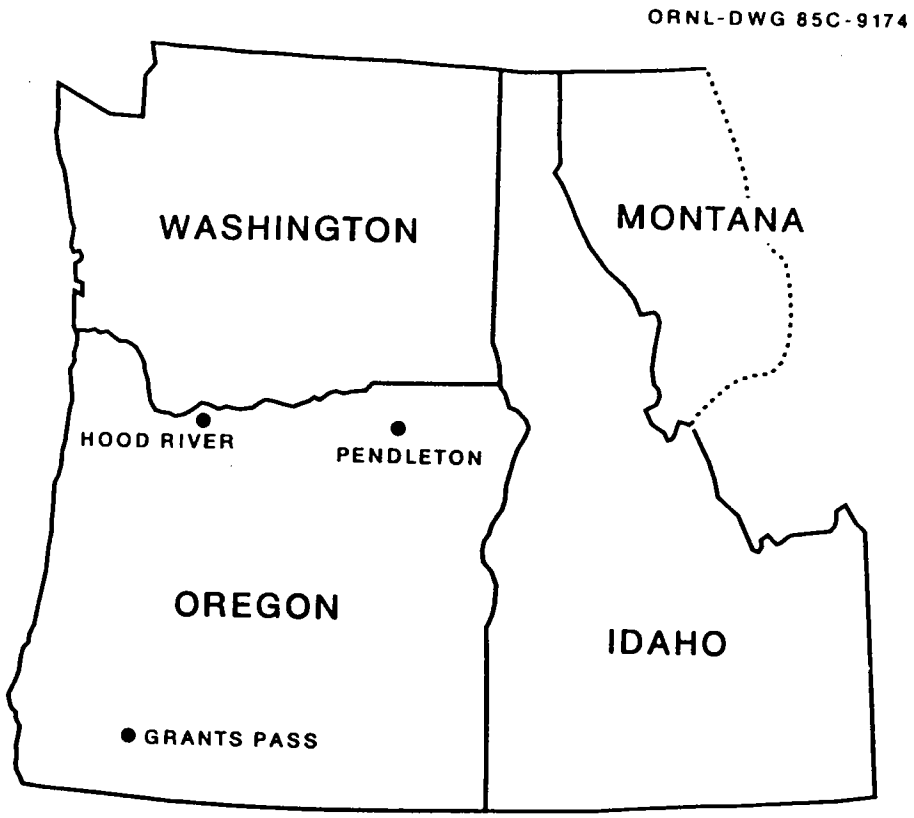

Figure 1. Map of the Pacific Northwest region showing the location of Hood River and the two comparison communities (Pendleton and Grants Pass). Data from the comparison communities will be used in the analysis of HRCP-induced electricity savings.

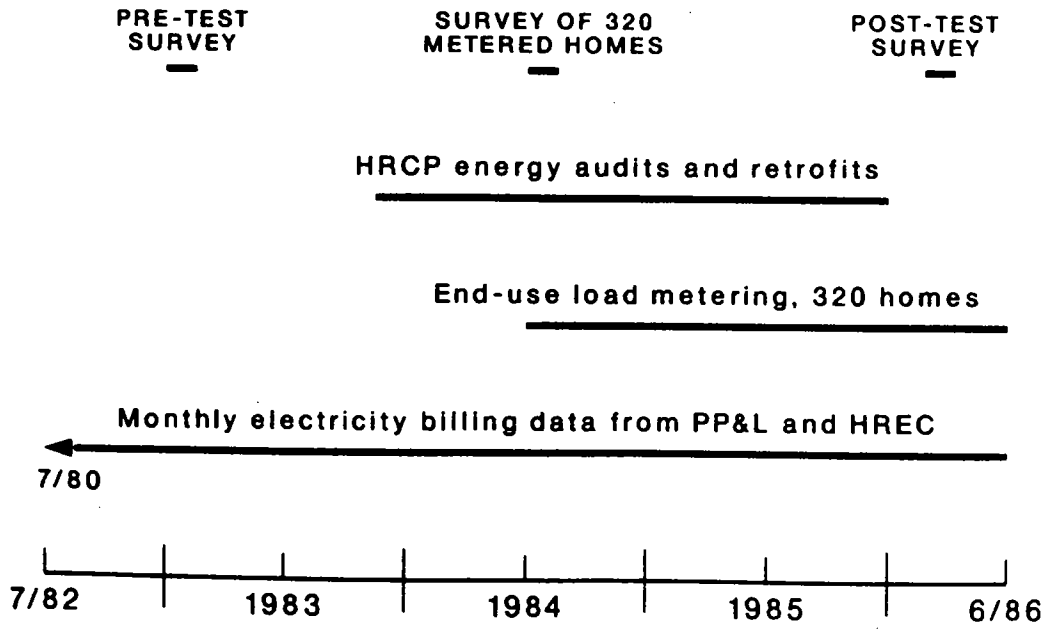

Figure 2. Timeline of the Hood River Conservation Project.

contacted HRCP, of whom 3,189 received energy audits and 2,988 had major measures installed in their homes (Hirst and Goeltz 1986). [See Philips et al. (1986), French and Peach (1986), and Quinn and Oliver (1985) for discussion of implementation issues.] Roughly 250 additional eligible homes did not participate in HRCP.

HRCP Evaluation Data Base

Because HRCP is a major and complex project, the data associated with the project are extensive and detailed. More important, the project's focus on research required collection of extensive data (see Table 3 in Hirst and Goeltz 1985; Oliver, Peach, and Modera 1984; and Pacific 1982).

HRCP data include pre- and post-program mail surveys conducted among random samples of households in Hood River and the two comparison communities [in early 1983 (Berg and Bodenroeder 1983) and Spring 1986, respectively], monthly electricity bills from 1980 through mid-1986 for all households in the three communities, detailed end-use load and weather data (15-minute intervals) and onsite home interviews for about 300 participant homes, a wood use survey conducted in Spring 1986 among HRCP participants, and a nonparticipant survey conducted in late 1985 among the few eligible households that did not participate.

The field-office data base provides the richest information on participants. These data include household demographics and appliance holdings at the time of the energy audit. The audit analyzed the applicable retrofit measures and their likely energy savings. The auditors installed several low-cost water-heating-conservation and infiltration-reduction measures at the time of the audit (or soon thereafter), and these actions were also recorded.[1]

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[1]The audit procedure did not estimate electricity savings for the four auditor-installed measures. Our estimates of the savings for these measures, based on conversations with staff at Pacific, Bonneville, and other research organizations (Meier 1985 and Biemer, Auberg, and Ek 1985) are: 350 kWh/year for water heater wrap, 350 kWh/year for low-flow showerheads, 400 kWh/year for a set of outlet gaskets, and 30 kWh/year for hot water pipe wrap. Anderson (1986) estimated the energy penalty of the air-to-air heat exchanger at 510 kWh/year for each unit.

HRCP #104
Rev. 3/84

Customer Name:
Customer Acct. #:

BARRIERS

Measures		Barrier #	Other Barriers
Ceiling Insulation/Attic Vent	1.		
Floor Insulation/Gr. Cover/Pipe Wrap	2.		
Wall Insulation/Kneewalls	3.		
Duct Insulation	4.		
Windows	5.		
Sliding Glass Doors	6.		
Insulated Doors	7.		
Window & Door Frame Caulking	8.		
Weatherstrip Windows/Sliding Doors.	9.		
Weatherstrip Doors.	10.		
Clock Thermostat.	11.		
Air to Air Heat Exchanger	12.		
Water Heater Wrap	13.		
Water Heater Pipe Wrap.	14.		
Low Flow Shower Heads	15.		
Infiltration Gaskets	16.		
Dehumidifier.	17.		
Heat Pump Conversion	18.		

