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Cost Analysis

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Natural Resources Defense Council • Northwest Public Power Association
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COST ANALYSIS

Final Report

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April 1987

Work Performed Under Contract No. DE-AC-79-83BP11287

Prepared for
U.S. Department of Energy
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Contents

Illustrations

Figures

Tables

Executive Summary

Total Project Costs

Budgets

The Hood River Conservation Project (the Project) was originally funded by a $12 million contract for weatherization and a $7 million contract for research and evaluation (R&E). A key to the success of the Project was contract and budget flexibility. The weatherization and R&E contracts each contained provisions for modification of contract timelines, deliverable schedules, tasks, and funds. This flexibility permitted the evolution of Project objectives and design from the planning stage to the production of scientific research and evaluation. Ten budget modifications extended the Project from 24 months to 70 months at a projected cost of $19.9 million. The total authorized amount was $21.5 million, which included funds allocated for weatherization but not spent. As Table 1 shows, total Project costs are $18.5 million, with 78 percent funding weatherization activities, and 22 percent funding R&E.

Table 1. Total Project costs, May 1986

Budget	$ Cost thousands	Percent Total
Operations		
Administration	1,288	7
Marketing	113	1
Computer system	395	2
Residential retrofit		
Audits	171	1
15 retrofit measures	11,141	60
Air-quality measures	1,294	7
Subtotal	14,402	78
Research & evaluation	4,116	22
Total	18,518	

Other costs incurred during Project planning that are not shown in Table 1 are $58,000 for pre-Project data collection and $141,000 for planning costs, both paid by Pacific Power, an estimated value of $87,000 for office space donated by Pacific Power for the period July 1983 to June 1987, and a conservation charge of almost $1.5 million Pacific Power must pay to the Bonneville Power Administration (Bonneville) over 20 years. Bonneville, the Northwest Power Planning Council, and the Pacific Northwest Utilities Conference Committee also incurred costs during Project planning, but these were not available for this study.

Operations' budget

Administration, marketing, and computer system costs were less than 10 percent of total Project costs. The largest administrative expense (72%) was for direct labor and labor overhead. The marketing budget went largely to a consultant, but almost 75 percent of the marketing budget was not spent because the community-oriented promotional plan and the attractiveness of the Project's "free" weatherization package met targets for customer requests for audits and retrofit contracts. The computer system budget went almost entirely to a consultant (77%) for computer hardware rental, installation, programming of custom software, and testing.

Residential retrofit budget

Cost per retrofit residence: the weighted average total cost of retrofit per residence is $4,385, not including air quality measures. The distribution of types of homes retrofit and the average total cost per residence is: single-family (60%, $5,755), duplex (2%, $4,489), triplex (1%, $3,774), multiplex (15%, $3,011), mobile homes (18%, $3,102), and cabins (4%, $1,993).

Audits: the Project paid for audits in 3,549 homes and four measures (outlet gaskets, water-heater wrap, hot-water pipe wrap, and low-flow shower heads) installed in 3,016 homes (2,859 non-oil and 157 oil heated) during the audit if no barriers existed. The Project hired a vendor who audited 3,220 electrically heated and 329 non-oil/nonelectrically heated residences at a total cost of about $266,000: $176,000 for audit fees and $90,000 for measures. The audit fee per home was $53.10 for electrically heated and $14.47 for non-oil/nonelectrically heated homes. Audit fees for 157 oil heated residences were paid by the Oregon Oil Heat Institute, but the Project paid about $5,000 for audit measures in these homes.

The average cost per audit was: $85 electrically heated homes; $43 non-oil/nonelectrically heated homes; and $32 oil-heated homes (measures only). The cost for all non-electrically heated homes was covered by the marketing budget as part of the community promotional plan, and the cost for electrically heated homes is included in residential retrofit costs. The average total cost per retrofit home (2,989 homes) for audits under the retrofit budget was $86.

Pricing systems: two pricing systems, competitive bid and unit price, were employed. Although unit prices superceded competitive bids as the Project's main pricing system in September 1984, competitive bidding continued to be used intermittently throughout 1985 for apartment house retrofit, difficult installations, or when requested by customers. Retrofit under these pricing systems was split 58 percent (unit prices) and 42 percent (competitive bids). The savings of unit-priced retrofit over competitive bids was in a range from seven percent to 22 percent for all types of housing except multiplex, which was 10 percent higher (see Table 18). Unit-priced measures for single-family homes were between five percent and 35 percent lower than bids when first adopted in 1984.

If competitive bids had been used exclusively throughout the Project, costs would have been 15.5 percent higher than the exclusive use of unit prices. If unit prices were used instead of the actual combination of pricing systems, the Project would have saved an additional seven percent in costs. We recommend that future projects use a combination of pricing for different housing types that might save eight percent of retrofit measure costs (see Table 22).

Package and individual measure costs: approximately 14,100 major measures (see Table 7) were installed in 2,989 homes at a total cost of $11.06 million. The most frequently installed measure package was insulation (ceiling, floor, wall, and duct), which had the highest total cost ($5.3 million) of all measure packages, but had the lowest cost/sq. ft./R-value of all measures. The windows and doors package had the highest cost/sq. ft./R-value, with storm windows, the most frequently retrofit measure (90% of homes), having the highest total cost of any individual measure ($4.52 million). However, storm windows were less expensive in dollars/sq. ft./R-value than sliding and insulated doors (see Tables 12 to 15).

Carried measures: 34 percent of all measures were carried at 34 percent of total measure cost. If residences shared the same roof and crawl space or basement, the building was treated as a single unit and dollars for measures were transferred to residences within the unit to carry measures. This method of carrying measures increased the number of measures retrofit in 38 apartment houses (342 apartments) and ten triplexes. The most frequently carried measures were the most expensive measures: doors (sliding, 70% and insulated, 98%) and windows, 36 percent. If these measures had not been carried, they would not have been installed under the Project's incentive limit. Not surprisingly the least costly measure was carried the least: only two percent of wall insulation was carried.

Mobile home retrofit: measure costs were significantly higher than costs for single-family homes; three percent to 42 percent more expensive for all measures except doors. Doors were typically installed as carried measures, but doors retrofit in mobile homes were usually not carried because the insulation measures did not generate enough excess incentive dollars to carry other measures (see Table 21).

Air-quality control: total cost is about $1.3 million. The monitoring and mitigation of possible air pollution was offered to every customer whose residence received air-tightening measures. The Project installed 1,160 air-to-air heat exchangers in 1,044 residences, 2,700 radon monitors in 2,300 homes, four dehumidifiers, and five heat-pump ventilators. Less than four percent of residences monitored had levels of radon gas specified by Bonneville as too high to meet indoor air-quality standards.

Prices for air-to-air heat exchangers were tried under five pricing systems: competitive bids 1, cost-plus prices, unit prices 1, competitive bids 2, and unit prices 2. When contractors submitted competitive bids 1 to the Project, the bids were higher than acceptable, and a cost-plus system was utilized until the schedule of acceptable unit prices 1 could be devised. A drop in the number of air-to-air heat exchangers to be installed resulted in contractors vying for contracts, and the Project replaced unit prices 1 with competitive bids 2 for two months to bring prices down further. Unit prices 2 were developed from these competitive bids. The savings from employing these pricing systems was considerable: unit prices 2 were 27 percent lower for non-ducted and 32 percent lower for ducted exchangers than cost-plus prices.

Research and evaluation budget

R&E costs as of May 1986 were $4.1 million, and are projected to total $5.6 million when the Project ends in March 1989. Approximately $1.3 million of the projected budget was rolled over from previously approved budgets. Budget modification #10 provided an additional $166,000, and proposed the following: extension of the analysis phase through December 31, 1987; extension of data collection through June 30, 1988; and removal of Project equipment from test-area homes with delivery of this equipment to Bonneville by March 31, 1989.

Introduction

The Hood River Conservation Project (the Project) is a model electric energy conservation experiment designed to produce research on the conservation potential of super-weatherized residences in a limited geographical area in and around Hood River, Oregon. Project research will inform regional and local electrical energy planning groups, like the Northwest Power Planning Council, when conservation is included in long-range electrical power programs.[1]

The Project was funded by Bonneville Power Administration (Bonneville) with two federal contracts. One contract, with Pacific Power & Light Company (Pacific) and the Hood River Electric Cooperative (HREC) for $12 million, funded weatherization operations from May 1983 to May 1985. The other contract, with Pacific for $7 million, supported the Project's research and evaluation (R&E) program from May 1983 to December 1986. Both contracts and their budgets were modified to meet changes in Project retrofit and research goals. The weatherization contract was extended six months to December 1985, and the R&E contract was extended to March 1989.

Although two contracts and two budgets were written, several R&E budget modifications funded weatherization activities, e.g., air-to-air heat exchangers. This study, therefore, categorizes expenditures in functional terms, i.e., if R&E funds supported a weatherization activity, they are listed as weatherization expenses. Costs in this study are total expenditures recorded by Pacific's Accounting Department through May 1986, but charges will continue to accrue for a projected total of $19.9 million.[2]

Chapter 1 discusses financial management of the Project, budget proposals, structures, modifications, and accounting practices. Chapter II covers operations' costs (administration, marketing, and the computer system). Chapter III analyzes retrofit measure costs -- actual costs and estimated savings. Chapter IV presents R&E expenditures and a projected R&E budget.

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1 See Philips et al. (1986) for a description of weatherization activity.

2 Numbers in the text are rounded to nearest appropriate digit.

I. Financial Management

The Project was designed and regulated by a consensus-driven steering committee, the Regional Research Advisory Group, primarily composed of the Northwest Power Planning Council, the Pacific Northwest Utilities Conference Committee, the Northwest Public Power Association, the Natural Resources Defense Council (NRDC), the Hood River Electric Cooperative (HREC), Bonneville, and Pacific.

The Project was implemented by three main staffs: a Bonneville staff, a Pacific corporate staff, and a Project staff. The Project staff included a weatherization operations team and a R&E team. Financial management of the Project was implemented according to federal contractual guidelines carried out by Pacific's Accounting Department and subject to audit by Bonneville.

Budgets

Budget proposals

In July 1982 when Bonneville requested further details about the project suggested by the NRDC and Pacific, several organizations that had testified before the Northwest Power Planning Council on conservation formed committees to work on program and cost specifics. Although records are not available on the dollar amount contributed to Project planning by these organizations, some of them assigned several staff members to committee work for almost ten months.

The technical, scientific design, and cost planning of the Project's R&E, the raison d'etre of the Project, was undertaken by a committee of six to 11 energy specialists. Members of the committee came from the Northwest Power Planning Council, Pacific Northwest Utilities Conference Committee, Bonneville, and three Pacific departments (Rates and Regulation, Energy and Conservation Services, and Forecasting and Economic Research).

Weatherization plans and proposed costs were devised by a committee of Pacific and Bonneville employees. Records of Pacific's investment in the planning committees are available, with the total cost expended by various departments shown in Table 2.

Table 2. Pacific's Project planning costs

Pacific Department	$ Amount
Energy and Conservation Services	82,903
Application Systems	47,132
Contract Services	2,309
Corporate Tax	5,819
Research and Development	2,473
Total	**$ 140,636**

Budget structures

Bonneville "obligates" federal funds to projects in a variety of ways that depend on the type of contract written and the conditions set out in the contract. The obligation of the Project's R&E funds differed from the obligation of weatherization funds. The type of contract, the nature of the deliverables, the timeline for completion, and the conditions under which funds were obligated determined how the budgets for the two contracts were structured.

Research and evaluation

The R&E contract is, in Bonneville parlance, a "completion contract," i.e., the contract contains a definite quantity of deliverable reports and tasks set in a schedule of due dates. Funds for the R&E program were obligated by Bonneville when the contract was signed. Funds were paid out to Pacific as costs were incurred.

The R&E contract is a "cost-sharing contract," which means Pacific bore some costs. The original total cost of performance for this contract was $6,995,523, with Bonneville obligated for $6,937,009 and Pacific obligated for $58,514. Pacific's share paid for a survey of the test area, a community assessment, and a post-Project survey.

Pacific was contractually bound to supply monthly reports to Bonneville detailing reimbursable R&E costs. Pacific also was required to maintain and

produce on demand accounting records for both Bonneville-obligated funds and Pacific's cost-share funds.

Weatherization

The weatherization contract was funded on a budget-year basis up to the total contract amount of $12 million. The federal budget year extends from the first of October to the 30th of September with budgets required to be submitted by the first of July. The Project submitted a weatherization budget to Bonneville for each federal budget year falling within the 33 months of extended contract time. Bonneville could approve the budget request, approve a portion of it, or inform Pacific that no funds were currently available for that budget year. If funds were not adequate to meet Project goals during the budget year, Pacific could submit contract modifications to increase the approved budget amount.

The proposed weatherization budget included expected units of accomplishment for each quarter of the budget year, quarterly estimates of payments for measures to be installed, and an estimate of payment for measures to be installed in future budget years. If during any quarter of a budget year Pacific did not achieve 80 percent of its projected units of accomplishment, Bonneville could reduce the budget amount.[3]

Weatherization funds were not given up front as were those for R&E, but were promised, not obligated, by Bonneville when the contract was signed. The funds became obligated as measures were installed in eligible homes and passed inspection. Bonneville payments forwarded to Pacific to support weatherization work during the contract time were provisional payments that became final only after all residential retrofit was completed, inspected, and accepted by a post-weatherization Bonneville audit.

Therefore, Pacific was potentially responsible for the weatherization costs of each residence. Pacific monitored this potential risk by identifying each residence with a bid number that was an account entry, or work order number, on its books. The bid number also was used as a residence packet identifier in the Hood River field office, the center of weatherization work and retrofit documentation. Each stage of contract fulfillment and cost from

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[3] This could be avoided if it was determined that the failure to achieve expected units of accomplishment was caused by nonrecurring events beyond Pacific's control.

installation to inspection to a possible Bonneville audit was tracked by the bid number.

Conservation charge. Although the weatherization contract was not a cost-sharing contract as was the R&E contract, Pacific was required to pay Bonneville a conservation charge of $1,476,000 over 20 years. This charge will be terminated at any time during those 20 years that Pacific signs Bonneville's regional conservation agreement containing a collection provision for a conservation charge.

