

ANALYSIS OF OREGON'S STATEWIDE  
WATER-HEATER EFFICIENCY/REPLACEMENT  
PROGRAMS

Anthony G. White  
Conservation/Hydraulic Section  
Oregon Public Utility Commissioner  
330 Labor & Industries Bldg.  
Salem, OR 97310

ABSTRACT

Five of Oregon's investor-owned utilities (IOU's) have for 18 months or more worked to "change-out" or supplement existing electric water heaters (WH). The three natural gas utilities have been permitted by the Oregon Public Utility Commissioner (PUC) to offer rebate incentives for gas space-heating customers to switch their electric WH to gas.

Another PUC-approved and regulated program links financial incentives for supplementing gas HWH with a solar HWH system. Electric IOU's offer substantial rebates (up to \$300) to those replacing or supplementing electric WH with a solar or heatpump unit. These companies operate and monitor these programs under research protocols approved by the PUC. One IOU offers a rebate based on projected kwh saved annually, while the other offers fixed-sum rebates or low-interest loans. Data is submitted to the PUC quarterly for review and analysis.

Program results to date indicate such programs are generally cost-effective both to the companies and to customers. Companies have to date replaced or supplemented almost 9,800 WH units, at a cost of over \$3 million (half in repayable, low-interest loans). Over the units' life spans, customers can expect: (A) for solar units, to break even; (B) for heat pumps, to save \$150-\$330; and (C) for gas replacement, to save \$2,000 in fuel costs. If current activities continue, about 2.25 billion kilowatt-hours of electricity will be conserved over 10 years.

1. THE PROBLEM

Historically, electric energy in the Pacific Northwest has been both plentiful and inexpensive. A region of heavy rainfall, the hydroelectric resource development in the mid-twentieth century has been extensive, aided by a large proportion of federally-owned or -controlled lands.

This latter factor enabled the building of some 30 large dams in the Columbia River Basin by the U.S. Army Corps of Engineers. Federal acts of the mid-1930's created the Bonneville Power Administration (BPA) to construct and operate transmission lines to deliver and market this power.<sup>1</sup>

By the 1960's, this inexpensive source of power had attracted several large direct-service industries (not

served through a local utility, such as large aluminum smelters), and served as a further attraction for post-World War II population influxes. Oregon, for example, grew in population 25.8% between 1970 and 1980.<sup>2</sup>

With an historical and sometimes radical approach to environmental preservation, the awareness that no new dams could be built along the Columbia System in the U.S. led Oregon's utilities toward development of thermal resources.<sup>3</sup> Nuclear plants were (and are) resisted because of their perceived environmental consequences. Similar considerations hold true for coal-fired plants, and there are no low-sulfur, high-yield coal sites located within the region.

The "energy crisis" of 1973 ruled out construction of new oil-fired plants. While some thermal plants were still under plan or construction (coal and nuclear), state and utility planners and policy-makers realized that without new non-thermal resources, regional and state growth and development would stagnate.

2. BACKGROUND

Energy loads among Oregon residential customers for space-heating are distributed as:<sup>4</sup>

TABLE 1. SPACE-HEAT ENERGY

<u>Energy</u>	<u>%</u>
Electricity	42.1
Natural Gas	22.4
Oil	18.4
Other (wood, solar, etc.)	<u>17.1</u>
	100.0

Water-heating loads, which make up about 31 percent of the total residential load, are:<sup>5</sup>

TABLE 2. WATER-HEATING ENERGY

<u>Energy</u>	<u>%</u>
Electricity	84.1
Natural Gas	12.2
Oil	1.6
Other (wood, solar, etc.)	<u>2.1</u>
	100.0

Thus, while it is necessary to "shotgun" conservation measures among various fuel sources for space-heating, to conserve electric generation it is highly productive to focus in on the electric water heater as a target for electric energy conservation. One approach is to replace, or increase the efficiency of, electric water heaters.

### 3. THE APPROACH

Oregon's Public Utility Commissioner (PUC) has jurisdiction over investor-owned utilities (IOU's) in the state, but no rate or effective programmatic control over publicly-owned utilities (POU's). In 1980, the distribution of electric energy to Oregon customers was:<sup>6</sup>

TABLE 3. ELECTRIC DISTRIBUTION - 1980

	<u>% All Customers</u>	<u>% kwh Sales</u>	<u># Customers</u>
IOU's [4]	77.4	72.8	913,214
POU's [33]	<u>22.6</u>	<u>27.2</u>	<u>266,969</u>
	100.0	100.0	1,180,183

PUC policies, then, directly affect electric energy consumption and conservation for over three-fourths of the state's residential, commercial, and industrial customers. The remaining one-fourth, the POU customers, have almost no generating capacity as direct customers of BPA.