Point of Barrier Occurrence (check one)

- ☐ Prior to EA
- ☐ During EA
- ☐ Between EA and Bid
- ☐ While Contractor Bidding Job
- ☐ After Customer Agreement
- ☐ During Installation
- ☐ During Inspection

Refused

☐ Audit _____ Barrier #

or

☐ Weatherization _____ Barrier #

_____ Prepared by

_____ Date

_____ Auditor ID#

BARRIER NUMBERS

Customer Barriers

1 - Degrade Appearance
2 - Make House Too Tight
3 - Refuses Contact with Utility
4 - Non-Electric Space Heat
5 - House Already Weatherized
6 - Measure Already Installed
7 - Customer Will Pay In Long Run
8 - Refuses Handouts
9 - Dislikes Grade of Materials
10 - Violates Privacy
11 - Contractors Not Acceptable
12 - House Vacant
13 - Owner Unavailable
14 - No Reason Given
15 - Interfere With Use Of Area/Appliance
16 - Not Cost Effective

Other Barriers

99 - Other (provide detail)

Reason For Supplemental Payment

40 - Exceeds Product or Installation Standards
41 - Exceeds Cost Effective Limit
42 - Exceeds Program Level
43 - Exception for Monitored Home

Physical Barriers

60 - Limited Physical Access
61 - Unable to Vent
62 - Ceiling will not Support Load
63 - Existing Insulation/Installation
64 - Ground Water Problem
65 - Rodent/Animal Problem
66 - Non Compatible Structure (e.g. Slab)
67 - Existing Dry Rot/Termite
68 - Structural Limitation
69 - Non Compatible With Heating Equipment
70 - Water Heater not Electric
71 - Audit Contract Restriction

Figure 3. HRCP form used to record barriers to recommendation or installation of retrofit measures.

Barriers that prevented recommendation or installation of retrofit measures were identified. A "barriers" form (see Figure 3) was completed at every stage in the project process (during the energy audit, between audit and contractor bid, during contractor bid, during retrofit installation, and during postinstallation inspection) to capture all the reasons for partial installation or noninstallation of measures. The field-office data base, especially the barriers form, provides the raw material for the analyses presented here.

Chapter 3: Summary Statistics on Participant Homes

Homes With No Major Measures Installed

Almost all (92%) of the households that contacted HRCP had at least one major measure installed in their homes by the Project.[2] Only 8% (261 of 3,249) had no major retrofit measures installed. A few of the four low-cost measures installed by the auditors (outlet gaskets, water heater wrap, hot water pipe wrap, and low-flow showerhead) were installed in these homes. On average, 1.9 measures/home were installed in these homes, compared with 7.4 measures in the other 92% of the homes.

The homes with no major measures installed differed substantially from the other homes (see Table 2). The homes with no major measures are characterized by households with higher incomes, more education, and that have lived in their homes for fewer years. In addition, these households are more likely to own their homes, to live in single-family homes that are newer and larger, and to have more electricity-using equipment than the other households. (These differences are generally significant at the 1% level or better.)

Many of the households in homes with no major measures installed had installed retrofit measures earlier, either on their own or with assistance from prior Pacific or HREC conservation programs. For example, 25% of these 261 households had participated in a prior conservation program, compared with 8% of the other households. Thus, participation in a prior program is strongly related to the potential for energy savings in HRCP.[3]

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[2]Major retrofits include the four insulation, three window and door, three infiltration reduction, and clock thermostat measures (measures 1-11, Figure 3).

[3]Participants in previous programs generally had fewer HRCP-installed retrofits than those who did not participate in prior programs. The mean cost of HRCP retrofits was $3,400 for participants in prior programs, compared with $3,900 for the other HRCP participants. Comparison of retrofit costs is obscured by large differences in housing type between those who did and did not participate in prior programs. Almost 95% of the previous participants live in single-family homes, compared with 58% of the remaining HRCP participants. Considering single-family homes only, the mean cost of the HRCP retrofits was $3,500 for prior participants, compared with $5,500 for the other HRCP participants.

Table 2. Comparison of HRCP homes with major measures installed vs those with no major measures installed[a].

	HRCP participants, with or without major measures installed	
	Without measures	With measures
Household income ($)[b]	24,600	21,000
Years in present home[b]	6.4	8.4
Number of household members	2.7	2.7
Education of household head (years)	13.0	12.7
Tenure (% that own home)[b]	78	66
Year house built[b]	1968	1958
House floor area (ft^2)	1,340	1,260
Single-family (% of homes)[b]	75	61
Presence of electric equipment (%)		
Air conditioner(s)	26	20
Clothes washer[b]	88	76
Dishwasher	64	58
Electric clothes dryer[b]	86	74
Food freezer	60	57
Number of households	261[a]	2,988

[a]Data were available for only 201 of these homes; energy audits were not conducted in the other 60 homes.

[b]These differences are statistically significant at the 1% level.

Barriers to installation of all major measures arose for various reasons. Overall, lack of cost-effectiveness (failure to meet the $1.15/kWh criterion) was the most frequent barrier (see Table 3). This single barrier, generally identified by the HRCP office staff after receipt of the contractor bid, accounted for 56% of these 261 homes.[4] In 23% of these cases, the

[4]Lack of cost-effectiveness was cited for almost 90 percent of the 66 homes that had participated in a prior program.

audit could not be conducted because the residents refused to allow the auditor to enter the house, the house was vacant, or the occupants were unavailable. Finally, 21% of these households declined to participate in HRCP after the energy audit was conducted. Thus, residents changed their minds about participation in HRCP some time after their initial contact with the Project in almost half (44%) of these cases.

Table 3. Reasons for noninstallation of any major retrofit measures.

	Percentage of homes with no major measures installed[a]
No energy audit conducted	
Various customer barriers	23
Audit conducted, no major measures installed[b]	
Not cost-effective	56
Other	21

[a]Based on 261 homes.

[b]Most (72%) of these barriers were identified by the HRCP office staff during their calculations of measure cost-effectiveness; 23% were identified between the audit and bid.

Aggregate Potential

The present analysis includes 15 measures (1-11 and 13-16 in Figure 3).[5] The hypothetical potential existed to install 48,735 measures (15 measures in 3,249 homes).[6] Slightly less than half were actually installed

[5]Heat pumps, dehumidifiers, and AAHXs are excluded from this analysis. The first two measures were almost never installed by HRCP. AAHXs are not intended to save energy; they were installed only if indoor air pollutants were a problem (Bonneville 1984). An average of 1.1 AAHX were installed in 801 homes at an average cost of $1,270, and had an estimated energy penalty of 560 kWh/year (which includes the electricity to operate the blower and the electricity required to compensate for the energy content of the exhaust air).

[6]One could define the potential even more expansively to include measures not installed in the roughly 250 eligible homes that had no contact with HRCP.

by the program (see Table 4), and measures were neither recommended nor installed in nearly half the cases. Thus most noninstallations occurred because the measure was not recommended.

Assume for the moment that all measures could be installed in all homes (a maximum definition of potential savings). If the average estimated savings for each measure were equal to the average savings for the homes in which the measure was actually installed, the potential savings would be 12,500 kWh/house.[7] The estimate of savings produced by measures actually installed is, of course, much less. The estimated savings for the auditor-installed measures in the homes with no major measures installed average 610 kWh/house. The estimated savings, averaged over all 15 measures, for measures installed in the remaining homes is 6,140 kWh. Thus, the average estimated savings per eligible house for measures actually installed is 5,700 kWh, almost half the theoretical potential (see top part of Table 5).

Table 4. Distribution of HRCP measures by recommendation and installation[a].

	Percent of total measures
Homes with no major measures installed (8%)[b]	8
Remaining homes (92%)	
Measures not recommended, not installed	38
Measures recommended	
Not installed	9
Installed	45

[a]Based on 48,735 measures (3,249 homes and 15 measures).

[b]Because a few measures were installed by the auditor in these homes, the 8% could be reduced to 7% and the 45% (recommended/installed) could be increased to 46%.

The preceding discussion is based on an artificial and unrealistic definition of potential (installation of every measure in every home). If

[7]These are engineering estimates. Reliable data on actual electricity savings will not be available until mid-1986 (after a full postretrofit heating year, 1985/86.)

one assumes that program planners have accurate information on the current condition of homes in their service area, then the potential can be defined to include only those measures applicable to that housing stock. This definition is more realistically based on the measures recommended during the energy audit. Of the 26,354 measures recommended during energy audits of the 2,988 homes that had major measures installed, 83% were actually installed. However, these installed measures accounted for 93% of the potential electricity savings for the measures recommended during the audits (see bottom part of Table 5).