Budget modifications

The Bonneville Project manager's role was to monitor progress, review and accept deliverables, and facilitate the performance of both contracts. Each contract had provisions for modifications of contract time, deliverable reports, tasks, and budget amounts. There were three occasions when budget modifications were made: 1) when clarification of Project time lines and/or production required transfers of funds between budget categories, 2) when the evolution of R&E deliverables and/or tasks required transfers of funds between budget categories, and 3) when new tasks required additional funding to accomplish performance goals.

Accounting

Pacific's Treasury had three objectives in handling Project accounts: 1) freedom from financial liability for weatherization costs; 2) avoidance of contractor cash-flow problems; and 3) avoidance of budget overruns.

According to Bonneville's Chief Auditor's report (1986, page 3), Pacific made a substantial effort to implement and control the Project. Two divisions of Pacific Accounting within Treasury handled Project accounts, General Accounting and Construction Accounting. A management accountant from General Accounting was put in charge of all Project accounts. General Accounting set up systems to facilitate the monetary exchange between Pacific and Bonneville, payment approvals, and vendor and contractor payments. Construction Accounting prepared a monthly summary of expenses and an invoice that was approved by General Accounting before being forwarded to Bonneville for payment.

The R&E manager approved R&E expenditures and the Project manager approved weatherization expenditures. Both managers were located at Pacific's corporate offices in Portland. Weatherization payment records were in the Hood River field office where Project staff could quickly verify the status of contractor and vendor payments.

Cash flow was critical to the timely completion of weatherization work and payments to contractors and vendors were made by Pacific after invoices were approved by Project management and forwarded to General Accounting. Normally payments to contractors, vendors, and consultants were made within two weeks of receipt of Project invoices. The weekly sum of invoices for the weatherization contract paid by Pacific was submitted to a Portland bank in a letter-of-credit form whereupon funds were transferred from Bonneville's bank account to Pacific's. Pacific was contractually bound to submit monthly reports of letter-of-credit claims to Bonneville. Preparation of these reports required the Project staff to reconcile its payment records with those of Accounting. Accounting prepared an expense summary and an invoice, which was reviewed by the Project's contract officer at Bonneville.

Bonneville required a 30-day holding period after receipt of Pacific's invoice for the R&E contract before a reimbursement check was issued. Pacific's preparation of the monthly report and invoice took about 60 days. The combined Pacific and Bonneville turnaround on invoices, which averaged $150,000, was 90 days.

Smooth accounting transactions developed from open communication between Project managers, Pacific's Accounting, and Bonneville personnel. Accounting was amenable to modifying procedures when necessary. For example, when contractors ran into cash-flow problems due to inspection delays, Pacific set up receivable accounts to permit early contractor payments and delayed Bonneville reimbursement. Although Bonneville would not reimburse retrofit costs for any jobs that had not passed inspection, Pacific's financial exposure was minimal because advance payment was made only to contractors with collateral in a bank of completed, but uninspected jobs.

Budget categories

The following accounting budget categories are used in this study:

Direct labor is the full-time, part-time, and overtime labor of Project and Pacific employees.

Labor overhead is calculated as a percent of direct labor to cover payroll taxes, benefits, and pensions for full-time and part-time employees.

Pacific administration is the labor of Pacific's Accounting Department calculated at an average 3.8 percent of the dollar amount of Project requisitions processed and archived. The federal government term for this category is general and administrative expense (G&AE).

Consultants includes the cost of labor and materials contracted for services such as advertising, legal advice, energy audits, software programming, survey research, editing, statistical work, and clerical help.

Direct materials includes load-monitoring equipment, radon monitors, computer printer supplies, and the cost of delivery.

Materials overhead was calculated at 4.73 percent of the cost of direct materials to cover purchasing and storing direct materials. This category includes the cost of supplies (wire, voltage meters, shop tools, etc.) needed to service direct materials.

Direct costs are fixed costs such as rent, utilities, and supplies.

II. Operations' Costs

Three major areas of operations' costs are discussed in this chapter: administration, marketing, and the computer system. The efficacy of budget strategies for each of these cost areas is shown by examining the area's original budget, modified budget, and final expenditures.

Table 3. Total administrative costs, May 1986

Budget Category	Dollar Cost		Percent Total
Direct labor		678,092	53
Labor overhead		244,640	19
Pacific administration		35,206	3
Consultants		17,690	1
Infrared wall tests	10,025		
Legal services	4,643		
Contract clerical	2,829		
Mobile home infrared tests	193		
Travel		75,743	6
Transportation	55,313		
Per diem	20,430		
Direct costs		236,331	18
Rent	40,369		
Utilities	6,778		
Telephone	53,092		
Postage	4,489		
Printing	8,730		
Equipment lease	66,895		
Office supplies	17,885		
Staff relocation	28,425		
Other	9,668		
Total		$ 1,287,702	

Administration

The dollar amount and percentage of total administrative costs are shown in Table 3. The administration budget provided for salaries, overtime, leave

pay, pensions, and insurance benefits for six to 17 full-time Hood River field office employees and six quarter-time (or less) Pacific corporate and Hood River district employees. Employee relocation, travel, meals and lodging, consultants' services, and field office expenditures also were funded by the administration budget.

Seventy-two percent ($923,000) of total costs paid for direct labor and labor overhead. Overtime accounted for 22 percent ($146,000) of direct labor, and was charged by Project inspectors, computer personnel, and clerical staff to meet retrofit production schedules.

Almost $76,000 was charged by Project management and staff for travel within the Hood River test area and between Portland and Hood River. Most travel charges were made by Project inspectors for trips within the test area to inspect (and sometimes reinspect) 2,989 weatherized residences.

Table 4, taken from Bonneville's "Chief Auditor's Report," shows Project overhead as a percentage of the Project's expenditures for direct labor (excluding overtime) and Pacific's general administration. Labor overhead was calculated at an average of 46 percent of direct labor. Overhead for Pacific's general administration was calculated at an average of 3.8 percent of the dollar amount of Project requisitions processed by Pacific's Accounting Department. The final average percentage calculated for labor overhead was 13 percent higher than originally budgeted.

Table 4. Project overhead

Year	Labor Overhead Percentage		Pacific Administration Percentage	
	Budgeted	Spent	Budgeted	Spent
1983	40.99	43.22	2.85	3.58
1984	40.99	47.81	2.85	3.78
1985	40.99	47.33	2.85	4.00

Figure 1 shows original budget provisions, modifications, and final expenditures for five administrative budget categories. The total original budget provision ($951,000) was 26 percent below actual total administrative expenditures ($1,288,000). This is because the weatherization contract was extended 20 percent, from 24 months to 30 months. Actual total expenditures were just four percent below the total amount budgeted after modifications to fund the extension. Therefore, management's budgetary predictions of administrative costs were fairly accurate.

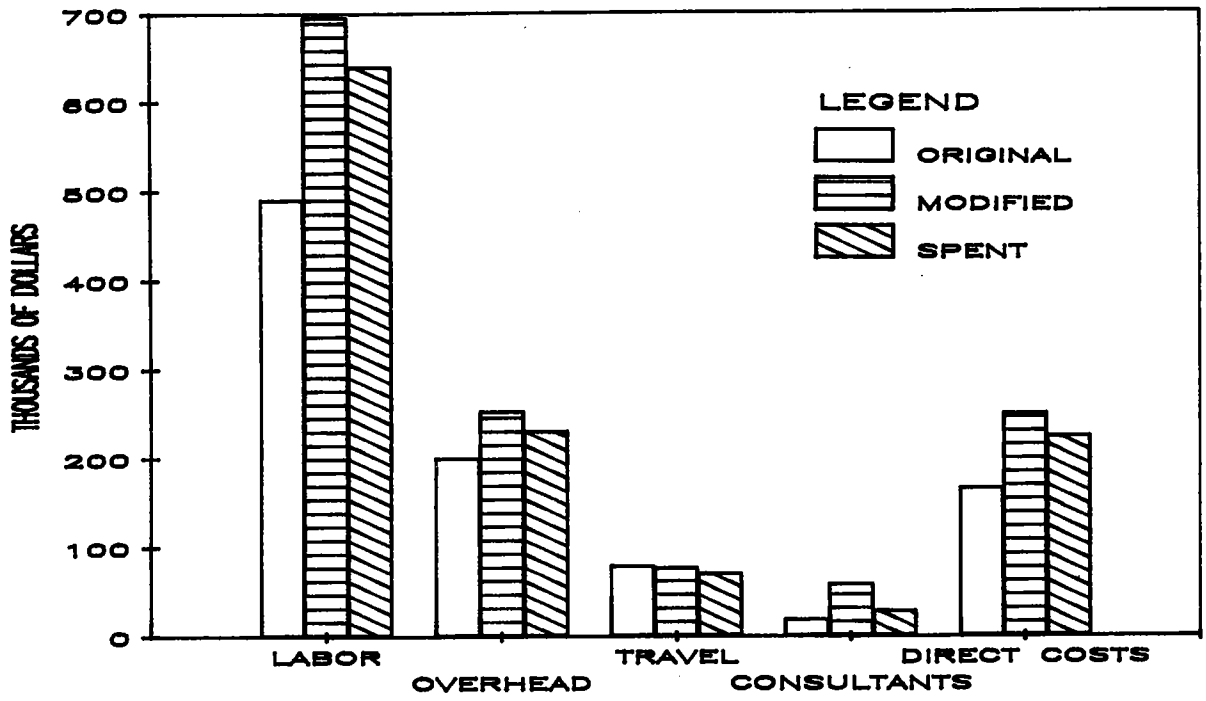

Figure 1. Administration budgets.

In Figure 1, direct labor has the largest increase between the amount originally budgeted and the amount actually spent. This budget category was modified to fund additional direct labor costs when the weatherization contract was extended six months, and to cover expansion of the field office staff from 11 to 17 in March 1985.

Marketing

Marketing was only six percent of the total cost ($1,796,000) of operations. Almost 75 percent of the marketing budget was not spent due to the early success of the promotional plan. The marketing program was guided by a promotional plan devised in 1983 by Project and Pacific employees (Engels, Kaplon, and Peach 1985). The promotional plan had three basic strategies: 1) promotional activities were incremental and cumulative, i.e., new levels of promotion would include previous elements; 2) Project publicity would be initially general and subsequently specific; and 3) promotional expenses would be initially low-cost with more expensive promotion purchased incrementally as needed.

Table 5. Total marketing costs, May 1986

Budget Category	Dollars Cost		Percent Total
Direct labor		424	*
Pacific administration		1,842	2
Consultants		80,622	71
Advertising	32,863		
Printing	33,370		
Non-electric home audits	14,389		
Special equipment		8,960	8
Direct costs		21,421	19
Audio visuals	11,725		
Community relations	7,528		
Other	2,168		
Total		**$113,269**	

* Less than one-half percent.

Employment of the simplest, least costly stages of the promotional plan generated enough requests by customers for audits to eliminate the more costly stages of the plan during the Project's first year. Over 55 percent of potentially eligible residents in the test area requested Project audits

before May 1984. Homes without electric heat were audited by the Project as a good-will gesture to the community. The community-oriented promotional plan and the Project's "no-cost" retrofit package attracted enough citizens in the test area to meet marketing goals without large marketing expenses.

As Table 5 shows, the largest marketing expenditures were for direct costs (19%) and consultants (70%). Direct costs covered promotional items such as standing displays, jacket patches, and Project pins. Consultants' costs covered printing and the services of an advertising agency. The agency was contracted to create art work, a Project logo, newspaper and billboard ads, posters, business cards, stationery, shirts, door hangers, and balloons. Although some of these items originally had been budgeted under direct materials, the advertising agency's agreement included the production of promotional materials, which had a 40 percent overhead. The agency also contributed to the writing of an instructional marketing plan that was submitted to Bonneville as a contract deliverable.

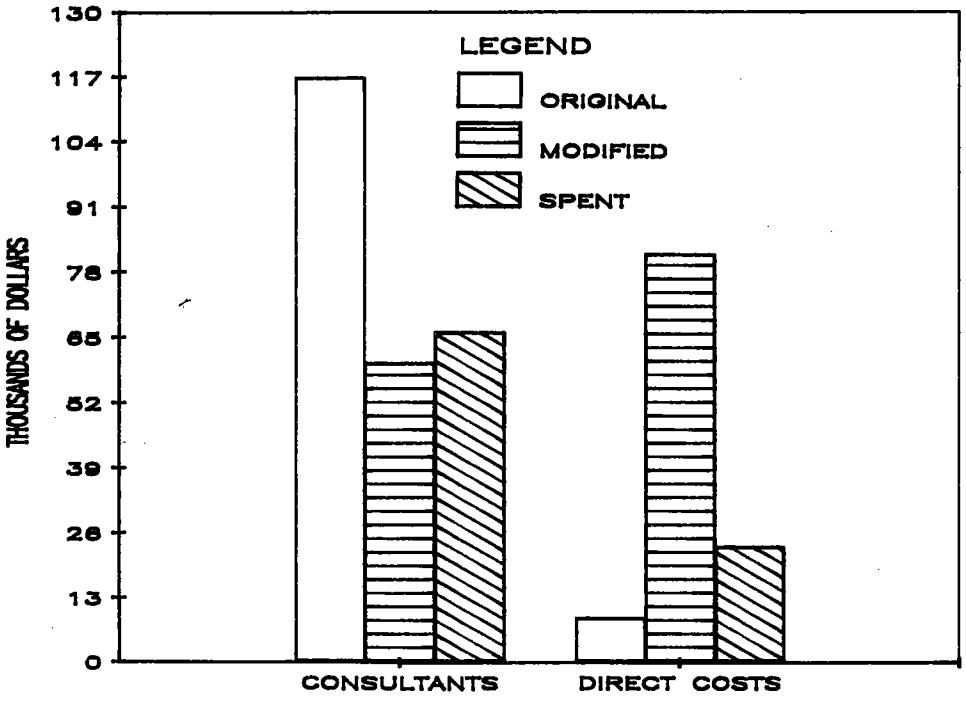

Figure 2. Marketing budgets.