Beginning in 1975, the PUC and IOU's began exploring the purchase of energy from existing customers in the form of conservation. Initially resolved in 1977, the PUC directed that IOU's purchase "conservation energy" at cost-effective levels, defined as avoided cost. The avoided cost of a kilowatt-hour (kwh) is currently defined as the long-term cost of building the next new facility for generating electricity, divided by the estimated kwh output. If the conservation measures' cost, divided by the conserved energy, is less than this avoided cost, then the utility can lend or expend money towards installing the measures.

Clearly, there are some limitations to this approach. Service territories are discontiguous, and do not (for the IOU's) cover the entire state, as indicated in Figures 1 and 2. Since most of the POU's do not participate in conservation programs, some customers do not qualify for conservation benefits. Different utilities have different avoided costs--an issue resolved by adopting the highest regional avoided cost as the standard.

During the period 1977-79, the PUC directed the electric and natural gas IOU's to use this methodology in residential weatherization programs. These programs address potential energy savings through increasing the efficiency of heating plants and the building envelope. Included within these programs was the lowering of water heater thermostats and the use of water-heater wraps--insulating blankets increasing the R-value of the heater jacket.<sup>7</sup>

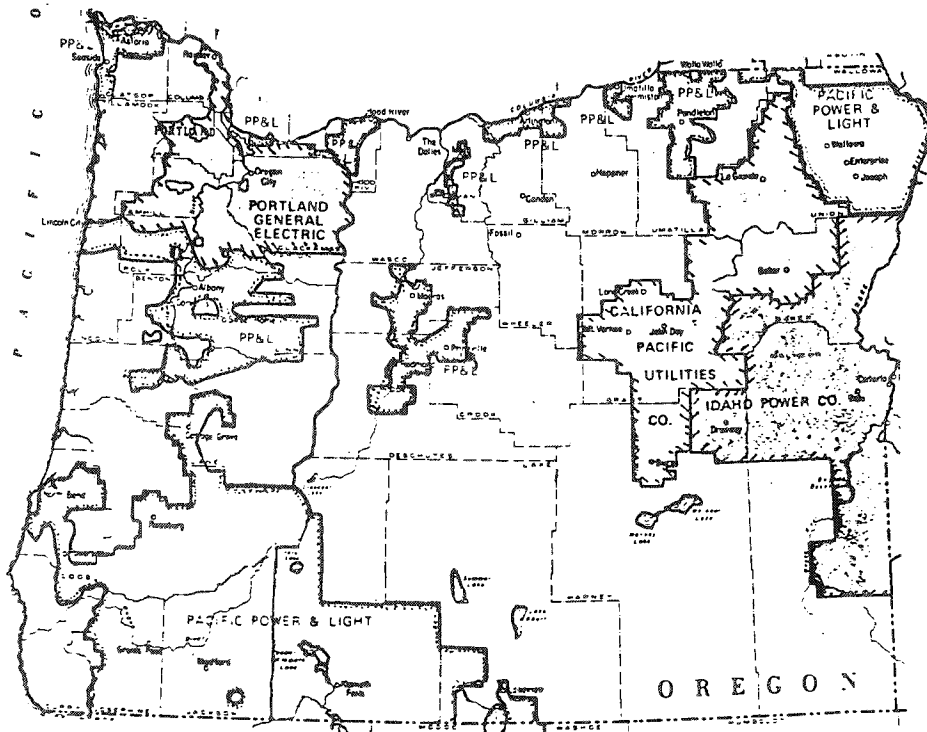


Figure 1. Oregon Investor-Owned Electric Utilities

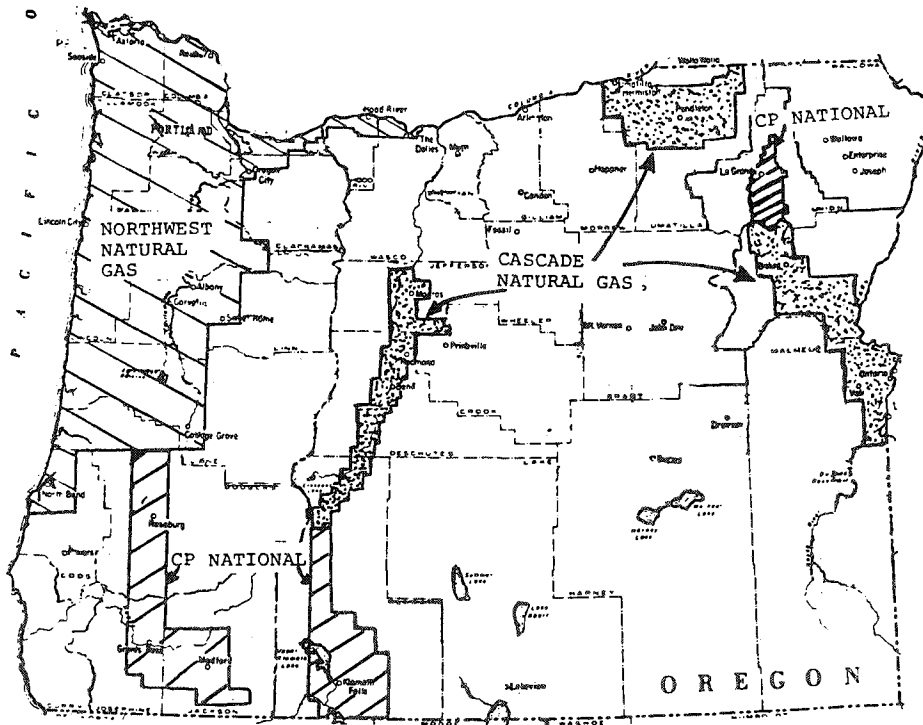


Figure 2. Oregon Investor-Owned Gas Utilities

In 1980 and 1981, proposals were made by five of Oregon's six gas and electric IOU's to conserve electric energy through water heater modification programs. All offer rebates to customers to reduce electric energy consumption:

TABLE 4. IOU WATER HEATER OFFERS<sup>B</sup>

Utility <sup>a</sup>	Original Date	Rebate Incentive	Alternative Incentive
PP&L	10/2/80	5.6¢/kwh-1st year Savings <sup>b</sup>	None
PGE	3/17/81	\$300 <sup>b</sup>	Max. 60% of cost loan, 0% interest, 1 yr., \$2,400 max.
CPN-Gas	2/20/81	\$150 <sup>c</sup>	None
NNG	12/8/80	\$150 <sup>c</sup>	Max. \$480 loan, 0% interest, 4 yrs.
Cascade NG	3/11/81	\$150 <sup>c</sup>	None

<sup>a</sup>PP&L - Pacific Power & Light; PGE - Portland General Electric; CPN - CP National; NNG - Northwest Natural Gas; Cascade NG - Cascade Natural Gas.