Thus, the fraction of potential savings achieved by a program depends on how potential is defined. Based on a hypothetical ideal of installing all measures in all homes, HRCP achieved 46% of its potential. Based on the auditor recommendations, HRCP achieved 93% of its potential.

Table 5. Comparison of maximum potential electricity savings with estimates of savings due to measures installed by HRCP[a].

	Audit estimate of savings per house (kWh/year)
All homes	
Homes with no major measures installed 0.08*610 kWh/house	50
Remaining homes 0.92*6140 kWh/house	5,650
Total	5,700
Total potential savings, if all measures installed in all homes	12,500
Homes with major measures installed	
Measures installed in homes with major measures	6,140
Total potential savings, if all audit recommendations installed	6,590

[a]Based on 3,249 homes and 15 measures.

Estimated Savings and Costs for Retrofit Homes

The remainder of this section involves only the 2,988 homes in which at least one major retrofit measure was installed. The HRCP retrofit measures (see Figure 3) were grouped into five categories:

Insulation - ceiling, walls, floor, heating ducts;
Windows and doors - storm windows, sliding glass doors, thermal doors;
Infiltration - caulking, window weatherstripping, door weatherstripping, outlet gaskets;
Water heating - water heater wrap, hot water pipe wrap, low-flow showerheads;
Other - clock thermostat, dehumidifier, air-to-air heat exchanger, heat pump.

The energy audits identified an average potential electricity savings of 6,590 kWh/year (see Table 6). The estimated savings for measures installed by HRCP averaged 6,140 kWh. Even though 17% of the recommended measures were not installed, only 7% of the estimated potential savings was not achieved.

The average cost of installed measures was $3,760 (see Table 6 and Figure 4). Only 10% of the participants paid anything for the HRCP retrofit measures installed in their homes. These households paid for measures that exceeded HRCP levels (e.g., attic insulation beyond R-49), exceeded the HRCP cost-effectiveness limit (i.e., cost more than $1.15/kWh-saved) or exceeded HRCP standards (e.g., storm windows that cost more than those called for by HRCP specifications). These households paid an average of $430. Averaged over all these homes, households paid only 1% of the total retrofit cost.

The HRCP payment for retrofit measures, averaged over these homes, was 69¢/kWh-saved, far below the cost-effectiveness limit (see Figure 5).[8]

The insulation measures as a group dominate the estimated energy savings for the installed measures (see Table 6 and Figure 4), accounting for 57% of the total savings and 48% of the total cost. The difference in percentages of savings and cost suggest that these measures are relatively cost-effective. The window and door measures, on the other hand, are expensive,

[8]These totals include AAHX installations. Excluding the cost and energy penalty of AAHXs reduces the total cost of HRCP retrofit measures to 61¢/kWh.

accounting for only 27% of the estimated electricity savings but 47% of the total retrofit cost. The infiltration reduction, water heating, and clock thermostat measures account for small fractions of both cost and savings.

The relationship between total retrofit cost and preretrofit (1982/83) weather-normalized annual electricity use is surprisingly weak; the correlation coefficient (r) between these two variables is only 0.30 (see Figure 6). We had expected preretrofit electricity use to be a strong predictor of the need for retrofit measures and therefore of actual retrofit cost.

Table 6. Retrofit measures recommended and installed by HRCP.

Measure type[a]	Mean value, per house		
	Estimated savings (kWh)[b]		Actual installed cost ($)
	Audit	Installed	
Insulation	3,930	3,480	1,790
Windows and doors	1,550	1,640	1,760
Infiltration	550	480	150
Water heating	480	480	20
Clock thermostat	80	60	40
Total	6,590	6,140	3,760

[a]Insulation measures include ceiling, wall, floor, and heating duct insulation. Window and door measures include storm windows, thermal doors, and sliding glass doors. Infiltration measures include caulking, window weatherstripping, door weatherstripping, and outlet gaskets. Water heating measures include water heater insulation, water heater pipe insulation, and low-flow showerheads.

[b]The first column is the savings estimated at the time of the energy audit. The second column is the savings estimated by the auditor after contractor installation of measures. More or less of the measure was often installed than was recommended in the initial audit.

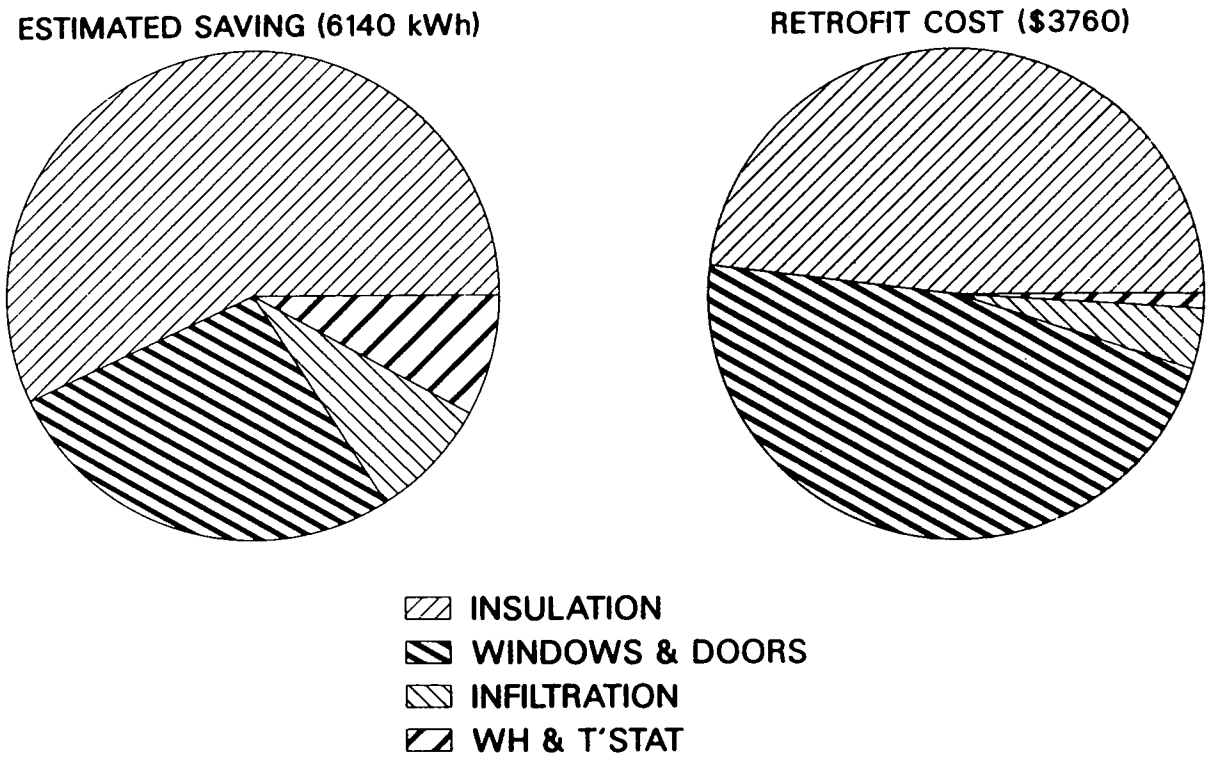

Figure 4. Estimated electricity savings and retrofit costs for HRCP-installed measures. (WH & T'STAT refers to water heating measures and clock thermostats.)