Only 25 percent of the total marketing budget ($403,500) was spent. A budget provision of $136,000 for direct labor and labor overhead was virtually unused. As shown in Figure 2, the only marketing budget modifications were in the consultants and direct costs categories. Approximately $60,000 was added to the original budget provision of $117,000 for consultants, but only 37 percent of the total amount reserved for consultants was actually spent. The original budget provision for other direct costs was $9,100, which was increased by a budget modification for $82,000 that was approved in anticipation of a hard-sell advertising campaign to begin in early 1985. However, application of the first level of the promotional plan resulted in high citizen response, and eliminated the need for the advertising campaign.

The Computer System

The computer system accounted for 22 percent of all operational costs. Most of the computer system costs were incurred during the Project's first 18 months when the system was installed, tested, and modified. Actual total costs were 92 percent of the original computer system budget. Table 6 shows the actual costs of the computer system. Almost 77 percent ($302,162) of the total cost went to consultants. Of this amount $286,000 was paid to a computer system vendor, and the remainder funded data base transmissions from Hood River to General Electric's (GE) Mark III and Mark 3000.

Hardware and software were provided by the computer consultant who purchased a GE Marklink terminal system, rented it to the Project, and programmed custom software.

The system's hardware consisted of a TI800 minicomputer with an 80-megabyte fixed disk and 16-megabyte removable disks. A GE-based Marklink terminal operating system accompanied the minicomputer. Six removable disk cartridges backed up the operating system and disk data base. Three data-entry terminals, a Terminet 200 printer, a modem, and a surge suppressor were installed. The modem connected the computer with two GE national computer facilities. Six hand-held HP75C computers for use by resident energy auditors also were obtained.

The Project rented time on Pacific's load research HP-1000 minicomputer and load-data translation system. Pacific's mainframe computer was employed to track customers' electrical consumption and validate data received from the other computers. The Project purchased four microcomputers in 1984 for use by the R&E team and the field office.

Table 6. Total computer system costs, May 1986

Budget Category	Dollars Cost		Percent Total
Direct labor		53,617	14
Pacific departments			
Application Systems	31,503		
Energy and Conservation	22,114		
Labor overhead		22,606	6
Pacific administration		2,573	*
Consultants		302,162	77
Travel		5,354	1
Transportation	2,966		
Per diem	2,388		
Direct costs		2,181	*
Direct material		6,087	2
Printer supplies	15		
Freight	6,072		
Total		$ 394,580	

* Less than one percent.

The next largest expense category (14%) was for the direct labor of Pacific employees who assisted in the design, implementation, and testing of the computer system. (It should be noted that the direct labor of computer personnel in the Hood River field office was not funded by the computer system budget, but by the administration budget.) The travel category of the computer system budget covered transportation and per diem costs for trips from Portland to Hood River, and trips by a team of three computer specialists (one Project and two Pacific employees) to the computer system vendor's offices about 900 miles distant.

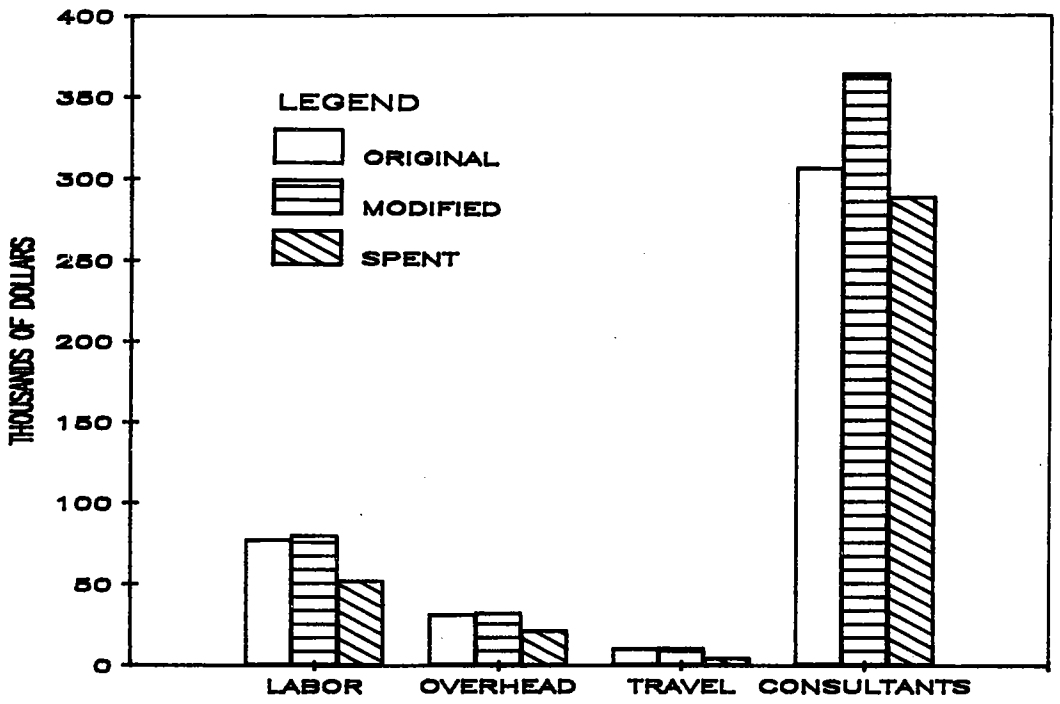

Figure 3. Computer system budgets.

Figure 3 shows provisions and actual expenditures of four categories of the computer system budget. The total modified budget amount of these four categories was 24 percent higher than the actual total cost. Only 83 percent of the consultants' budget, and 67 percent of the direct labor and labor overhead budgets, were spent. This area was over budgeted because Project management anticipated more costly modifications to the computer system than were necessary.

III. Installation Costs and Estimated Savings

This chapter analyzes the costs and projected savings of about 14,000 weatherization measures that were retrofit in 2,989 residences. The chapter begins with a description of the planning method used to devise estimates for the cost and number of measures to be installed in the test area. The main body of the chapter analyzes the costs of 15 Project retrofit measures. The four measures installed during the audit and the 11 major measures installed in homes receiving Project weatherization are examined as follows: audit costs and estimated first-year kWh savings, aggregate costs, quantile distributions of measure costs, and the number and cost of "carried" measures. Measure costs under two pricing systems, competitive bid and unit price, are examined and compared. The costs of air-to-air heat exchangers, radon monitors, heat pump ventilators, and dehumidifiers are also presented. Costs under the exclusive use of each pricing system are projected, and an optimal cost projection based on a mix of both pricing systems is recommended. The chapter ends with a section on estimated kWh savings, a theoretical analysis of estimated $/kWh savings, and projections of the amount of participation and measure penetration under another incentive limit.

Planning Estimates

The weatherization contract anticipated 100 percent market penetration of electrically heated homes in the Hood River test area. During Project planning, a committee reviewed the records of customers in the Pacific and HREC service territories to identify potential Project customers. Approximately 3,100 homes were targeted for weatherization. Almost 250 homes were not included in this target because according to utility records they had been retrofit with major weatherization measures under one of Pacific's prior conservation programs.

Initially, weatherization costs were estimated by multiplying prices for the maximum measures that might be installed in each residence by the 3,100 targeted homes. The product was almost twice the figure suggested by Bonneville. In order to reduce this, the test site's housing stock was analyzed in terms of age and construction properties. Each block of homes was assigned an average condition for the floors, walls, windows, ceilings, etc., and the range of measures necessary to produce first-year energy savings at an incentive limit of $1.15/estimated first-year kWh saved was listed.

Manufacturers and suppliers were queried on prices, but these were difficult to obtain because the package of 11 measures planned was to be installed at very high levels (see Table 7). A few measures were not commonly manufactured (e.g., double-pane storm windows) and/or there were no industry standards for materials and installation (e.g., mobile home retrofit).

Final estimated costs were found by multiplying the number of measures identified in the housing stock analysis times the estimated cost of manufactured measures, supplies, and installation labor. These final estimates were within the range of funding Bonneville considered feasible.

Table 7. Hood River retrofit measures

Measures	Target Levels
Home energy audit	Electrically heated homes
Insulation	
Ceiling	R-49
Floor	R-38
Wall	R-11 to R-19
Duct	Crawl space R-11, attic R-30
Windows and doors	
Windows	Triple glazed
Doors	
Insulated	Thermal
Sliding	Triple glazed
Infiltration	
Caulking, weather stripping	Where applicable
Clock thermostat	Where applicable
Audit installed measures	
Hot water pipe wrap	R-3
Electric water-heater wrap	R-11
Outlet & switchplate gaskets	Where applicable
Low-flow shower heads	Where applicable
Heat pump conversion of existing furnace	Where appropriate conventional measures cannot be installed
Air-to-air heat exchangers and dehumidifiers	As required

Table 8. Audits and audit measures: Dwellings and costs

Type of Dwelling	Type of Heat: Electric	Other*	Oil**
	Homes Audited		
Single	1,927	286	--
Duplex	68	4	--
Triplex	42	0	--
Multiplex	461	9	--
Mobile	584	15	--
Cabin	138	15	--
Total	3,220	329	--
	Homes with Audit Measures		
Total	2,703	156	157
Item	Dollar Cost		
Auditors	170,982	4,761	--
Measures	85,279	4,571	5,057
Total	256,261	9,332	5,057
Average			
Audits	53	14	--
Measures	32	29	32

* Wood, gas, or propane heat.
** Data on Oregon Oil Heat Institute audits are not available.

Retrofit Measure Costs

Audits

The types of homes audited and audit costs are shown in Table 8. A home energy audit was the first step in the weatherization process. The audit determined the level and number of measures appropriate for installation and the amount of incentive dollars available for each residence. The auditor also recorded any barriers to retrofit work: 81 percent of all barriers were

noted during the audit, and 83 percent of measures recommended by auditors were installed.[4]

The Project audited 3,220 electrically heated homes and 329 homes heated with other fuels such as wood, gas, or propane. Audits for oil heated residences were paid by the Oregon Oil Heat Institute, but the Project paid for audit measures (outlet gaskets, water-heater wraps, hot-water pipe wraps, and low-flow shower heads) installed by the auditor if no barriers existed. These audit measures also were installed in 84 percent (2,703) of electrically heated homes and 47 percent (156) of homes heated with wood, gas, or propane that were audited. Nine percent of all homes retrofit with the 11 major measures (269 of 2,989) did not receive any audit measures. The cost of audits and measures for wood, gas, propane, and oil heated homes is in the marketing budget in Chapter II.

The Project hired a vendor who conducted audits of 3,549 non-oil heated homes, and installed $89,850 in measures. Calculations were not done during the audit to estimate how many kWh these measures might save, but they are the least expensive of the 15 retrofit measures. The number of non-oil (electric, wood, gas, or propane) heated homes receiving audit measures, the number of measures, and their average cost is shown in Table 9.

Table 9. Audit measures in non-oil heated homes

Audit Measure	Measures Installed	Total Homes	Average Cost
Outlet gaskets	2,689	2,689	$ 11.41
Water-heater wraps	1,599	1,590	19.74
Hot-water pipe wraps	2,251	2,040	5.44
Low-flow shower heads	2,538	1,999	6.05

[4] The barrier most frequently identified in the eight percent of homes that contacted the Project but were not accepted for retrofit of major measures was measures were more costly than the residential cost limit of dollars generated by the audit's calculation of estimated first-year kWh savings (Goeltz and Hirst 1986).

Estimated first-year kWh savings

Table 10 is based on analysis of the estimated kWh savings calculated by the Standard Heat Loss Methodology (SHLM) and recorded by the auditor (Bonneville 1982). Shown are the estimated average first-year kWh savings per measure. Wall insulation has the highest average estimated savings per residence: 50 percent of homes with wall insulation are estimated to save about 2,200 kWh each. Floor insulation has the second highest average savings. Ceiling insulation has the widest range of estimated kWh/sq. ft. savings. Ninety-nine percent of ceiling insulation was below a 10.10 kWh/sq. ft. savings estimate. Duct insulation has the widest range of estimated kWh/lineal foot savings, and 99 percent of duct insulation was below an estimated savings of 53.73 kWh/lineal foot.

Table 10. Estimated first-year kiloWatt-hour savings

Measure Installed	Number of Homes	Mean kWh	Std. Dev.	Quantile Distribution (kWh)				
				Min.	Q1	Median	Q3	Max.
Insulation								
Ceiling	1,980	1,691	1,931	28	536	1,049	1,920	13,807
Floor	1,864	2,093	1,365	38	993	1,873	3,070	9,725
Wall	1,163	2,480	1,930	12	1,032	2,227	3,480	15,612
Duct	357	726	923	13	122	390	915	5,848
Windows & Doors								
Windows	2,641	1,678	1,150	49	840	1,446	2,240	9,385
Doors								
Sliding	872	504	458	117	237	395	662	9,107
Insulated	86	208	101	102	147	166	207	616
Infiltration								
Caulking	2,307	136	69	12	88	127	175	564
Weather stripping								
Windows	2	284	76	230	230	284	338	338
Doors	2,046	46	23	4	32	43	59	155
Clock thermostat	758	253	26	174	261	261	261	261

Storm windows have the highest estimated kWh savings among glazing treatment offered: 50 percent of homes might save 1,446 kWh/year or more, and 25 percent might save 2,240 kWh/year or more. Clock thermostats have the most narrow range of savings; at least 75 percent are estimated to save 261 kWh.

Table 11. Estimated standardized savings, insulation

Measure Installed	Number of Homes	Mean kWh/ Sq.ft.	Std. Dev.	Quantile Distribution				
				Min.	Q1	Median	Q3	Max.
kWh/square foot								
Ceiling	1,980	1.89	2.80	0.03	0.64	1.00	1.87	74.25
Wall	1,163	2.43	1.93	0.01	0.89	2.28	3.59	17.04
Floor	1,474	2.35	1.55	0.01	1.49	2.58	2.97	28.46
kWh/lineal foot								
Floor	58	4.80	3.26	0.86	2.69	4.21	6.16	21.76
Duct	357	7.26	11.19	0.07	1.98	2.71	8.89	114.00

Incentive limit

During the residential energy audit, a calculation was run on a hand-held HP75C computer programmed with Bonneville's SHLM. The auditor recommended measures if the SHLM indicated they could be funded under an incentive limit. The SHLM estimated first-year electrical energy savings if appropriate Project measures were retrofit in the residence under audit. The estimated amount of kWh savings during the first year following weatherization was multiplied by $1.15, and the product was the dollar amount available for weatherization of the residence being audited.