<sup>b</sup>Solar and heat-pump systems.

<sup>c</sup>Must be gas space user with electric water-heater.

As Table 4 indicates, the two electric utilities offer rebates to supplement electric water heaters with solar or heat pump systems. The gas utilities offer to replace electric water heaters with gas units if gas is already used. The tariffs, or rules, spelling out the conditions of payment are found in Appendix A.

Electric IOU's promote solar and heat pump water heaters on the bases of state and federal tax credits, current utility rates, and projected fractional savings.<sup>9</sup> It is important to remember that these supplemental systems keep the customer as a paying consumer for the electric utility.

Gas IOU's, on the other hand, push the concept that fuel conversion to gas "contributes substantially towards postponing or preventing electric blackouts or brownouts . . .,"<sup>10</sup> providing deferral of new electric generating capacity construction, rate savings to customers, a continuing availability of gas supplies, and--not incidentally--more paying customers for the gas companies.<sup>11</sup>

#### 4. PROGRAM RESULTS

Most of the water heater programs got off to a slow start. While PP&L's tariff was filed in 1980, no funds were paid until the end of 1981. Company explanations cited the depressed economy of the state, public uncertainty over new technologies, and a reluctance to advertise the program until BPA conservation offerings and the 1981 Oregon legislative programs became clearly defined.

On the other hand, PGE--centered in the often cloudy Willamette Valley--has experienced a high demand for solar water system rebates. This interest can be attributed to PGE's generally higher electric rates, an advertising campaign held early in 1981, or perhaps an increased sensitivity to energy conservation issues in general.

Heat pump water heaters appear to have a low level of acceptance within the state. Initial problems with certifying authorities' approvals and disputes over heat pump wiring requirements of local building codes dampened initial enthusiasm.

Each utility program has been effectively operational for about one year. Some expectations were met, some were not. Table 5 outlines the number of units financed since the beginning dates indicated.<sup>12</sup>

Clearly, the Cascade and CP National tariffs as replacement programs are relatively minor in their scope and impacts, as well as in data generation. Each has displaced about 1.5 million consumed kwh annually, to date.