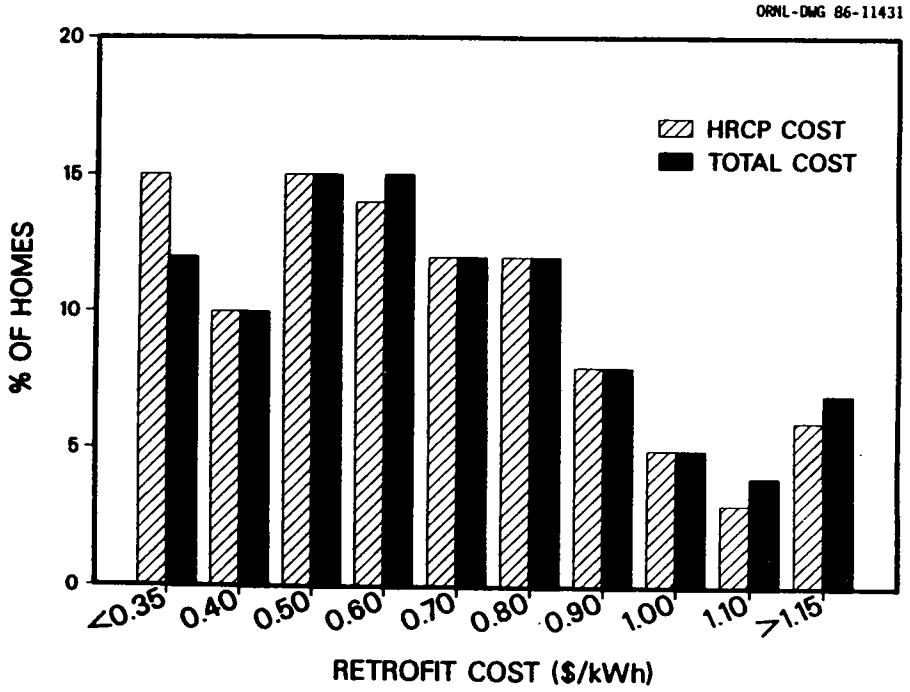

Figure 5. Distribution across homes of HRCP payments and total costs for retrofit measures ($/estimated first-year kWh-saved).

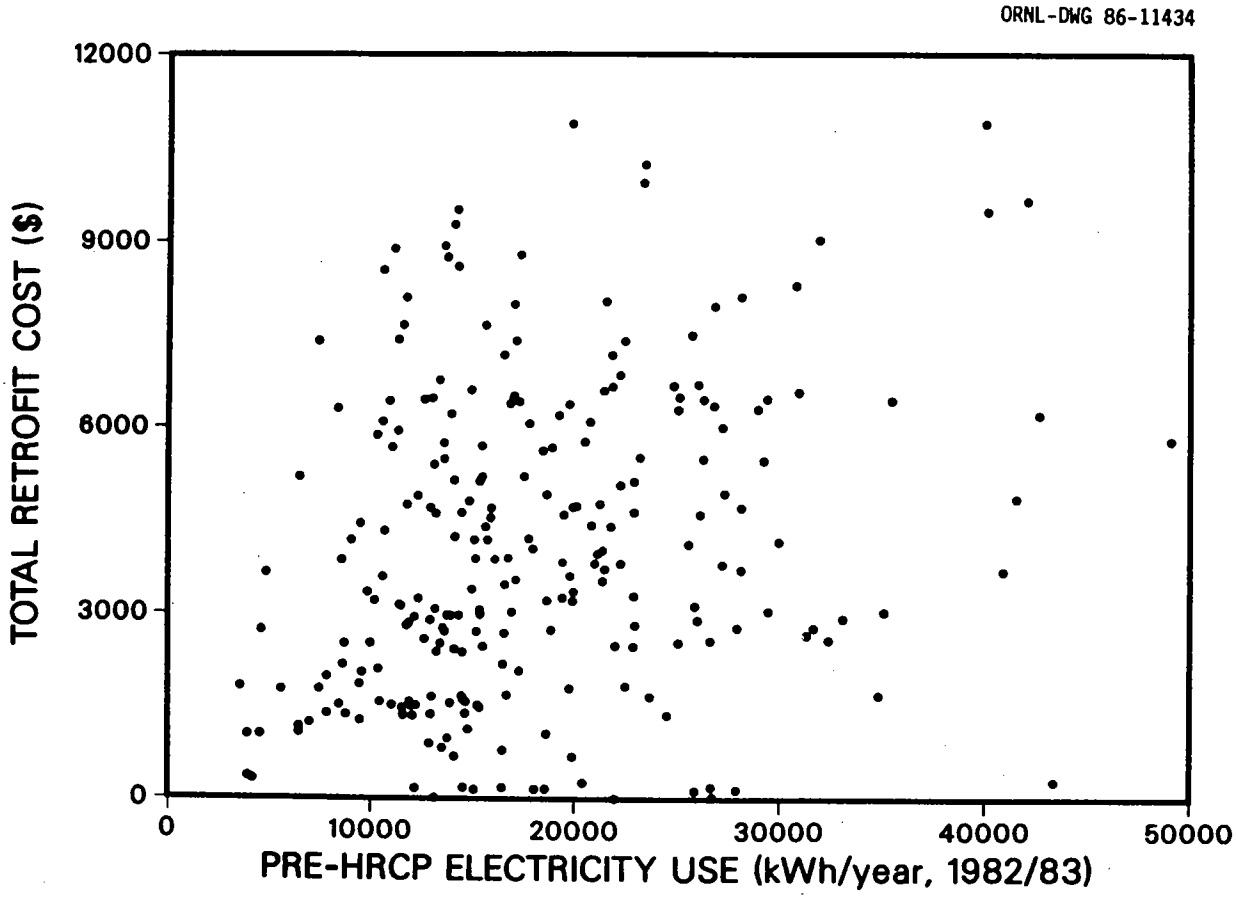

Figure 6. Actual retrofit cost as a function of 1982/83 weather-adjusted electricity use for homes that participated in HRCP and received at least one major retrofit measure. (To improve clarity, the figure shows data for only a 1/10 random sample of these homes.)

Savings and Costs by House Type and Age

The preceding discussion presented summary statistics for the 2,988 homes retrofit by HRCP. Here we examine these statistics by housing type (see Table 7) and by age of housing unit (see Table 8).

Table 7. Estimated electricity savings and retrofit costs for measures recommended and installed by HRCP, by housing type.

	Mean values, by housing type [a]		
	Single-family	Multi-family	Mobile home
Estimated savings (kWh/yr)			
Recommended measures	8,150	3,780	4,160
Installed measures	7,680	3,760	3,230
Installed savings, as percent of recommended savings (%)[b]	94	104	78
Retrofit cost ($)	5,380	2,180	2,370
Cost per first-year estimated savings (¢/kWh)[b]	79	60	78
Year house built	1952	1962	1973
House floor area (ft^2)	1,530	780	1,060
Number of household members	2.9	1.9	2.6
Number of homes	1,811	513	534

[a]Multi-family includes all structures with two or more dwelling units. Mobile homes include trailers. Of the 2,988 homes, 140 cabins are not shown in this table.

[b]These represent the mean values of the ratios, not the ratios of the mean values.

Single-family homes account for the majority (60%) of HRCP participants. Because these dwelling units are, on average, substantially larger than multi-family units and mobile homes, the energy savings associated with recommended and installed measures and the retrofit costs are much higher for single-family homes. The ratios of estimated energy savings (installed/recommended measures) are much higher for single- and multi-family units than for mobile homes. About 8%, 1%, and 6% of the single-family, multi-family, and mobile home units, respectively, had no major measures installed.

Table 8. Estimated electricity savings and retrofit costs for measures recommended and installed by HRCP, by year house was built.

	Mean values, by year house built					
	≤1945	1946-1959	1960-1969	1970-1974	1975-1979	1980+
Estimated savings (kWh/yr)						
Recommended measures	9,720	7,900	5,800	4,900	4,370	3,620
Installed measures	9,130	7,460	5,490	4,540	3,860	3,210
Installed saving, as percent of recommended saving (%)	96	97	94	92	88	96
Retrofit cost ($)	5,500	5,180	4,310	3,330	2,990	2,110
Cost per first-year estimated savings (¢/kWh)	66	75	85	73	72	60
Number of homes[a]	782	341	454	600	598	209

[a]Year built was missing for four of the 2,988 homes.

Finally, the estimated electricity savings per unit floor area are about 50% higher for single- and multi-family units than for mobile homes. Apparently, the opportunities to retrofit mobile homes are limited.

There are also substantial differences in estimated savings and costs as a function of house age (see Table 8). As expected, the savings and retrofit

costs increase with house age. This is reflected in the incidence of cases with no major measures installed: only 3% of the homes constructed before 1960 had no major measures installed, compared with 7% for homes constructed during the 1970s and 17% for homes constructed during the 1980s. However, the cost-effectiveness of retrofit is largely independent of house age.