The $1.15 per estimated first-year kWh-saved incentive limit was derived from several figures employed in the calculation: Bonneville's "long-run incremental cost" with Bonneville's transmission loss and Pacific distribu-

tion loss, the capacity savings of a base load thermal plant, the 10 percent conservation bonus provided by the Regional Power Act, and an assumed average useful measure life of 35 years.

Table 12. Number and cost* of major measures

Measure Installed	Number	Dollar Cost (thousands)
Insulation		
Ceiling	1,980	1,896
Floor	1,864	2,508
Wall	1,163	836
Duct	357	95
Subtotal	**5,364**	**5,335**
Windows & Doors		
Windows	2,641	4,528
Doors		
Sliding	872	624
Insulated	86	38
Subtotal	**3,599**	**5,190**
Infiltration		
Caulking	2,307	255
Weather stripping		
Windows	2	1
Doors	2,046	167
Subtotal	**4,355**	**422**
Clock thermostat	758	111
Total	**14,076**	**11,058**

* Rounded to nearest 1,000.

Aggregate measure costs

The number and cost of installed measures is shown in Table 12. The insulation package and the windows and doors package had the largest shares of total dollar costs, 48 and 47 percent respectively. Storm windows were installed most often and also were the most costly measure at $4.5 million.

Costs per measure

The average cost of each measure and its quantile[5] distribution are presented in Table 13 and the standardized cost of insulation measures is shown in Table 14.

Average costs were highest for storm windows, and lowest for door weather stripping. Although storm windows were the most expensive measure, nearly 90 percent of homes had them installed at an average cost of $1,714. The Project's target condition was triple-glazed windows. Sometimes dual-glazed storm windows were installed over single-glazed windows, and sometimes the existing windows were replaced by double-glazed windows and single-glazed storm windows were installed over them. The storm window cost in Table 13 is the total cost of both retrofit remedies. Included in this cost is reinforcement of window frames in older homes where the weight of triple-glazed window treatments tended to sag the frames. Labor costs for handling the relatively heavy windows were also high.

As Table 14 shows, the insulation measure with the highest cost per square and lineal foot was floor insulation, which was retrofit in 51 percent of all homes. Floors were more expensive per square foot than wall and ceiling insulation. This was because walls and ceilings were most often insulated with cellulose, which is less costly than fiberglass, while floors were insulated only with fiberglass. The labor costs for installing floor insulation also were higher than those for ceilings or walls. There were 58 homes built on concrete slabs and perimeter floor insulation, which was relatively costly, was all that was possible.

The least frequently installed measures were window weather stripping, duct insulation, and insulated doors. Only two homes had their windows weather stripped because most homes received storm windows. Only 12 percent of homes had duct insulation because most homes had baseboard heat. Insulated doors were placed in only three percent of homes because of a Project policy limiting the circumstances under which insulated doors were appropriate. Table 15 shows conditions, existing and target, for windows and doors in single-family homes, and their cost per condition.

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5 A quantile distribution may be either positively or negatively skewed. When the mean falls to the right of the median, the distribution of costs is positively skewed, when it falls to the left of the median it is negatively skewed. A perfectly symmetrical distribution has coinciding mean and median values.

Table 13. Costs per measure

Measure Installed	Number of Homes	Mean Cost	Std. Dev.	Quantile Distribution ($)				
				Min.	Q1	Median	Q3	Max.
Insulation								
Ceiling	1,980	957	542	26	571	906	1,227	7,536
Floor	1,864	1,345	710	27	806	1,311	1,784	4,400
Wall	1,163	718	558	5	260	640	1,028	3,903
Duct	357	266	244	11	55	220	400	1,926
Windows & Doors								
Windows	2,641	1,714	1,143	88	922	1,518	2,221	12,737
Doors								
Sliding	872	716	393	180	450	612	800	5,500
Insulated	86	442	235	166	325	325	452	1,700
Infiltration								
Caulking	2,307	111	55	7	85	100	150	600
Weather stripping								
Windows	2	138	88	75	75	138	200	200
Doors	2,046	82	54	5	48	65	106	400
Clock thermostat	758	147	39	93	129	129	144	486

Carried measures

At times the field specialists were able to recommend measures that exceeded the incentive limit by "carrying" the measures. The cost of these measures was carried by inexpensive measures, such as the insulation package (see Table 13). For example, the cost of installing wall insulation was lower than the dollars the wall insulation was estimated to save (based on the audit) in the first-year after retrofit. The remaining dollars were applied to pay for measures like storm windows that were costly. Thus, wall insulation "carried" storm windows.

Table 14. Standardized costs, insulation

Measure Installed	Number of Homes	Mean	Std. Dev.	Quantile Distribution				
				Min.	Q1	Median	Q3	Max.
				$/square foot				
Ceiling	1,980	0.96	0.63	0.01	0.69	0.89	1.11	20.58
Wall	1,163	0.68	0.50	0.01	0.23	0.69	0.97	3.65
Floor	1,474	1.46	0.92	0.05	1.22	1.43	1.60	24.83
				$/lineal foot				
Floor	58	7.32	4.21	1.11	3.76	5.98	9.69	23.20
Duct	357	2.44	1.80	0.12	1.64	2.07	3.00	20.00

The auditor evaluated each dwelling unit for its estimated kWh savings potential. The building was the unit of Project measurement. Dollars left over from installation of measures in one unit could not be transferred to pay for measures in another unit. However, if two or more residences shared the same roof and crawl space or basement the building was treated as a single unit and measures were carried between residences. Thirty-eight apartment houses and ten triplexes were treated as single units and dollars for measures were transferred to neighboring residences to carry measures.

Table 15. Single-family homes, cost per target condition

Measure	R-Value Condition Existing	Target	# of Conditions	Cost ($) /sq. ft. /R-value
Insulation				
Ceiling	0-11	49	356	0.0303
	12-19	49	375	0.0269
	20-30	49	178	0.0272
	31-38	49	29	0.0322
	39+	49	5	0.0393
Floor	0-7	38	620	0.0426
	8-11	38	28	0.0428
	12-19	38	37	0.0517
	0-7	30	25	0.0476
	12-19	30	1	0.1072
	0-7	19	33	0.0562
Wall	--	11	103	0.0907
Duct*	0-4	11	181	0.2964
	5-7	11	14	0.4897
Glass				
Windows	a	e,f,g	741	13.3511
	c	i	481	8.7402
	d	e	136	10.9831
	d	f	5	8.1103
	a,b,c,d	h	27	19.4713
Sliding doors	a	e,f,g	295	17.1697
	c	i	417	12.2054
	d	e	7	15.8706
	a,b,c,d	h	33	17.8400

* lineal feet.
a = single glass.
b = single glass + single sash mount storm.
c = single glass changeout to double glass (1/4" air space).
d = single glass + single non-sash mount storm.
e = single glass + double storm (1/4" air space).
f = single glass changeout to double glass + storm (1/4" air space).
g = single glass total replacement to double glass + storm (1/4" air space).
h = triple glass (1/4" air space).
i = double glass + single storm (1/4" air space).

Table 16. Number and cost of carried measures

Measure Installed	All Measures	Carried Measures			
	Number	Number	Percent Total	Dollar Cost*	Percent Total
Insulation					
Ceiling	1,980	580	29	510	27
Floor	1,864	382	20	471	19
Wall	1,163	26	2	20	2
Duct	357	71	20	26	27
Subtotal	**5,364**	**1,059**	**20**	**1,027**	**19**
Windows & Doors					
Windows	2,641	960	36	1,998	44
Doors					
Sliding	872	611	70	425	68
Insulated	86	84	98	37	97
Subtotal	**3,599**	**1,655**	**46**	**2,460**	**47**
Infiltration					
Caulking	2,307	623	27	87	34
Weather stripping					
Windows	2	--	--	--	--
Doors	2,046	1,385	68	139	83
Subtotal	**4,355**	**2,008**	**46**	**226**	**53**
Clock thermostat	758	64	8	17	15
Total	**14,076**	**4,786**	**34**	**3,730**	**33**

* Thousands.

The number of carried measures, their cost, and percentages of totals are shown in Table 16. Thirty-four percent of all measures were carried at 34 percent of total cost. Parallels between the percentages of cost and number of installations were constant in all cases except door weather stripping, which was 15 percent higher in cost. The infiltration package and windows and doors package were each carried in 46 percent of installations. Ninety-eight percent of insulated doors and 70 percent of sliding doors were carried. Windows, the most frequently installed measure, were carried 36

percent of the time. Not surprisingly the least costly measure was carried the least; only two percent of all wall insulation was carried.

Pricing Systems

The Project employed two pricing systems, competitive bid and unit price. Although unit prices superceded competitive bids as the Project's pricing system in September 1984, competitive bidding continued to be used intermittently throughout 1985.

The Project contract called for utilization of a unit-price system. In the fall of 1983 Project managers, in order to develop a realistic range of prices, invited the Project's five contractors to submit a single round of bids based on their own projected costs. The bids submitted were double the costs for comparable levels of measures in most of Bonneville's other residential weatherization programs. Contractors defended their bids by asserting they wanted a cushion against the cost of installation of the Project's high target levels and the close inspections their work would have to pass before they were paid. However, acceptance of the contractor's prices would have made attainment of Project goals impossible without considerable additional funding. Project staff, Bonneville management, and contractors spent several weeks in negotiation discussing price schedules.

In early 1984, Bonneville and Project managers agreed to temporarily adopt a competitive-bid system in hopes of reducing the unit prices discussed by contractors. After seven months of competitive bidding a unit price schedule was devised by matching the average dollar amounts of contractors' bids and invoices with those of several other Bonneville weatherization projects. The Project's unit-price system was adopted in September 1984.

Competitive bids

Under the competitive-bid system at least two bids had to be submitted for each component measure to be retrofit. Contractors were sent to randomly assigned residences to conduct construction surveys and calculate bids. Contractors were not paid for the time spent preparing bids, though the competitive-bid system tripled their paperwork. Although this was a normal cost of doing business, it was more time-consuming and costly than bid preparation they had done for other retrofit work.

The Project staff did not post or discuss bids with contractors, but prices did not come down as far as Project managers hoped they would. At times one of two bids was unrealistically high or low, or basic details of physical surveys varied so much that competition was a moot point. If all bids were high, the job either was re-evaluated or done at a high cost. Project managers decided there might not be a sufficient level of competition to significantly bring prices down under this system.

Unit prices

In June 1984 a unit-price schedule was developed through analysis of audits, bids, and invoices from both the Project and Bonneville's Residential Weatherization Program. Contractors' books, however, were not reviewed. When the second-round contractors joined the Project in September, the unit-price system was accepted by all 11 Project contractors.

Under this system only one contractor surveyed a residence and prepared cost proposals for insulation and/or glass. The cost proposal was based on the square (or lineal) feet of each measure times the unit price. If the contractor's cost proposal reconciled with the cost limit set during the residential audit, the job was awarded. Upon completion of the job a Project inspector verified the square footage of measures installed.

If a contractor's cost proposal was above the Project's cost limit for a given residence, a field specialist negotiated the cost with the contractor and the customer. If the proposal was over the cost limit by less than $200, the contractor would be asked to lower the proposal. If the contractor would not lower the proposal, the customer was asked to pay the amount over the cost limit. If a contractor's cost proposal exceeded the cost limit by more than $200, the field specialist asked the customer and contractor to split the difference.

The Project did not keep records of how much contractors contributed to weatherization costs by dropping their bids. The Project did track customer contributions to the cost of weatherizing their own residences: ten percent of all customers made an average payment of $520. The total amount of customer contributions, $156,000, was forwarded by Pacific to Bonneville.

Comparison of pricing systems

The Project weatherized 1,728 homes (58 percent) under unit prices and 1,242 homes (42 percent) under competitive bids; 19 homes were retrofit under both systems. Figures 4 and 5 show the number of "notices to proceed" with work on residences sent to contractors under both pricing systems. These notices were sent after retrofit work had been priced, approved, and awarded to contractors.

Sixty-two percent of all retrofit was done in 1985, with almost 90 percent of that work under unit prices, but they were slow in getting started in the fall of 1984. Figure 4 shows that unit-priced jobs rose promisingly in October, shortly after they were adopted. This rise was due to a file of second-round contractors' cost proposals that had been approved and awarded during September. Notices to proceed for both pricing systems took a plunge during November when handling a severe inspection backlog of finished jobs became the focus of the field office staff (Philips et al. 1986). Unit prices took off again in December when the inspection problems were solved, and 130 notices to proceed were issued. The high point of unit-priced retrofit work took place between May and December 1985 when 62 percent (1,064) of jobs under this system were started.

In December 1984 when the number of unit-priced jobs first exceeded competitive-bid jobs, 70 percent of all competitive-bid work had already been awarded. In 1985 competitive bidding was used for apartment house work, homes with difficult installation problems, or measures or contractors that were requested by customers, but not covered under the Project's cost limit. In Figure 4, the spike in June 1985 competitive-bid jobs was mainly retrofit work on 85 residences in 11 apartment houses that contractors had bid lower than unit prices. Competitive bids also were used for work that was unattractive to contractors, i.e., homes with difficult retrofit problems. If a contractor reported this work could not be done under unit prices, the contractor's unit-price proposal was considered a competitive bid, and another contractor was asked to submit the second bid. About a third of the cabins retrofit in 1985 were under competitive bids, which indicates difficult retrofit problems were encountered. The third instance where competitive bids were preferred to unit prices was when customers requested measures or contractors not covered under the Project's cost limit for that home. In such instances the customer paid the excess cost for the job.