Table 6 details the expected and observed distributions of replacement strategies and fractions, by major program:

TABLE 6. REPLACEMENT, SAVINGS DISTRIBUTION EXPECTATIONS AS OF JUNE 30, 1982

	Solar		Heat Pump	
	Expected	Observed	Expected	Observed
<u>Replacement Proportion</u>				
PP&L	33%	86%	67%	14%
PGE	33%	89%	67%	11%
NNG	5%	1%	-	-

<u>Savings Fraction</u>				
PGE Measurements*	.50	.34	.45	.33

\*As per PGE Quarterly Water Heater Incentive Program (WHIP) Report, as of June 30, 1982. Represents nine full months of data, 27 monitored units.

An analysis of solar-unit purchasers shows a larger family size (3.6) than the heat pump families (3.4). As the solar users generally use more hot water, their pre- and post-installation water-heating energy consumption is higher:

TABLE 7. MEASURED KILOWATT-HOUR CONSUMPTION AND SAVINGS (ANNUAL)

	Solar	Heat Pump
Pre-Installation	6,455	5,440
Post-Installation	4,583	3,101
Annual Average Savings/Household	1,872	2,339

Thus, while in this sample heat pump water heaters save many more kwh's per year than the solar units, in spite of their much higher costs (\$3,600 vs \$1,600 for heat pumps) the solar units are in much wider use.

In the instance of gas replacement of electric water heaters, unless intermittent ignition devices are used, 100% of the electric energy is saved in favor of

burning natural gas in a less-efficient system. Using an average electric consumption figure of 540 kwh per month, the gas water heater would release 6,480 kwh annually for other uses.

Conserved energy, program-to-date (PTD), is then summarized as:

TABLE 8. CONSERVED ELECTRICAL ENERGY, COSTS, PTD, WATER HEATER PROGRAMS

Type	Number	Savings kwh/Unit/Yr.	Total kwh
Solar	2,571	1,872	4,812,912
Heat Pump	309	2,339	722,751
Gas	6,907 <sup>b</sup>	6,480	44,757,360
Totals	9,326		50,293,023

Type	Company Costs (000,000's)	Cost Per kwh
Solar	\$ 1.92	16.0¢ <sup>a</sup>
Heat Pump	0.09	12.8¢
Gas	1.04	2.3¢
Totals	\$ 3.05	

<sup>a</sup>Factoring loan costs into present value figures involved in making one-year zero-interest loans. Approximately 70% of PGE's outstanding monies are such loans.

<sup>b</sup>Includes approximately 80 solar-assisted gas units.

This 50+ million kwh represents some 5,740 average kilowatts of generating capacity (10-15 megawatts of peaking capacity) that need not be built--enough energy to power 233 all-electric homes each year.

Cost-effectiveness must also be considered from the customer's standpoint. If several assumptions are made, it is possible to calculate the individual's long-term benefit: a) the systems' lives average 10 years; b) electric rates will increase at a real annual rate (adjusted for general inflation) of 5%, gas rates at 3%; and c) maintenance costs are negligible and efficiency remains constant.

TABLE 9. AVERAGE CUSTOMER COST-EFFECTIVENESS

Type	Average Cost	Tax Credit <sup>a</sup>	Company Rebate
Solar			
-PGE	\$3,600	\$2,016	\$300
-PP&L	\$3,600	\$2,016	\$105 <sup>d</sup>
Heat Pump			
-PGE	\$1,600	-	\$300
-PP&L	\$1,600	-	\$131 <sup>d</sup>
Gas			
-NNG, etc.	\$ 300 <sup>e</sup>	-	\$150 <sup>f</sup>

Type	Saved kwh <sup>b</sup>	Saved Fuel Cost <sup>c</sup>	Customer Savings
Solar			
-PGE	18,720	\$1,310	\$ 26
-PP&L	18,720	\$1,143	\$ (336)
Heat Pump			
-PGE	23,390	\$1,637	\$ 337
-PP&L	23,390	\$1,428	\$ (41)
Gas			
-NNG, etc.	23,100 <sup>g</sup>	\$2,000 <sup>h</sup>	\$1,850

<sup>a</sup>Federal credit of 40%, Oregon credit of 25% interact to create an effective rate of 61%.

<sup>b</sup>Table 7 times 10 years.

<sup>c</sup>Escalated as discussed, electric at 5% real, gas at 3% real.