Chapter 4: Individual Retrofit Measures: Installation and Barriers

The preceding section reviewed HRCP's overall success in installing retrofit measures in participant homes. This section focuses on individual measures recommended and installed in the 2,988 homes that had at least one major retrofit measure installed.

Recommendation and Installation

Several measures were recommended in the vast majority of homes (see Table 9): ceiling insulation, floor insulation, storm windows, caulking, and door weatherstripping (see Figures 7 - 10). Heating duct insulation, insulated doors, and window weatherstripping were installed in very few homes. Homes with baseboard heating have no heating ducts, insulated doors are rarely cost-effective, and the need for window weatherstripping was usually obviated by installation of storm windows.

The measures also differ substantially in retrofit cost and in estimated energy savings. Storm windows and floor insulation are the most expensive measures; the four measures installed at the time of the audit are the least expensive. Estimated energy savings are largest for wall insulation, which had a relatively low retrofit cost. Ceiling and floor insulation and storm windows are also large energy savers.

Barriers for Measures Not Installed

The obstacles to recommendation and/or installation of retrofit measures noted in the HRCP barriers form (see Figure 3) do not constitute an exhaustive and mutually exclusive set of choices. For example, the presence of R-30 insulation in the attic of a home could lead to any one of three barriers:

Measure Already Installed,
Not Cost Effective,
Existing Insulation/Installation.

The first barrier occurred if the resident knew how much insulation was in the attic and did not allow the auditor to inspect the attic. The second

occurred if the auditor computed the estimated electricity savings for addition of R-19 to bring the ceiling to the HRCP level of R-49; staff in the HRCP office then determined, after the contractor prepared a bid, that the installation cost was too high to pay for the estimated savings, given the $1.15 limit. The third choice occurred during the audit if the auditor recognized that the attic already contained sufficient insulation.

Table 9. Retrofit measures recommended and installed by HRCP[a].

Measure	Percentage of homes in which measure			Installed		Ratio of cost to estimated savings[c] (¢/kWh)
	Recommended	Installed	Installed as % of recommended	Cost ($)	Savings (kWh/yr)[b]	
Insulation						
Ceiling	88	67	76	960	1,690	57
Floor	87	63	72	1,350	2,080	65
Wall	49	39	80	720	2,460	29
Duct	19	12	63	270	720	37
Windows and doors						
Storm windows	99	89	90	1,730	1,670	104
Sldg glass doors	40	29	73	720	500	143
Insulated doors	12	3	25	430	210	208
Infiltration						
Caulking	89	78	88	110	140	82
Window w'strip	17	0	0	-	-	-
Door w'strip	90	69	77	80	50	180
Outlet gaskets	d	85	100	10	400	3
Clock thermostat	32	26	81	150	250	59
Water heater						
Insulation	d	51	100	20	360	6
Pipe insulation	d	63	100	10	30	18
Low-flow shwrhds	d	62	100	10	450	2

[a]Based on 2,988 homes.

[b]These are engineering estimates of expected electricity savings for the measures installed by HRCP.

[c]These numbers are the ratios of the mean cost to mean estimated annual savings for each measure.

[d]Installations equal recommendations for these four auditor-installed measures.

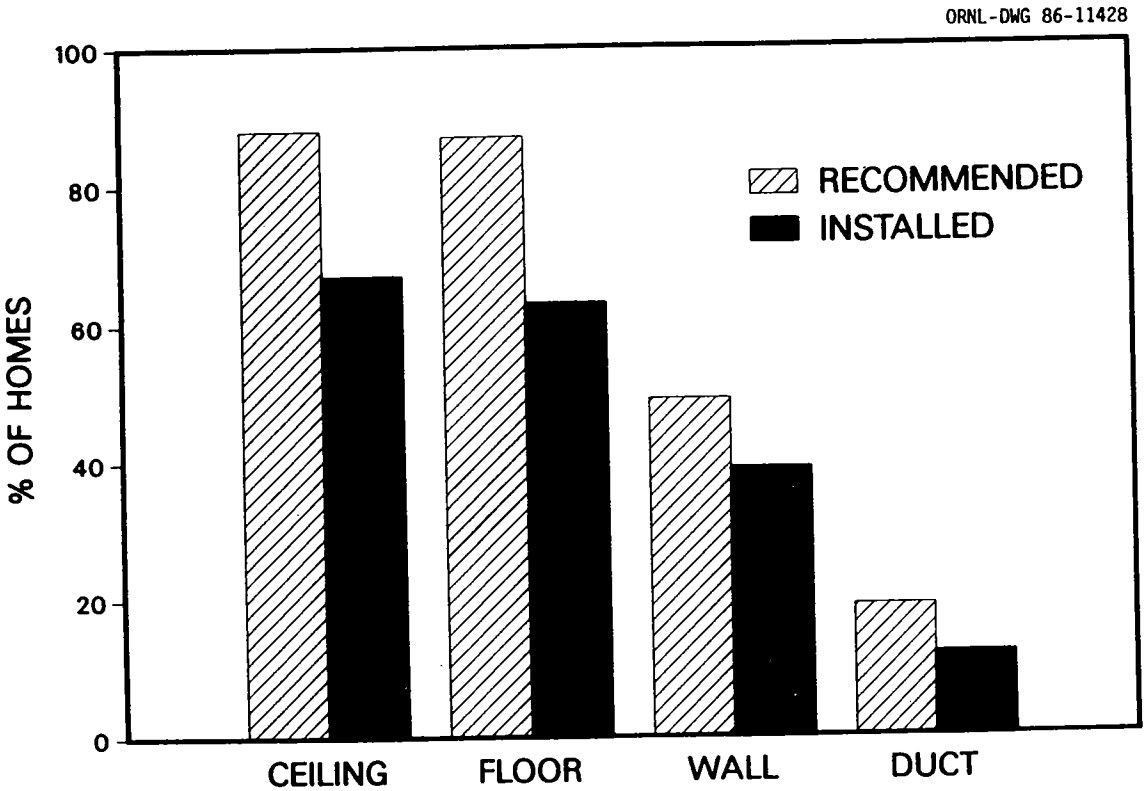

Figure 7. Percentage of HRCP homes in which insulation measures were recommended and installed.