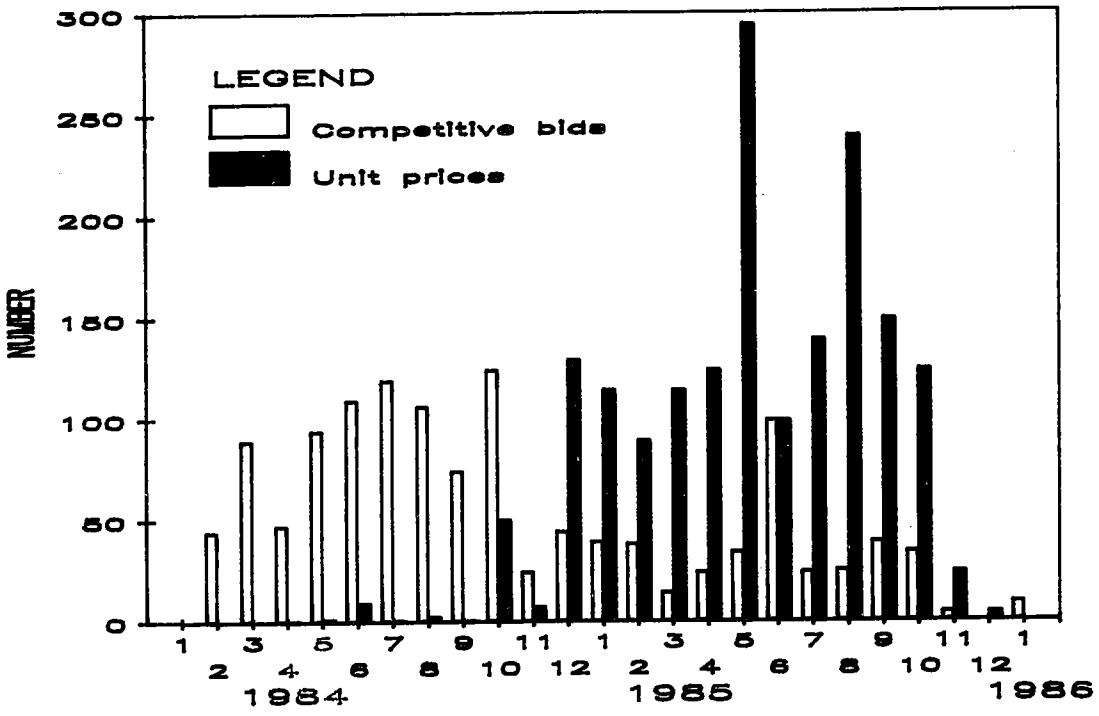

Figure 4. Notices to proceed, competitive bids and unit prices (frequency).

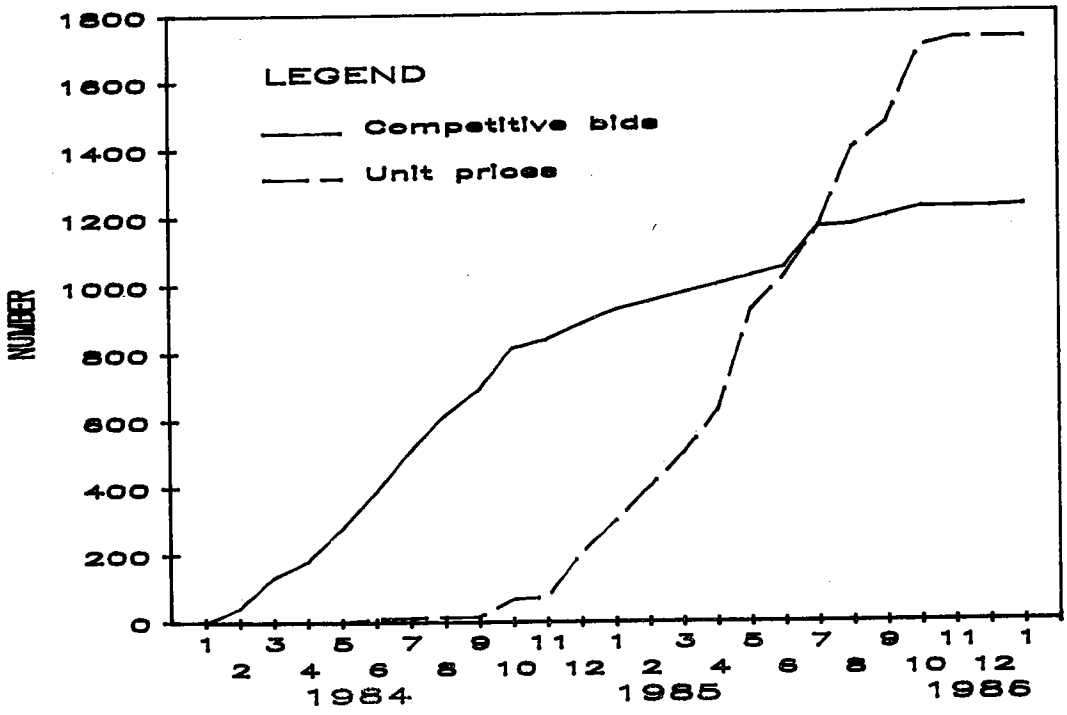

Figure 5. Notices to proceed, competitive bids and unit prices (cumulative).

Housing distribution

Table 17 shows the type of dwellings retrofit under each pricing system. Single-family homes accounted for 60 percent of all retrofit work, split 50-50 between the two pricing systems even though 62 percent of all retrofit was done in 1985. The Project concentrated on single-family homes in 1984; they accounted for 80 percent of all jobs that year.

Table 17. Type of homes retrofit under unit prices and competitive bids*

Type of Housing	1984 Unit #	1984 Bid #	1985 Unit #	1985 Bid #	1984-85 Total /type #
Single	138	759	748	153	1,798
Duplex	6	12	30	2	50
Triplex	3	12	15	0	30
Multiplex	79	72	169	111	431
Mobile	0	0	468	63	531
Cabin	12	27	61	30	130
Total	**238**	**882**	**1,491**	**359**	**2,970**

* Based on per residence "notices to proceed" sent to contractors.

The Project retrofit 25 duplexes and 10 triplexes mostly under unit prices. In 1985 only two triplexes were retrofit under competitive bids. Multiplex retrofit was done on 15 four-plexes, six five-plexes, and 38 apartment houses that contained 342 apartments. When unit pricing geared up in December 1984, the field office awarded 79 residences in multiplexes under this system. The trend to use unit prices for multiplex work was reversed in mid-1985 when Project management discovered that contractors considered apartment houses attractive work, and they were willing to bid aggressively below unit prices for these jobs. However, only about a third of all Project apartment house retrofit was done under competitive bidding. Table 18 shows

unit prices were lower than competitive bids for all types of housing, except multiplexes, which were ten percent higher than bids under unit prices.

The biggest savings under unit prices are from measures installed in triplexes, duplexes, and mobile homes. The smallest savings (7%) were obtained in single-family homes. This figure is disappointing in light of 1984 savings of unit prices over bids shown in Table 19, which did not continue in 1985 for single-family residences, some 80 percent of all Project retrofits.

Table 18. Average total cost by housing type, competitive bid, and unit prices

Housing Type	Bid	Unit Price	Percentage Change	All Types
Single	$4,763	$4,417	- 7	$4,594
Duplex	3,781	3,128	- 17	3,328
Triplex	3,084	2,392	- 22	2,613
Multiplex	1,752	1,921	+ 10	1,850
Mobile	2,309	1,886	- 18	1,941
Cabin	880	806	- 8	832

Single-family homes

Table 19 presents 1984 and 1985 measure costs for single-family residential retrofit under the Project's two pricing systems. Bids in 1985 dropped from 1984 bids in a range from one to 24 percent for all measures except windows and doors upgraded from double to triple glazing. However, unit prices in 1985 were higher than 1984 in a range from four to 22 percent for all measures except windows (double to triple glazed) and doors.

Insulation. Unit prices for insulation measures rose in 1985 in a range from five to 22 percent. Walls, the least costly measure (see Tables 13 and 14), were 22 percent higher under 1985 unit prices than they were in 1984. Unit prices for insulation measures in 1984 had produced savings over bids in a range from 13 to 35 percent. However, in 1985 when bids were from one to 18 percent lower than bids in 1984, unit prices were higher than bids for floor and duct insulation.

Windows and doors. Unit-priced windows retained their 1984 cost advantage over bids in 1985. The 1985 savings for unit-priced doors (single- to triple-glazed) over bids rose slightly from the 1984 unit-price savings. However, double- to triple-glazed unit-priced doors rose eight percent over bids in 1985 after an 11 percent drop in 1984.

Table 19. Measure costs for single-family homes, competitive bids & unit prices

Measure	1984* Bids	1984* Unit	1985 Bids	1985 Unit	Percentage Changes '84 '85 Bids	'84 '85 Unit	'84 Unit to Bids	'85 Unit to Bids
	Cents/sq. ft./R-Value							
Insulation								
Ceiling	3.45	2.97	3.43	3.13	- 1	+ 5	- 14	- 9
Floor	4.97	4.30	4.62	4.80	- 7	+ 12	- 13	+ 4
Wall	11.91	7.74	9.81	8.87	- 18	+ 15	- 35	- 10
Duct**	29.74	22.66	26.91	27.64	- 10	+ 22	- 24	+ 3
	Dollars/sq. ft.							
Windows, glazed:								
1 to 3	14.38	11.73	14.87	12.22	+ 3	+ 4	- 18	- 18
2 to 3	10.62	9.92	10.18	9.41	- 4	- 5	- 7	- 8
Doors, glazed:								
1 to 3	18.11	17.17	18.33	17.22	+ 1	0	- 5	- 6
2 to 3	14.39	12.75	11.00	11.91	- 24	- 7	- 11	+ 8

* Adjusted 3.5% (1984-85 GNP deflator).
** Lineal feet.

A comparison of measure costs for single-family homes under the combination of both pricing systems in Table 20 shows the savings for most measures in 1985 to be rather small except for windows and doors (double- to triple-glazed). Moreover, wall insulation costs rose four percent. The total increase in unit-price costs in 1985 was about $123,000. Why did 1985 unit prices for single-family homes lose some of the savings they had in 1984?

The main reason is contractors installed more "adders"[6] in 1985 to meet inspection standards. In the wake of the firing of two contractors for substandard work, contractors were aware of the serious consequences of repeated inspection failures and took more precautions to meet Project standards.

Table 20. Measure costs for single-family homes, combined pricing systems

Measure	1984	1985	Percentage Change
	Cents/sq. ft./R-value		
Insulation			
Ceiling	3.29 (3.41)	3.18	- 7
Floor	4.70 (4.87)	4.77	- 2
Wall	10.13 (10.49)	10.89	+ 4
Duct**	27.95 (28.93)	27.76	- 4
	Dollars/sq. ft.		
Windows, glazed:			
1 to 3	13.57 (14.05)	12.48	- 11
2 to 3	10.16 (10.52)	9.53	- 9
Doors, glazed:			
1 to 3	17.44 (18.05)	17.45	- 3
2 to 3	13.63 (14.11)	11.74	- 17

* Numbers in parenthesis are adjusted by the 3.5 percent GNP deflator for 1984-85.
** Lineal feet.

6 "Adders" were additional costs for installing measures in non-standard areas such as: 1) ceilings -- open attics, roof-ceiling cavities, sloped ceilings, rigid interior ceilings, baffling, vent connections, sealing vent ducts, mobile home attics; 2) floors -- crawl spaces, exterior perimeter insulation, ground covers, crawl space venting, frame and reframe existing openings, post and beam support systems, mobile home floor support systems, skirting repair; 3) walls -- blown glass or sheet rock, asbestos shingles or aluminum siding, portions of wall above nine feet, mobile homes walls of R-3 or less; and 4) windows -- vinyl or angle build outs, removal of existing storm windows, ladders, bronze finish.

Mobile homes

Most mobile homes were retrofit under unit prices. Only an initial block of about 60 homes set aside in 1984 for experimental mobile home retrofit was priced under competitive bids. Mobile homes presented contractors with special insulation challenges that were worked out during the experimental retrofit to enable the Project to retrofit an additional 471 mobile homes. The higher mobile home costs in Table 21 reflect mobile home retrofit difficulties that were not typically encountered in single-family homes.

Table 21. Measure costs, single-family & mobile homes

Measure	Single-family homes		Mobile homes		Percentage difference
	Number	Cents/sq.ft. /R-value	Number	Cents/sq.ft. /R-value	
Insulation					
Ceiling	1,439	3.24	124	3.33	+ 3
Floor	954	10.53	63	14.94	+ 42
Wall	961	4.73	211	6.07	+ 28
Duct*	145	27.85	96	31.77	+ 14
	Dollars per sq. ft.				
Windows, glazed:					
1 to 3	239	13.06	29	16.84	+ 29
2 to 3	277	9.79	54	10.10	+ 3
Doors, glazed:					
1 to 3	163	17.44	29	12.83	- 26
2 to 3	344	12.60	41	11.16	- 11

* Lineal feet.

The costs for single-family retrofit measures were, as Table 21 shows, significantly below those of all mobile home measures except doors. Doors for mobile homes were not more expensive than those for single-family homes because most doors were carried measures. The margin of dollars for insula-

tion measures that typically carry expensive measures like doors was much smaller in mobile homes than in single-family homes. Therefore, the mobile home doors had to pay for themselves under the Project's incentive limit, and so were less costly than doors in single-family homes.

Projected pricing system costs

The total costs of the 11 major measures under each pricing system, if that system had been used exclusively by the Project, were $10.319 million under unit prices, and $11.917 million under competitive bids. If only competitive bidding was used, it would have been 15.5 percent ($1.6 million) more expensive than the exclusive use of unit prices. If unit prices had been instituted at the beginning of the Project, instead of the actual combination of pricing systems used, the Project would have saved an additional seven percent, or $737,000.

Optimal cost projection

Based on the data evaluated above (Tables 17 and 18, Figures 4 and 5), we can construct a cost projection grounded in a recommended pricing mix from the actual housing stock distribution for 1985 (when 2,500 homes were retrofit) that is the most cost-efficient.

We recommend using a mixture of unit prices and competitive bids, provided unit prices are the primary pricing system. Use of the unit price system places the establishment and adjustment of prices to field conditions (e.g., mobile home retrofit) in the hands of management. If this system does not attract contractors to difficult retrofit work, or if customers prefer measures or contractors not assigned to them, then competitive bidding can be employed as needed. Bidding is also, as we have seen, an effective system to lower costs below unit prices when contractors want to aggressively compete for work such as apartment house retrofit or AAHX installation. Conversely, if competitive bids are the primary pricing system the establishment of the range of prices and their modification is done primarily by contractors, with management in the position of a respondent. A final, and not insignificant, benefit to employing unit prices as the primary pricing system is the reduction of administrative work and paperwork required by management and contractors under competitive bids. This reduction saves costs and permits greater control of scheduled production (Philips et al. 1986).