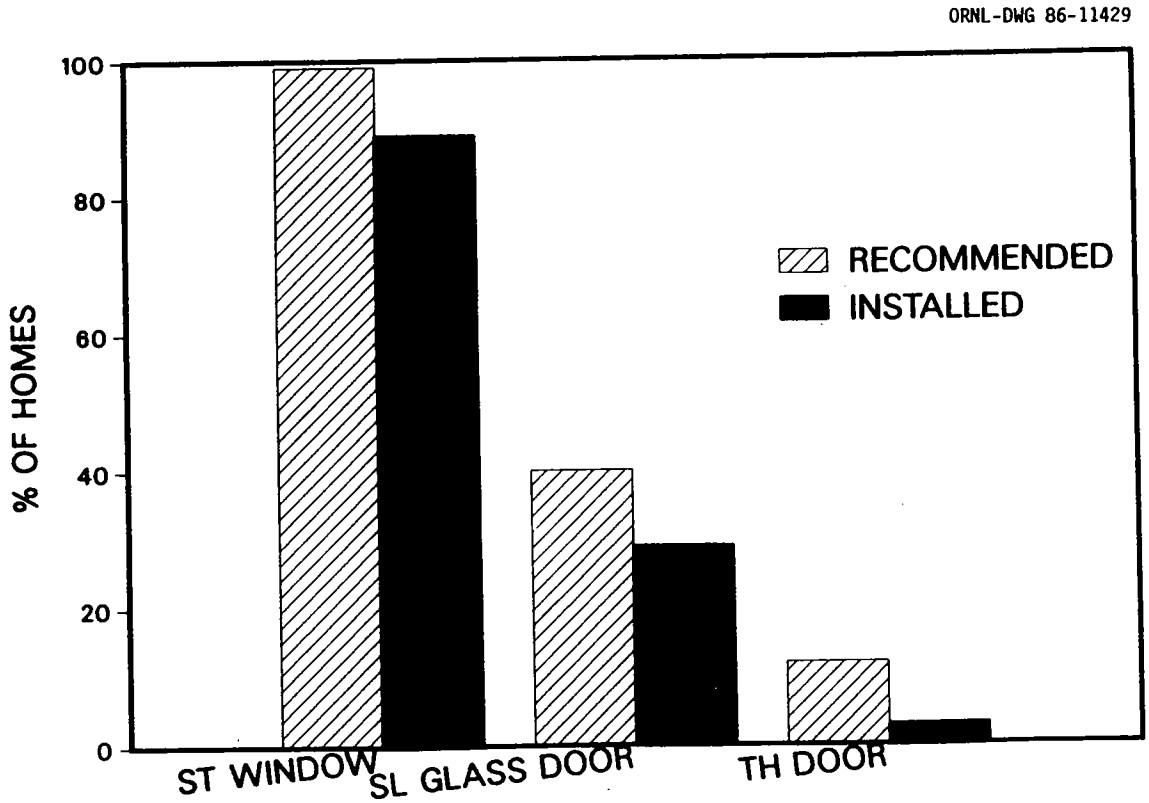

Figure 8. Percentage of HRCP homes in which window and door measures were recommended and installed.

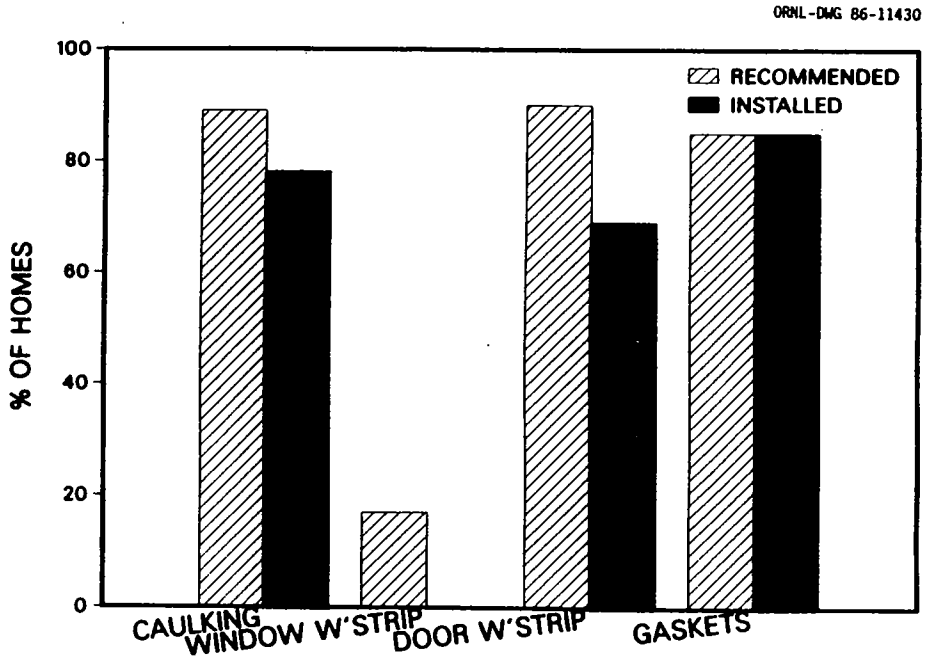

Figure 9. Percentage of HRCP homes in which infiltration measures were recommended and installed. Window weatherstripping was rarely installed because installation of new windows and frames obviates the need for weatherstripping. Outlet gaskets were installed at the time of the energy audit so recommendations equal installations.

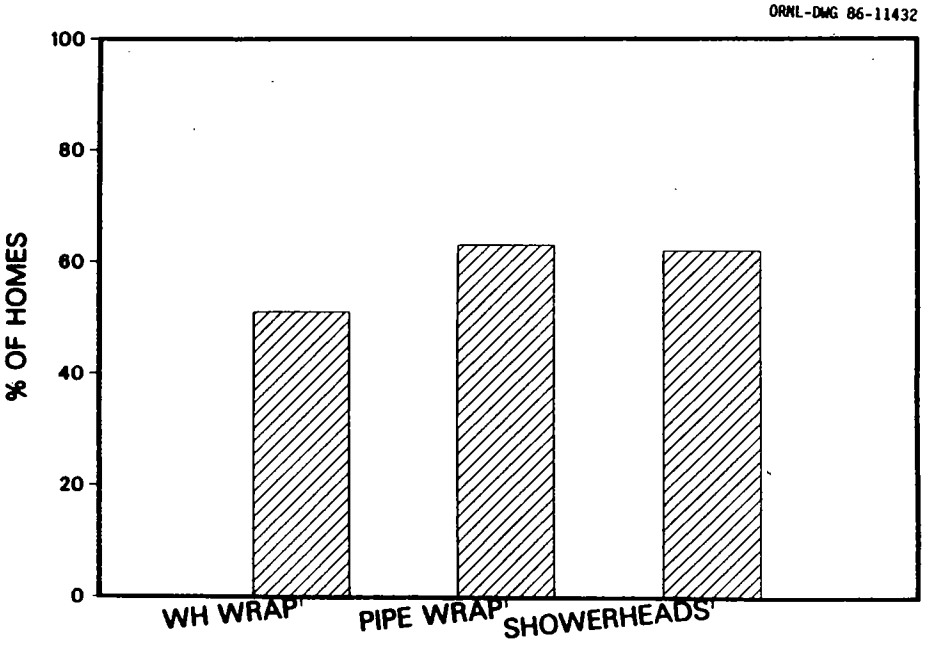

Figure 10. Percentage of homes in which water heating measures were installed (identical to percentages in which measures were recommended).

We aggregated the individual barriers into five groups:

Not compatible (66, 69, 70[9]) - refers to measures that are not applicable to the particular house, such as duct insulation in a house that has no ducts or floor insulation for a house on a concrete slab.

Physical (60-62, 64, 65, 67, 68, 71) - refers to conditions in the house that prevent installation of a measure, such as spaces too small to install additional insulation or water heaters without pressure relief valves.

Existing installation (16, 63) - refers to situations in which some or all of the recommended measure is already in place; installation of more of the measure would not be cost-justified.

Customer (1-15) - refers to cases in which the resident decides that the measure will not be installed.

Other/none (40-43, 45, 99) - refers to other barriers that are infrequently cited or to measures not installed for which no barrier was recorded.

Noncompatible conditions were cited for 19% of the noninstalled measures (see Table 10 and Figure 11).[10] An additional 31% of the measures were not installed because of physical conditions that prevented installation. Thus, half of the measures could not be installed, regardless of potential energy savings or measure costs.

The presence of partial measures or lack of cost-effectiveness (NCE) prevented installation in another 45% of the cases. In these cases, the homes already had sufficient quantities of a measure (e.g., double-pane windows) so additions to bring the measure up to the project level (e.g., triple-pane) could not be justified.

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[9]These numbers refer to the barriers in the form shown in Figure 3.

[10]More than one barrier was sometimes identified for individual measures. On average, there were 1.2 barriers per noninstalled measure. In addition, barriers were not recorded for 3% of the noninstalled measures. The discussion, Tables 10 and 11, and Figures 11 and 12 ignore these small anomalies.

Customer concerns prevented installation of only 4% of the measures. The fact that almost all measures were installed at no cost to the household contributed significantly to the lack of customer barriers. Finally, other barriers were cited for less than 2% of the measures.

Table 10. Barrier type for measures not installed by HRCP[a].

Measure	Percentage of barriers by barrier type[b]				No. of measures not installed
	Existing Installation	Physical	Not Compatible	Customer	
Insulation					
Ceiling	32	62	2	2	1,919
Floor	35	55	5	2	2,058
Wall	74	20	3	2	2,455
Duct	14	17	68	0	2,951
Windows and doors					
Storm windows	84	3	0	7	350
Sliding glass doors	18	43	35	3	2,256
Insulated doors	93	2	0	1	3,170
Infiltration					
Caulking	61	32	0	4	815
Window w'strip	94	4	0	1	3,163
Door w'strip	74	20	0	3	1,010
Outlet gaskets	12	68	1	13	470
Clock thermostat	1	1	94	2	2,254
Water heater					
Insulation	24	59	1	15	1,926
Pipe insulation	11	75	1	11	1,354
Low flow showerheads	16	71	1	8	1,313
Averages	45	31	19	4	27,464

[a]Based on 2,988 homes and 15 measures.

[b]Percentages do not add to 100% because other barriers occasionally occurred, accounting for 2% of the total.

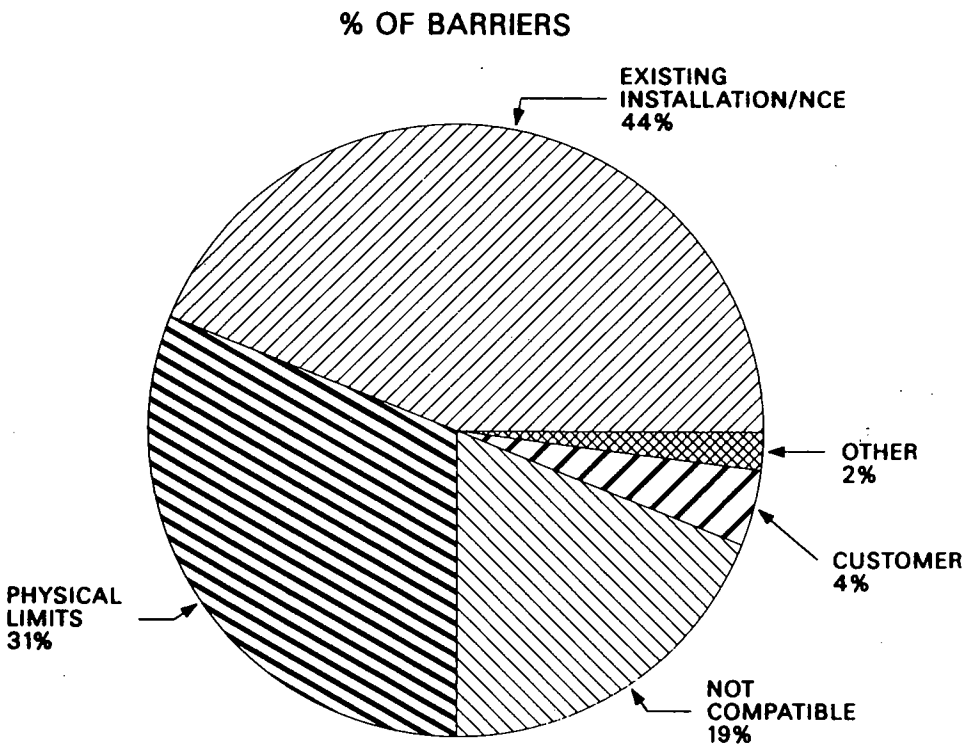

Figure 11. Distribution of barriers for measures not installed, by type of barrier. (NCE is not cost-effective.)

The vast majority of barriers (81%) were identified during the energy audit (see Table 11 and Figure 12). The only exceptions were ceiling and floor insulation and caulking (for which some barriers surfaced during the contractor bid) and storm windows (for which more barriers appeared during the bid process than during the audit). This result suggests that the auditors generally did a good job examining the suitability of each measure for each house.

Table 11. Point of barrier occurrence for measures not installed[a].

Measure	Percentage of barriers by point of barrier			
	Audit	Between audit/bid	During bid	After bid
Insulation				
Ceiling	70	4	21	6
Floor	65	3	24	8
Wall	84	2	9	5
Duct	88	1	7	4
Windows and doors				
Storm windows	10	17	62	10
Sliding glass doors	80	3	14	3
Insulated doors	91	1	5	4
Infiltration				
Caulking	40	7	38	15
Window w'strip	90	2	5	3
Door w'strip	30	6	36	28
Outlet gaskets	95	3	0	2
Clock thermostat	91	0	3	5
Water heater				
Insulation	94	4	0	2
Pipe insulation	92	5	0	2
Low flow showerheads	93	4	0	2
Averages	81	3	11	5

[a]Based on 2,988 homes.

The auditors were particularly adept at identifying barriers related to incompatibility with the heating system or structure and physical limitations. Barriers related to cost-effectiveness and customer concerns were frequently identified during the contractor bid phase (which included calculations of cost-effectiveness by the HRCP office staff).

Only a few of the 32 barriers included in the HRCP form (see Figure 3) were frequently cited (see Table 12). Structural limitation was the predominant barrier for several measures: ceiling and floor insulation, sliding glass doors, and low-flow showerheads.

Existing installation (presence of the measure), the most frequently cited barrier, was cited for the majority of homes in which wall insulation and weatherstripping were not installed. Existing installation was also a major barrier for caulking.

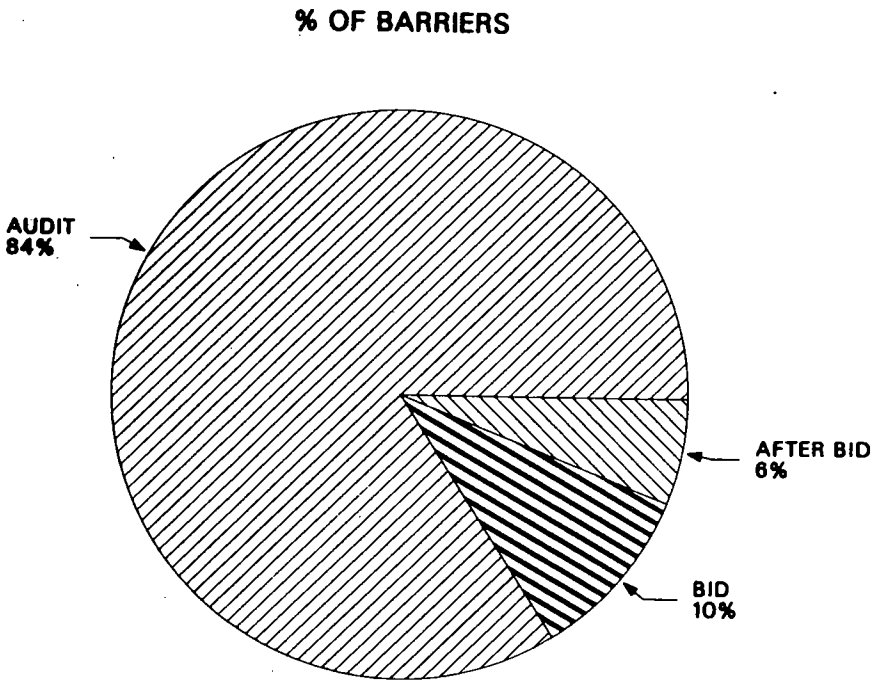

Figure 12. Distribution of barriers by time of identification.

Table 12. Most frequently cited individual barriers[a].

	Percentage of barriers					
	Structural limitation	Existing installation	Noncompatible structure or heating equip.	Not cost-effective	Limited access	Restriction in auditor contract[b]
Insulation						
Ceiling	34	-	-	21	26	-
Floor	30	-	-	26	21	-
Wall	-	66	-	-	-	-
Duct	-	-	68	-	-	-
Windows and doors						
Storm windows	-	-	-	81	-	-
Sliding gl doors	43	-	35	-	-	-
Insulated doors	-	20	-	75	-	-
Infiltration						
Caulking	32	38	-	24	-	-
Window w'strip	-	50	-	44	-	-
Door w'strip	20	50	-	24	-	-
Outlet gaskets	-	-	-	-	-	60
Clock thermostat	-	-	94	-	-	-
Water heater						
Insulation	24	24	-	-	-	20
Pipe insulation	30	-	-	-	-	27
Showerheads	44	-	-	-	-	27
Total[c]	19	23	15	22	6	5

[a]The percentages are based on all the barriers identified for measures not installed in the 2,988 HRCP homes. Only those that accounted for 20% or more of the total barriers for each measure are shown.

[b]These contract restrictions refer to the four auditor-installed measures and were generally cited for water heater wraps. Thus, the 227 outlet gaskets not installed because of this barrier were actually not installed because the absence of a pressure relief valve on the water heater prevented installation of 370 water heater wraps.