By extending the distribution of housing types between the two pricing systems in 1985, and considering the cost advantages of each system, we developed the projection shown in Table 22. The savings from this projection is 7.8 percent of the actual total cost ($11.056 million) of the Project's 11 major measures, or $858,000.

Table 22. Retrofit costs at simulated housing & price systems mix

Housing Type	Unit Prices			Competitive Bids		
	Number	Cost		Number	Cost	
		Average	Total*		Average	Total*
Single	1,494	$ 4,416	$ 6,598	305	$ 4,763	$ 1,453
Duplex	48	3,127	150	2	3,781	8
Triplex	30	2,391	72	--	--	--
Multiplex	91	1,921	175	342	1,752	599
Mobile	472	1,885	890	64	2,309	148
Cabin	86	806	69	44	808	36
Total cost	**$ 10,198,000**					

* Thousands.

Air-Quality Control

Air-quality control was offered to every customer whose residence received air-tightening insulation measures. The monitoring and mitigation of air pollution included for the most part radon monitoring, and the installation of air-to-air heat exchangers. A few dehumidifiers and heat pump ventilators also were installed.

Air-to-air heat exchangers

The Project installed 1,160 air-to-air heat exchanger (AAHX) units in one-third of the residences weatherized (Philips et al. 1986). Some homes received more than one AAHX. The distribution of AAHXs throughout the Project's housing stock is shown in Table 23.

Table 23. Air-to-air heat exchangers housing distribution and units per home

Type of Housing	Homes
Single family	827
Duplex	15
Triplex	9
Multiplex	114
Mobile homes	72
Cabins	7
Total	**1,044**

AAHX units/home	Homes	Units
One	935	935
Two	103	206
Three	5	15
Four	1	4
Total	**1,044**	**1,160**

AAHX pricing systems

The Project employed the following AAHX pricing systems during the periods indicated:

1. Competitive bidding -- September 1984,
2. Cost-plus pricing -- November 1984 to January 1985,
3. Unit pricing -- January to March 1985,
4. Competitive bidding -- March and April 1985,
5. Unit pricing -- May to December 1985.

In September 1984 the field office asked the Project's pool of 11 contractors to submit bids on several residences to be installed with AAHXs. The plan at this time was to install AAHXs in every home receiving air-tightening measures. The initial round of competitive bids received from contractors was uniformly much higher than prices quoted by contractors in other areas of the region. Therefore, none of the bids were awarded and the Project devised a system of "cost-plus" pricing.

Under cost-plus pricing the Project paid contractors for their itemized wholesale costs plus $400 for overhead and profit. However, the itemization of costs by contractors was inconsistent, and there were varied interpretations by contractors of what the $400 payment covered.

In January 1985 a unit-price schedule was devised from contractors' invoices, and pricing lists that had been gathered from wholesale suppliers and non-Project contractors in the Pacific Northwest. To control contractor's costs, the Project began to provide contractors with more detailed AAHX specifications and installation guidelines. As Table 24 shows, the average cost of ducted units fell $471, and non-ducted units dropped $65 under unit prices.

During the spring of 1985 Project management revised its goals of installing AAHXs in every air-tightened residence. Only homes that tested positive for radon gas and customers that complained of poor air quality were to receive AAHXs. Therefore, the number of job awards to contractors for AAHX installation dropped dramatically when this policy was adopted in March 1985, and contractors began vying for AAHX jobs. The Project took advantage of this situation, and employed competitive bidding for two months to bring prices down further.

After two months the Project eliminated a few high-priced AAHX units from contractors' shopping lists. Another cost-cutting device was the identification of contractors whose bids were consistently lower than other contractors. These contractors' low bids were used to set the upper price limits for a second unit-price system that was adopted in May 1985.

Table 24 shows the second unit-price system was an average of $221 lower for ducted units and $192 lower for non-ducted units than the first set of unit prices. The new unit prices were almost $700 lower for ducted units, and about $260 lower for non-ducted units than under the cost-plus pricing system. Overall costs for non-ducted AAHXs would have dropped further if the percentages of these units to ducted units had remained constant throughout all three periods. However, after customers in the small Hood River community compared AAHXs, customers scheduled for AAHX installation increasingly requested ducted units because they found them more aesthetic than non-ducted wall or ceiling units. Ducted units were more costly than non-ducted units because of higher material and installation labor costs.

Table 24. Pricing systems, air-to-air heat exchangers

Type of Unit	Pricing Systems					
	Cost-plus Nov & Dec 1984		Unit Prices 1 Jan - May 1985		Unit Prices 2 July - Dec 1985	
	Number	$ Cost	Number	$ Cost	Number	$ Cost
Non-ducted, 0 - 70 cfm*	117	957	127	892	576	700
Ducted, over 70 cfm	116	2,189	98	1,718	126	1,497

* cfm = cubic foot per minute of airflow.

Radon monitors

The total cost of radon monitors was $35,100. Almost 2,700 radon monitors were installed in 2,300 homes that received a full package of air-tightening measures. The Project hired a radon monitor vendor who placed the monitors in residences with the help of a service club from the Hood River high school. Analysis of the monitors showed less than four percent of residences had levels of radon gas specified by Bonneville as too high to meet indoor air-quality requirements.

Heat pump ventilators and dehumidifiers

Five heat pump ventilators were installed in five residences where radon gas was present in amounts over Bonneville's minimum standards for air quality. These units were installed for research purposes, and cost an average of $3,793 or a total of almost $19,000.

The Project supplied only four dehumidifiers to residential customers at a cost of $233.54 each, or $934 total. There were no installation costs as these units plugged into wall outlets.

Total air-quality control costs

The original budgeted amount for AAHXs was about half of the actual expenditures necessary for the purchase and installation of 1,160 units. Both the number of units needed and the cost per unit were underestimated in the original budget. The total cost and total average cost per unit of the Project's air-quality control units are shown in Table 25.

Table 25. Air-quality control costs

Measure	Number Units	Total Cost	Average Unit Cost
AAHXs	1,160	$1,239,363	$1,068
Radon monitors	2,700	35,100	13
HPVs	5	18,965	3,793
Dehumidifiers	4	934	234
Total		**$1,294,362**	

Total Retrofit Costs

The sum of installation costs discussed in this chapter is about $12.6 million as shown in Table 26. The average total cost per home by housing type shown in Table 27 includes the average cost per residence of operations (see Chapter II), and the average cost per residences not including air quality measures; administration; air quality measures and administration; and air quality measures, administration, and auditor-installed measures.

Table 26. Total retrofit costs

Budget item	$ Cost
15 retrofit measures	11,145,850
Air-quality measures	1,294,362
Auditors' fees	170,982
Total	**12,611,194**

Table 27. Project cost per retrofit residence

Total cost per residence	$4,820
Total cost excluding air quality measures	$4,389
Total cost excluding administration	$4,217
Total cost excluding air quality measures and administration	$3,785
Total cost excluding air quality measures, administration, and four low-cost measures	$3,756

Estimated Savings

Dollar per kWh savings

This section provides theoretical estimates of first-year $/kWh savings. These are merely predictions, and are not based on actual electricity consumption records. A future study of actual total savings achieved by homes weatherized by the Project is planned, but will not include per measure analysis of savings due to the difficulty in segregating actual savings by measure installed. A note of caution is prudent in reading these estimates as other studies have shown actual average energy savings usually fall short of estimated savings (Hirst et al. 1985). These studies also indicate extensive variation in the actual energy savings across weatherized residences and the relationship between actual and estimated savings (Hirst et al. 1983 and Hirst, White, Holub, and Goeltz 1985). Several factors have been proposed that might contribute to the differences between estimated and actual savings:

> errors in audit methodology, errors in auditor data collection and interpretation, installation of inappropriate measures, use of poor quality retrofit materials, sloppy installation of measures, changes in occupant energy-related behavior after retrofit, errors in electricity billing data, and errors in methods used to analyze electricity-use data.[7]

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7 See Hirst, White, Holub, and Goeltz (1985) page 11.

Table 28. Aggregate costs and estimated savings, major measures

Measure Installed	Dollar Cost*	Percent Cost	Estimated First-year Savings kWh*	% kWh	$/kWh
Insulation					
Ceiling	1,895	17	3,348	21	0.57
Floor	2,507	22.5	3,901	24.5	0.64
Wall	835	7.5	2,884	18	0.29
Duct	95	1	259	1.5	0.37
Subtotal	**5,332**	**48**	**10,392**	**65**	**0.51**
Windows & Doors					
Windows	4,527	41	4,432	28	1.02
Doors					
Sliding	624	6	439	3	1.42
Insulated	38	**	18	**	2.11
Subtotal	**5,189**	**47**	**4,889**	**31**	**1.06**
Infiltration					
Caulking	256	2	314	2	0.82
Weather stripping					
Windows	1	**	1	**	--
Doors	167	2	94	1	1.78
Subtotal	**423**	**4**	**408**	**3**	**1.04**
Clock thermostat	111	1	192	1	0.58
Total	**11,056**		**15,882**		**0.70**

* Thousands
** Less than one-half percent

This report's theoretical projections of $/first-year estimated kWh savings are found in Table 28 for the 11 major measures installed by Project retrofit contractors. The sum of the costs of all measures was divided by the sum of estimated first-year kWh savings (computed during the audit) with the ratio yielding the $/estimated kWh saved. Table 28 shows the average cost per estimated first-year kWh savings for all major measures is $0.70, some 39 percent below the Project's incentive limit of $1.15/estimated first-year kWh savings.

Most of the estimated savings were generated by the insulation package, which produced 65 percent of total estimated first-year kWh savings at 48 percent of total cost. The percentage of total estimated savings of all other packages was higher than or equivalent to that of total dollars spent. Except for clock thermostats, the insulation measures had the lowest cost per estimated savings, and wall insulation produced twice as much estimated savings as it cost. The insulation package as a whole cost $0.51/estimated first-year kWh, $0.19 below $0.70/estimated first-year kWh savings of all major measures, and 56 percent below the actual incentive limit of $1.15/estimated first-year kWh saved.

Windows and doors were the least beneficial in terms of estimated savings, producing only 31 percent of estimated first-year kWh savings at 47 percent of total cost. All individual measures, except doors (sliding, insulated, and weather stripping), were purchased comfortably below the $1.15/kWh incentive limit.

When postweatherization calculations were run for the four measures installed during the audit and added to those in Table 28, the average cost per estimated first-year savings for all 15 measures dropped from $0.70/kWh to $0.61/kWh, as illustrated in Table 29.

We may pose two questions based on the $0.70/estimated first-year kWh savings from Table 27: How many homes might receive some measures at an incentive limit of $0.70/estimated first-year kWh savings, and how many measures might be retrofit at this limit? A model was devised to find the expected number of measures (including carried measures) to address these questions.[8] Table 30 shows this model predicts 97 percent of actual in-

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[8] The method used to determine the number of measures installed at alternate incentive limits follows. For each measure: 1. Find $/kWh ($/kWh = total measure cost / estimated kWh savings); 2. If $/kWh is less than or equal to the incentive limit (IL), then $ surplus = (estimated kWh savings X IL) - total measure cost. However, if $/kWh is greater than the IL limit, then $ deficit = (estimated kWh savings X $/kWh) - (estimated kWh savings X IL); 3. Sum $ surplus; 4. Sort measures with deficits by ascending order of $/kWh cost; 5. If the $ surplus is greater than or equal to $ deficit of the measure nearest to the IL, the measure is carried and $ surplus = $ surplus - $ deficit. However, if the $ surplus is less than the $ deficit of the measure over the IL by the least amount, then the measure is not carried. Repeat this step with the next measure to be carried that has the lowest $/kWh until the $ surplus is exhausted or no measures remain to be checked. Finally, perform a validation check -- calculate cost/kWh of the total of all measures (including carried) each time a measure is carried.

stallations when the actual incentive limit of $1.15/estimated first-year kWh savings was simulated, and 73 percent at the simulated limit of $0.70.

The Project's actual incentive limit purchased 27 percent more measures than the simulated $0.70 limit: 24 percent more insulation, 45 percent more windows, 58 percent more doors, and 17 percent more infiltration. However, when the number of residences receiving any major measure was computed, 97 percent (2,914) of homes weatherized by the Project might receive some measures at the simulated $0.70/estimated first-year kWh saved limit.

Table 29. Aggregate costs and estimated savings, all measures

Measure Installed	Dollars Cost*	Percent Cost	Estimated First-year Savings		
			kWh*	% kWh	$/kWh
Major measures	11,056	99.10	15,882	86.61	0.70
Audit measures					
Outlet gasket	35	0.32	1,016	5.54	0.03
Water heater wrap	36	0.32	549	2.99	0.07
Hot-water pipe wrap	13	0.12	56	0.31	0.23
Low-flow shower head	16	0.14	834	4.55	0.02
Subtotal	100	0.90	2,455	13.39	0.04
Total	11,156		18,337		0.61

* Thousands.

Table 30. Installations at simulated incentive limits

Measure	Number Actual Installations	Simulated Incentive Limits		Simulated Percent of Actual	
		$1.15	$0.70	$1.15	$0.70
Insulation					
Ceiling	1,980	1,944	1,305	98	66
Floor	1,864	1,834	1,403	98	75
Wall	1,163	1,165	1,099	100	94
Duct	357	357	294	100	82
	5,364	5,300	4,101	99	76
Windows	2,641	2,423	1,441	92	55
Doors					
Sliding	872	806	345	92	40
Insulated	86	85	57	99	66
	958	891	402	93	42
Caulking	2,307	2,281	1,957	99	85
Weather stripping					
Windows	2	6	4	300	200
Doors	2,046	2,027	1,666	99	81
Clock thermostat	758	751	719	99	95
	4,355	4,314	4,346	99	83
Total	14,076	13,679	10,290	97	73

IV. Research and Evaluation Costs

Research and evaluation (R&E) is the primary objective of the Project. The R&E program was designed and modified throughout the Project with the input of the Regional Research Advisory Group, a consensus-driven steering committee composed of conservation scientists, managers, and energy policy analysts from the Northwest Power Planning Council, Pacific Northwest Utilities Conference Committee, Northwest Public Power Association, Natural Resources Defense Council, Hood River Electric Cooperative, Bonneville, Pacific, and others. This group worked closely with Project staff to tailor R&E objectives and implementation.