[c]These six barriers accounted for 90% of all those cited; the remaining 26 barriers accounted for the other 10%.

A noncompatible structure or heating system frequently prevented recommendation and/or installation of heating duct insulation and clock thermostats. Houses with individual room electric heaters (68% of the total) cannot have duct insulation or clock thermostats installed.

Insulated doors were frequently identified as not cost-effective during the energy audit. HRCP policy defined thermal doors as inappropriate unless the existing door was in poor condition. This explains why this measure was recommended and installed less frequently than any other measure. Storm windows were often identified as not cost-effective during the contractor bid phase.

Outlet gaskets, water heater insulation, water heater pipe wrap, and low-flow showerheads were not installed under certain circumstances, spelled out in the contract between HRCP and the auditors. For example, water heater wraps were often not installed because the water heater did not have a pressure relief valve. Until their instructions were clarified, auditors installed none of the four low-cost measures if the water heater did not have a pressure relief valve. This explains the high percentages for contract restriction (see Table 12) for these measures.

Noninstalled Measures: Recommended vs Not Recommended

About 51% of the measures were not installed in the 2,988 homes considered here. Roughly 20% of these noninstalled measures were recommended during the energy audits, while the remaining 80% were neither recommended nor installed. Here we examine differences in the types of barriers between these two sets of noninstalled measures.

For the measures recommended but not installed, existing installation accounted for more than half the total (see Figure 13). In many of these cases, the barrier noted was not cost-effective (NCE), identified during the contractor bid. Ceiling and floor insulation were the two measures most frequently recommended but not installed; these two measures accounted for more than 40% of all the NCE measures. In many other cases, physical limitations were uncovered by the contractor that prevented installation of the recommended measure, accounting for 36% of the measures recommended but not installed.

Measures were frequently not recommended at all because of physical limitations (30%) or because the measure would not be compatible with the structure or heating system (25%).

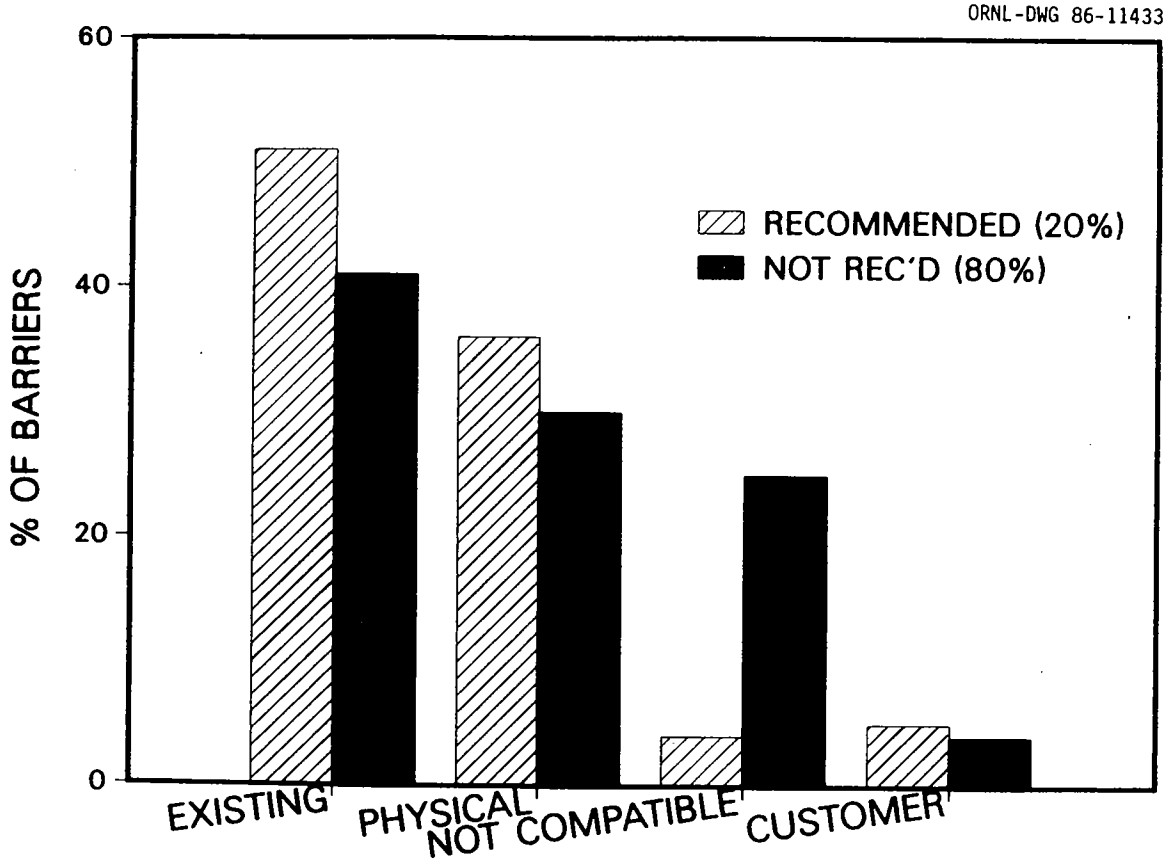

Figure 13. Distribution of barriers for noninstalled measures, recommended vs nonrecommended measures.

Recommended Measures: Installed vs Noninstalled

As noted earlier, 17% of the measures recommended during the energy audit were not installed by HRCP (see Table 4). Examination of the estimated energy savings for these measures provides some explanation of why they were not installed. For all the insulation and glass measures, the ratio of estimated energy saving to cost was relatively low. For measures that were installed, the ratio was much higher. In other words, rejected measures, on average, were expected to save less energy than installed measures; almost 60% of these measures were rejected because they did not meet the Project's

cost-effectiveness limit (NCE; see Figure 13). This difference was most dramatic for the insulation measures; measures that were not installed typically would have saved only half as much electricity as the measures that were installed.

Chapter 5: Discussion

Presentation and analysis of data on retrofit measures installed by HRCP demonstrate the enormous richness and value of the HRCP data base. Clearly, HRCP and its extensive and competent data collection yield valuable and unique information on residential retrofit in the Pacific Northwest. These data form the basis for a variety of analyses that will provide important new insights concerning the design, operation, and success of residential retrofit programs. This and subsequent reports will use the HRCP data to analyze participation in the Project, installation of retrofit measures, and actual energy and load reductions. The HRCP data are also being used for analysis of residential wood use, postretrofit changes in indoor temperatures, actual electricity savings produced by installation of water heating conservation measures, and comparison of actual savings with audit predictions.

The high level of HRCP retrofits and the substantial financial contribution minimize the importance of existing levels of structure thermal performance and capital cost, two major obstacles to retrofit in most conservation programs. Removal of these barriers, coupled with the details provided on types and times of barriers, greatly increases our knowledge of the practical limits of residential retrofit programs in terms of both participation in such programs and adoption of recommended measures.

HRCP was remarkably successful in getting recommended measures installed. Of the measures recommended by the HRCP energy auditors, 83% were subsequently installed by the Project. These installed measures accounted for 93% of the estimated electricity savings. These results demonstrate the feasibility of installing most of the recommended measures in a program that is well run and that pays for virtually all of the retrofit cost.

The conservation potential in existing homes is difficult to define and to determine. Different definitions are possible depending on how one considers measures that are not applicable, that cannot be installed because of physical limitations, that are already partially or fully in place, or that residents do not want installed.

Accurate determination of conservation potentials requires detailed data on the current condition of the region's housing stock. This includes information on existing levels of conservation measures, types of structure and heating equipment, physical barriers that prevent installation of otherwise

needed measures, and installation cost. HRCP data show the importance of these factors; almost half the measures hypothetically applicable were not recommended because of these factors (and therefore not installed).

HRCP succeeded in gaining participation from more than 90% of the eligible households (3,249 of 3,500 signed up for the Project). HRCP was also successful in installing more than 80% of the retrofit measures recommended. However, it is too soon to know whether the Project is actually saving energy and reducing electrical loads as anticipated. Information on actual kWh and kW reductions must wait until sufficient postretrofit electricity billing and load metered data are available, in Fall 1986.

Acknowledgments

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