The R&E staff grew from two members in the summer of 1983 to six members in November 1985. The staff was located in Pacific corporate offices in Portland, but frequently travelled to the field office in Hood River to oversee monitoring equipment installation, computer system modifications, data collection, conduct surveys and special studies, and maintain community research relations. The R&E staff was frequently expanded by consultants who worked closely with the staff on research, analysis, preparation and publication of findings, and production of contract deliverables.

Table 30 provides a detailed account of R&E expenditures as of May 31, 1986, and the projected budget through March 1989. Costs as of May 1986 were $4.1 million and are projected to total $5.6 million by March 1989. The projected budget will fund R&E activities from June 1986 to March 1989. Approximately $1.3 million of this budget was rolled over from previously approved budgets and budget modifications. The remainder, $166,000, was obtained through budget modification #10 that proposed the following: extension of the analysis phase through December 31, 1987; extension of data collection through June 30, 1988; and removal of Project equipment from test-area homes with delivery of this equipment to Bonneville by March 31, 1989.

The largest areas of expenditures as of May 1986 have been for direct material (44 percent) and consultants (21 percent). Direct labor (27 percent) and consultants (29 percent) are the largest areas of estimated costs in the projected budget.

Table 31. Research & evaluation costs

Budget Category	Cumulative $ Costs May 1986	Cumulative $ Costs March 1989
Direct Labor	**661,690**	**1,070,368**
Research & Evaluation team	371,832	666,089
Installation, operation, & removal of load monitors	215,761	330,182
Pacific departments:		
Energy & Conservation Services	21,498	21,498
Others	6,580	6,580
Field office staff	21,370	21,370
Heat loss study	16,481	16,481
Other	8,168	8,168
Labor Overhead	**256,473**	**445,404**
Pacific Administration	**112,176**	**224,352**
Consultants	**847,883**	**1,284,947**
Consumption data	42,039	48,618
Weather stations	147,004	268,003
Oak Ridge National Laboratory	355,735	525,000
Community assessment & monitoring	85,917	98,745
Follow-after survey	19,551	21,826
End-use survey	33,047	58,047
Wood heat study	8,153	47,606
Editor, statistician, & clerk	46,641	107,306
Baseline survey	20,575	20,575
House doctor study	79,713	79,713
Non-participant survey	4,704	4,704
Heat loss study	3,691	3,691
Other	1,113	1,113
Travel	**92,373**	**132,622**
Transportation	42,778	67,110
Per diem	48,046	63,963
Other	1,549	1,549
Special Testing	202	**106,882**
Direct Material	**1,818,269**	**1,861,250**
Load/feeder & wood heat study equipment	1,740,534	1,750,541
Monitoring supplies	55,801	67,338
End-use study monitoring equipment rental	4,576	21,389
Other	17,358	21,982
Material Overhead	**82,190**	**84,224**
Direct Costs	**245,058**	**429,963**
Data processing	208,326	368,853
Delegation tours	6,040	6,040
Presentations	8,114	8,564
Equipment repair & supplies	1,932	11,932
Hood River shop rental	6,196	16,124
Other	14,450	18,450
Total	**4,116,314**	**5,640,012**

Selected Activities

A detailed account of the costs of selected R&E surveys, studies, and reports follows. The total cost of some of these activities is underestimated because they do not include charges accounted for in other budget categories such as direct labor, labor overhead, computer costs, and other direct costs. Records were not kept of how much staff time, supplies, overhead, or computer time contributed to various R&E activities or products.

Some of the surveys, studies, and reports detailed below were completed before May 31, 1986, and total costs for these activities are as of this date. The total expected costs of ongoing activities are the sum of expenses as of May 1986 plus costs provided for in the R&E budget projected through March 1989.

Baseline survey

This survey was administered by the Oregon State University Survey Research Center. It provided baseline data on electrical energy use in Hood River county and two comparison communities, Josephine and Umatilla counties, that were surveyed to obtain statistical control for assessment of the impact of Project weatherization.

Direct labor		$ 6,230
Labor overhead		1,777
Computer		4,200
Travel		200
Direct costs		3,420
Printing	$ 1,800	
Postage	1,170	
Copying	50	
Telephone	400	
General administration . .		4,748
Total		**$20,575**

Follow-after survey

This survey was also conducted by Oregon State University and is similar to the baseline survey with the exception that it was done after completion of weatherization in the test area.

Direct labor	$ 6,945
Labor overhead	2,333
Travel	218
Computer	451
Direct costs	4,855
General administration . .	5,033
May 1986 subtotal.	19,835
Projected costs.	2,275
Total	**$ 22,110**

Weather stations

Oregon State University and the University of Oregon were hired as consultants to install, maintain, and monitor three weather stations erected near the Hood River test area. The consultants collect and process meteorological data, and provide the Project with translated data tapes.

Labor.		$ 43,601
Labor overhead		13,399
Travel		1,627
Computer		2,350
Direct material.		50,154
Supplies	$ 12,112	
Equipment	36,323	
Maintenance	1,719	
Direct costs		5,399
Communication	2,557	
Rent/lease	26	
Fees	2,816	
Other.		319
General administration . .		30,155
May 1986 subtotal.		147,004
Projected costs.		120,999
Total		**$268,003**

Measure penetration

This study of measure penetration by Richard Goeltz and Eric Hirst of the Oak Ridge National Laboratory was published as Residential Retrofit Measures in the Hood River Conservation Project: Recommendations, Installa-

tions, and Barriers in June 1986. The study documents the extent that Project measures were recommended and retrofitted in participating residences. The reasons for lack of measure installation are also analyzed.

Labor	$ 36,513
Labor overhead	20,239
Travel	4,480
Computer	17,244
Direct material	3,745
Total	**$ 82,221**

Project participation

This study by Eric Hirst and Richard Goeltz of the Oak Ridge National Laboratory was published as Dynamics of Participation and Supply of Services in the Hood River Conservation Project in July 1986. The publication documents participation in the Project by potentially eligible households in the Hood River test area. The dynamics of various levels of customer participation and program services (e.g., the time between an audit request and the audit, and between the audit and actual weatherization) are analyzed.

Labor	$ 32,750
Labor overhead	11,853
Travel	714
Computer	3,865
Direct material	3,181
May 1986 subtotal	52,363
Projected costs	29,022
Total	**$ 81,385**

Non-participant survey

The results of this survey of test-site residents who did not participate in the Project, even when economic barriers were almost eliminated and community support for the Project was high, are documented by Shellie Kaplon and Danielle Engels of the R&E staff in "Profile of a Non-Participant." A telephone survey was administered to all eligible non-participants to collect demographics, attitudes, and kWh energy data. This information was then directly compared with data collected on Project participants. Charges listed below are for three consultants who performed the activities indicated.

Design of survey & questionnaire	$ 1,288
Survey administration . .	1,850
Key punch, coding	1,566
Total	**$ 4,704**

End-use study

This is a study of 320 residences weatherized by the Project and equipped with monitoring devices. The residential monitors recorded four data elements at 15-minute intervals one year before and three years after Project weatherization. The data elements for the 320 homes are: 220 homes monitored for the use of electric space heat, total kWh used, kWh used to heat water, and indoor temperatures; and 100 residences monitored for electric space-heat usage, total kWh used, indoor temperatures, and the heat output of wood stoves.

The residential feeder portion of the study required monitoring of a selected feeder for each of three phases at two primary monitoring points with pole-mounted equipment. Selected additional monitoring was performed on the feeder section to account for small commercial and agricultural pumping loads. A feeder survey consultant was hired to compile a list of all customers in the monitored section of the residential feeder study area, their electric utility account numbers, pole numbers, transformers, and phases. The consultant also noted each feeder serving dwelling units outside the monitored portion of the residential feeder (including both Pacific and Hood River Electric Cooperative areas).

Oak Ridge National Laboratory was hired as a consultant to evaluate electric loads before and after weatherization for the 320 end-use monitored residences. This work by Therese Stovall is documented in Load Study Analysis.

Three areas of the budget contain costs directly related to the end-use study that are not included in the account of costs below: 65 percent of the R&E computer budget, and direct labor and overhead for 5.75 full-time employees. These costs should be considered significant budget areas for any similar future end-use study.

The costs for three major areas of the end-use study (residential monitoring, commercial monitoring, and consultants) as of May 1986 follow, along

with the projected remaining budget for this study and the total projected cost.

A. Residential monitoring			**$ 1,663,960**
Group of 220 homes:			
1 recorder	$	1,500	
2 meter transponders		870	
2 pulse transponders		840	
10 program plugs		20	
2 bubble cartridges		600	
1 receiver		475	
1 integrator		255	
1 pulse initiating meter		173	
Installation cables		120	
1 temp. transmitter		73	
2 current transformers		50	
1 indoor temp. cover		57	
Per residence cost		**5,033**	
220 residences			1,107,260
Group of 100 homes:			
1 recorder		1,500	
1 meter transponder		435	
3 pulse transponders		1,260	
10 program plugs		20	
2 bubble cartridges		600	
1 receiver		475	
2 integrator		510	
1 pulse initiating meter		173	
Installation cables		120	
1 temp. transmitter		73	
2 current transformers		50	
1 indoor temp. cover		57	
Radiometer		280	
Pole assembly		14	
Per residence cost		5,567	
100 residences			556,700
B. Supplemental feeder monitoring equipment			**25,001**
15 pulse transponders		7,050	
15 240V pulse transponder cables		750	
60 program plugs		120	

5 single-phase meters		190	
15 3-phase meters		1,761	
15 meterbase adapters		330	
Use of 20 Westinghouse recorders & receivers		12,800	
Use of 6 current transformers & pulse transponders		2,000	
C. Consultants			162,247
Technical feeder survey specialist		8,600	
Load study analysis		153,647	
Labor	$83,236		
Labor overhead	37,384		
Travel	6,816		
Computer	22,882		
Direct material	3,329		
Costs as of May 1986			$ 1,851,208
Projected costs			25,000
Total			$ 1,876,208

House Doctor study

This study assessed the incremental savings of adding additional caulking and weather stripping to homes already weatherized by the Project. Air leaks were sealed after the homes were pressurized and tested for leaks. Part of this study involved blower-door tests that pressurized and depressurized the residence to measure the flow of air before and after house doctoring was applied. The rates for house doctoring per residence were as follows: less than 1,200 sq. ft., $420; 1,200 - 1,800 sq. ft., $570; over 1,800 sq. ft., $720. This work was published by Danielle Engels and other members of the R&E team as House Doctor Study in September 1985.

210 blower door pretests	$ 20,811
75 house doctorings	33,240
150 blower door posttests	14,865
Total	$ 68,916

Community assessment

Social researchers conducted six weeks of field work in the Hood River test area, which included snowball[9] interviews of residents and documentary research. Topics of reports generated by this field work include: description and history of the community; identification of industry, major employers, and markets; description of social groups, their occupations, and attitudes; media; and potential social barriers to participation in the Project. A summary report, Community Assessment, by Cynthia Flynn was produced in January 1983.

Total cost	**$ 17,000**

Process evaluation

This study, published in October 1986 by Cynthia Flynn-Brown as Process Evaluation, evaluates Project implementation documented in the weatherization logistics report (Philips et al. 1986), and compares implementation to original planning goals. Data for this report was gathered through interviews conducted during almost 30 months of Project weatherization operations with community members, Project staff, and contractors. Field work was conducted monthly and bi-monthly with over 300 interviews completed. Regularly scheduled field work cost $1,650 to $2,400 per report. Five reports of interviews with staff and contractors had the following average costs: staff reports, $1,750; and contractor reports, $2,250.

Costs as of May 1986. . .	$ 39,217
Projected costs	12,758
Total	**$ 51,975**

9 "Snowball" is an interview technique in which each interviewee is asked for names of other possible respondents.

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References

Bonneville Power Administration (1986). "Chief Auditor's Report." (draft).

Bonneville Power Administration (August 1984). Final Environmental Impact Statement, The Expanded Residential Weatherization Program, 2 vols.

Bonneville Power Administration (April 1982). BPA Standard Heat Loss Methodology Technical Appendix.

Engels, Danielle, Shellie Kaplon, and H. Gil Peach (1985). Marketing and Promotional Plan, Final Report, Hood River Conservation Project, DOE/BP-11287-9, September.

Goeltz, Richard and Eric Hirst (1986). Residential Retrofit Measures: Recommendations, Installations, and Barriers, Final Report, Hood River Conservation Project, ORNL/CON-208, DOE/BP-11287-3, July.

Hirst, Eric and Richard Goeltz (1986). Dynamics of Participation and Supply of Service, Final Report, Hood River Conservation Project, ORNL/CON-210, DOE/BP-11287-7, July.

Hirst, Eric, Richard Goeltz, Dennis White, Benson Bronfman, David Lerman, and Kenneth Keating (1985). Evaluation of the BPA Residential Weatherization Program, Final Report, Oak Ridge National Laboratory, ORNL/CON-180.

Hirst, Eric, Dennis White, and Richard Goeltz (1983). Comparison of Actual Electricity Savings with Audit Predictions in the BPA Residential Weatherization Pilot Program, Final Report, Oak Ridge National Laboratory, ORNL/CON-142.

Hirst, Eric, Dennis White, Ed Holub, and Richard Goeltz (1985). Actual Electricity Savings for Homes Retrofit by the BPA Residential Weatherization Program, Final Report, Oak Ridge National Laboratory, ORNL/CON-185.

Northwest Power Planning Council (1986). Northwest Conservation and Electric Power Plan. 2 vols.

Northwest Power Planning Council (1983). Northwest Conservation and Electric Power Plan.

Philips, Marion, Susan French, Dennis Quinn, and H. Gil Peach (1986). Field Weatherization Logistics, Final Report, Hood River Conservation Project, U.S. Department of Energy, DOE/BP-11287-5.

U.S. Congress (November 1978). National Energy Conservation Policy Act, Public Law 95-619.

U.S. Department of Energy (June 1982). "Residential Conservation Service Program, Final Rule," Federal Register, 47.

Bibliography

Bacon, Kathi (1985). "Electronic Data Processing: Field Use of a System," Unpublished internal paper, Pacific Power & Light Company, Hood River Conservation Project.

Berg, Helen and Pam Bodenroeder (1986). Report on Pre-Test and Follow-After Surveys, Oregon State University, Corvallis, Oregon, June.

Berg, Helen and Pam Bodenroeder (1983). Hood River Community Conservation Project Evaluation Plan, Report on Pre-Test Survey, Oregon State University, Corvallis, Oregon, June.

Burnett, Michael, Muhannad Khawaja, and H. Gil Peach (1987). Evaluation of Conservation Supply Curve Methodologies, Hood River Conservation Project, DOE/BP-11287-23, forthcoming.

Brown, Marilyn, Dennis White, and Steve Purucker (1987). Impact of the Hood River Conservation Project on the Electricity Used for Residential Water Heating, Oak Ridge National Laboratory, ORNL/CON-238, Oak Ridge, Tennessee, August.

Dinan, Terry (1987). An Analysis of the Impacts of Residential Retrofits on Indoor Temperature Choices, Oak Ridge National Laboratory, ORNL/CON-238, Oak Ridge, Tennessee, September.

Engels, Danielle, Susan French, Karen Schoch, Susan Block, and H. Gil Peach (1985). House Doctor Study, Final Report, Hood River Conservation Project, DOE/BP-11287-1, September.

Engels, Danielle, Shellie Kaplon, and H. Gil Peach (1985). Marketing and Promotional Plan, Final Report, Hood River Conservation Project, DOE/BP-11287-9, September.

Engels, Danielle and H. Gil Peach (1985). "Real World Application: Field Testing the Value of House Doctoring as an Incremental Conservation Measure," proceedings from the Second Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. I, pp. 93-107, August.

Engels, Danielle, H. Gil Peach, and Terry Oliver (1984). "House Doctor & Blower Door Tests in the Hood River Conservation Project," 1984 ACEEE Summer

Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. I, ppp. 227-237, August.

Flynn-Brown, Cynthia B. (1986). Process Evaluation, prepared by Social Impact Research, Inc. for the Hood River Conservation Project, Final Report, DOE/BP-11287-6, October.

Flynn, Cynthia B. and Kenneth M. Keating (1984). "The Diamond in Your Future: Community Assessment Goes Celluloid," presented at the Annual Meeting of the Rural Sociological Society, College Station, Texas, August.

Flynn, Cynthia B. (1983). Community Assessment, prepared by Social Impact Research, Inc. for the Hood River Conservation Project, Final Report, DOE/BP-11287-15, January.

French, Susan, H. Gil Peach, and Terry Oliver (1986). "The Best Laid Plans of Mice and Men: A Process Evaluation of the Hood River Conservation Project," 1986 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. 10, pp. 55-69, August.

French, Susan, Susan Block, Shellie Kaplon, Muhannad Khawaja, and H. Gil Peach (1985). Regional Adaptation of Results: The Transferability Study, Final Report, Hood River Conservation Project, DOE/BP-11287-2, October.

French, Susan and Karen Schoch (1985). "Salvaging Fruit: Finding and Fixing Data Errors in the Hood River Conservation Project," proceedings from the Second Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. II, pp. 238-247, August.

French, Susan, H. Gil Peach, and Terry Oliver (1984). "Cost Effectiveness and Control: Long-Term Project Management Using PERT/CPM," 1984 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. I, pp. 238-249, August.

French, Susan and H. Gil Peach (1984). "Decision Making in Conservation Projects: Using PERT/CPM for Project Management and Evaluation," proceedings from the First Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, August.

Goeltz, Richard and Eric Hirst (1986). Residential Retrofit Measures: Recommendations, Installations and Barriers, Final Report, Hood River Conservation Project, ORNL/CON-208, DOE/BP-11287-3, July.

Hirst, Goeltz, Richard Goeltz, and Marjie Hubbard (1987). "Determinants of Electricity Use for Water Heating: The Hood River Conservation Project," Energy Conversion and Management, forthcoming.

Hirst, Eric and Richard Goeltz (1987). "The Hood River Conservation Project: Participation, Installation of Measures, and Electricity Savings," proceedings from the Third Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. 2, pp. 467-476, August.

Hirst, Eric, Richard Goeltz, and David Trumble (1987). Electricity Use and Savings in the Hood River Conservation Project, Final Report, Hood River Conservation Project, ORNL/CON-231, DOE/BP-11287-16, April.

Hirst Eric (1987). Cooperation and Community Conservation: The Hood River Conservation Project, Final Report, ORNL/CON-235, DOE/BP-11287-18, June.

Hirst, Eric and Richard Goeltz (1986). Dynamics of Participation and Supply of Service, Final Report, Hood River Conservation Project, ORNL/CON-210, DOE/BP-11287-7, July.

Hirst, Eric and Richard Goeltz (1986). "Barriers to Installation of Retrofit Measures in the Hood River Conservation Project," Seaogram, Volume 5, No. 1, pp. 15-17, Spring.

Hirst, Eric and Richard Goeltz (1986). "Recommendation and Installation of Retrofit Measures in the Hood River Conservation Project," Energy and Buildings, 9, pp. 221-229.

Hirst, Eric and Richard Goeltz (1985) Development of Methods to Analyze Actual Electricity Savings, Working Paper, Hood River Conservation Project, December.

Hirst, Eric and Richard Goeltz (1985). Potential vs. Practice: Installation of Retrofit Measures in the Hood River Conservation Project, Oak Ridge National Laboratory, ORNL/CON-189, Oak Ridge, Tennessee, September.

Kaplon, Shellie (1987). Report on Wood Heat in Hood River, Hood River Conservation Project, DOE/BP-11287-19, forthcoming.

Kaplon, Shellie ed. (1987). Volume II: The Hood River Story -- Marketing a Conservation Project, Final Report, Hood River Conservation Project, DOE/BP-11287-13, September.

Kaplon, Shellie, Muhannad Khawaja, and H. Gil Peach (1987). Final Report on Baseline and Follow-After Surveys, Draft Report, Hood River Conservation Project, DOE/BP-11287-14, September.

Kaplon, Shellie, Dennis White, and Rachel Yoder (1987). "Up in Smoke: An Investigation of the Wood Heat Factor In Hood River," proceedings from the Third Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. 2, pp. 477-485, August.

Kaplon, Shellie and Terry Oliver (1987). "A Conservation Marketing Success Story," proceedings from Demand-Side Management Strategies in Transition: Third National Conference on Utility DSM Programs, Houston, Texas, June.

Kaplon, Shellie and Danielle Engels (1986). "Profile of a Nonparticipant," 1986 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. 7, pg. 119-133, August.

Keating, Kenneth M., Ruth M. Love, Terry V. Oliver, H. Gil Peach, and Cynthia B. Flynn (1985). "The Hood River Project: Take a Walk on the Applied Side," The Rural Sociologist, Volume 5, No. 2, pp. 112-118, May.

Keating, Kenneth M. (1984). "Where the Fiberglass Ends, Research Begins," presented at the Annual Meeting of the Rural Sociological Society, College Station, Texas, August.

Keating, Kenneth and Cynthia Flynn (1984). "Researching the Human Factor in Hood River: Buildings Don't Use Energy, People Do," 1984 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. I, pp. 251-259, August.

Northwest Power Planning Council (1983). "Aggressive Conservation Study to Begin," Northwest Energy News, Vol. 2, No. 1, March/April issue.

Oliver, Terry, H. Gil Peach, Dennis Quinn, and Susan French (1986). "Demand Side Experience in the Hood River Conservation Project," Productivity Through Energy Innovation, proceedings of the Third Great PG&E Energy Expo, Permagon Press, Elmsford, New York, April.

Oliver, Terry, H. Gil Peach, and Mark Modera (1984). "An Investigation Into Quantifying the Contribution of Wood Stoves to Space Heat Energy Use," 1984 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. I, pp. 260-273, August.

Oliver, Terry, Don Peters, H. Gil Peach, and Danielle Engels (1984). "Measuring Conservation: A Report on Instrumentation in the Hood River Conservation Project," 1984 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. I, pp. 274-285, August.

Pacific Power & Light Company (1983). Scope of Work, Hood River Conservation Project Evaluation, Portland, OR, August.

Pacific Power & Light Company (1982). "Hood River Conservation Project Proposal," submitted to Bonneville Power Administration.

Pacific Northwest Utilities Conference Committee (1986). Evaluation Guidelines. Prepared by the Conservation Assessment Work Group.

Patton, Anne, Rachel Yoder, and Marion Philips (1987). "Radon Detection and Control in Air-tightened Residences in the Hood River Conservation Project," proceedings from the Third Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. 2, pp. 454-464, August.

Peach, H. Gil (1988). Winter Peak Load Impacts Two Years After Retrofit, Hood River Conservation Project, DOE/BP-11287-22, forthcoming.

Peach, H. Gil, Karen Schoch, Rachel Yoder, and Michael Burnett (1987). Energy Use of Air-to-Air Heat Exchangers, Draft Report, Hood River Conservation Project, DOE/BP-11287-4, January.

Peach, H. Gil and Eric Hirst (1987). "Evaluation Design: Factors in the Organization of Evaluation as an Extension of the Theory of Evaluation Design," proceedings from the Third Conference on Energy Conservation Program

Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. 2, pp. 283-294, August.

Peach, H. Gil, Terry V. Oliver, Mark Cherniack, David Goldstein, and Marion Philips (1986). "Dialectic of Cooperation: How the Hood River Project Worked," 1986 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. 10, pp. 129-143, August.

Peach, H. Gil (1985). "Argumentation in Applied Research: Organizational Dances Around a Circle of Freedom -- The Hood River Consensus Experiment," presented at the Tenth Annual Meeting of the Society for Social Studies of Science, Troy, New York.

Peach, H. Gil (1985). "Insights from Critical Theory in Applied Research," presented at the 56th Annual Meeting of the Pacific Sociological Association, Albuquerque, New Mexico.

Peach, H. Gil (1984). "Scientific Credibility, Positivism & Social Integration," presented at the Annual Meeting of the Rural Sociological Society, College Station, Texas, August.

Peach, H. Gil, Terry V. Oliver, and David Goldstein (1984). "Cooperation & Diversity in a Large-Scale Conservation Research Project" 1984 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. I, pp. 286-293, August.

Peach, H. Gil (1983). "The Hood River Conservation Project: A Model for Consensus-Building in Applied & Energy Research," presented to the Eighth Annual Meeting of the Society for Social Studies of Science, Blacksburg, Virginia.

Peach, H. Gil, Fred Keast, Kenneth M. Keating, and Michael Warwick (1983). Research Plan: Hood River Project Evaluation, Final Report, Hood River Conservation Project, DOE/BP-11287-11, August.

Philips, Marion, Muhannad Khawaja, Danielle Engels, and H. Gil Peach (1987). Cost Analysis, Final Report, Hood River Conservation Project, DOE/BP-11287-8, April.

Philips, Marion, Susan French, Dennis Quinn, and H. Gil Peach (1986). Field Weatherization Logistics, Final Report, Hood River Conservation Project, DOE/BP-11287-5, August.

Quinn, Dennis and Terry Oliver (1985). "The Reality of Super Insulating Existing Homes," Conservation in Buildings: A Northwest Perspective, conference proceedings from the National Center for Appropriate Technology Conference, Butte, Montana, May.

Schoch, Karen (1987). Long Term Three Community Comparison of Electricity Use, Hood River Conservation Project, DOE/BP-11287-21, forthcoming.

Schoch, Karen (1987). Two Year Stability of Electricity Use and Savings, Draft Report, Hood River Conservation Project, DOE/BP-11287-20, September.

Schoch, Karen ed. (1987). Volume I: The Hood River Story -- How a Conservation Project Was Implemented, Final Report, Hood River Conservation Project, DOE/BP-11287-12, September.

Schoch, Karen and Muhannad Khawaja (1987). "In Search of the Optimum Incentive Limit," proceedings from the Third Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. 2, pp. 407-414, August.

Schoch, Karen and H. Gil Peach (1987). "SHLM: Baseload Assumptions and Model Efficiency," proceedings from the Third Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. 1, pp. 167-174, August.

Schoch, Karen and Susan French (1986). "Building a Strong Foundation: The Collection and Contents of Hood River Conservation Project Databases," Seaogram, Volume 5, No. 1, pp. 14-21, Spring.

Schoch, Karen, Muhannad Khawaja, and H. Gil Peach (1986). "Are We Fighting a Battle We've Already Won?," 1986 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. 7, pp. 207-223, August.

Stovall, Therese (1987). Load Analysis, Final Report, Hood River Conservation Project, ORNL/CON-240, DOE/BP-11287-17, September.

Stovall, Therese (1987). "Hood River Conservation Project Load Analysis," proceedings from the Third Conference on Energy Conservation Program Evaluation: Practical Methods, Useful Results, Argonne National Laboratory, Argonne, Illinois, Vol. 2, pp. 486-491, August.

Tonn, Bruce and Dennis White (1987). Use of Wood for Space Heating: Analysis of Hood River Conservation Project Submetered Homes, Final Report, Oak Ridge National Laboratory, ORNL/CON-234, July.

U.S. Department of Energy, Bonneville Power Administration (1984). Final Environmental Impact Statement, The Expanded Residential Weatherization Program, 2 volumes.

Yoder, Rachel (1987). Comparison of SUNDAY Model Predictions and Monitored Space Heat Energy Use, Draft Report, Hood River Conservation Project, DOE/BP-11287-10, August.

Yoder, Rachel, Graig Spolek, and Mark Modera (1987). "Evaluation of a Wood Heat Monitoring Study: The Hood River Experience," presented at Solar '87, Twelfth National Passive Solar Conference, American Solar Energy Society, Portland, OR, July.

Yoder, Rachel and Margie Gardner (1986). "Overview of the Heat Loss Study for the Hood River Conservation Project," 1986 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, Vol. 2, pp. 302-304, August.

October 6, 1987