<sup>d</sup>Savings times 5.6¢ per kwh for the first year.

<sup>e</sup>Average costs vary by amount of plumbing to be modified.

<sup>f</sup>Also estimated present value of 4-year, 0%-interest loan.

<sup>g</sup>At 300 therms per year, converted to BTU's and kwh.

<sup>h</sup>Difference in 10-year gas and electric projected rates.

## 5. CONCLUSIONS

It is first necessary to note that Oregon's water heater supplementation/replacement programs are just that: programs, and not projects or experiments. As such, measurements and data collection cannot be performed in classical, "double-blind" fashion to eliminate bias and error in the results.

In general, however, it is possible to conclude the following, based upon the data examined:

1) In order of energy-savings precedence, the preferred water-heating change should be a shift from electricity to natural gas, if there already exists a natural gas line to the residence. With a minimal IOU outlay, the greatest number of kwh's can be saved, at the lowest capital cost, and with the greatest customer fuel-cost savings.

This latter statement is predicated on the assumptions that: a) natural gas for the Northwest will continue to be readily available, which is dependent both upon the whims of geology and Canadian-U.S. politics; and b) that the gradual real increase in natural gas prices from Canadian sources will continue at its historical rate. Oregon has few proven natural gas reserves, and is heavily dependent upon imports.

2) Heat-pump water heaters rank next in efficiency, but behind solar units in attractiveness to customers. Both result in about the same return over a 10-year span, but the heat pump units must amortize out without the up-front extra cash from tax credits--the resultant out-of-pocket outlay is about the same.

However, heat-pump units got a slow start due to an initial lack of local manufacturers or even of distributors of the eastern-seaboard producers. Initial

units installed had to be withdrawn and replaced when an Underwriters Laboratory revoked approval on some heat-pump water heaters.

Some customers have mentioned noise, construction, and reliability problems. Average unit retail costs have risen from \$900 in early 1980 to \$1,600 in mid-1982. There is some question as to whether this rapid increase accurately reflects increased materials and labor costs, or is in part affected by the availability of utility rebates.

3) Solar water heater modifications, by the samples monitored in PUC-regulated programs, rank third among the modifications in terms of energy efficiency. Yet, far more solar than heat-pump units are financed or rebated.

One efficiency problem lies in measurements: 35% of the monitored solar units have F-chart design saving fractions of 0.38, compared to 0.48 for the other 65%. Another problem resulted from Oregon's lack of actual-to-expected sunshine ratio during the latter part of 1981. Still another problem centered around poorly installed units, whose frequent breakdowns lowered overall efficiency.

In their favor, solar water heating units, like storm windows and doors, are a highly visible "statement" about the customer's commitment to energy conservation and renewable resources. The psychological impact of such "statements" should not be underrated in designing similar programs calling for water heating conservation.

## 6. AGENDA FOR THE FUTURE

The electric utilities' programs are defined as experimental in nature, although they show some promise of permanence. Once sufficient data is collected, they can be expected to modify or even abolish their incentives, a result that could also occur should conservation ever become de-emphasized.

Gas utilities are expanding the scope of their replacement programs. Northwest Natural Gas's tariff, which once looked like Cascade's (see Appendix A), now reaches beyond space heaters to all gas users and those with services stubbed off at the dwelling, with zero-interest loans (Appendix A). This program saves substantial amounts of electricity while increasing gas sales, a not necessarily negative impact (see footnote 7).

These programs will continue to be in a state of flux, as their managers (see Appendix B) seek to fulfill requirements for conservation with innovative and effective approaches. Lessons learned in Oregon should be fairly readily transferable to states with similar utility regulatory control.

## 7. REFERENCES

<sup>1</sup>Ines M. Massella "Power Brokering in the PNW" Public Utilities Fortnightly, April 29, 1982, pp. 63-6.

<sup>2</sup>Census Bureau, US Dept. of Commerce, Census of Pop., 1980, Wash. DC, USGPO, 1981.

<sup>3</sup>Massella @ p. 63.

<sup>4</sup>Elrick & Lavidge, Inc., PNW Residential Energy Survey, Portland, OR: BPA, 1980. Vol. 6: Oregon Cross Tabulations, p. 61.

<sup>5</sup>Ibid., p. 121.

<sup>6</sup>Oregon PUC. 1980 Ore. Util. Stats., Salem, OR: OPUC, 1981, p. 7.

<sup>7</sup>A. G. White, "Oregon's Weatherization Programs," ACEEE Summer Session. Santa Clara, CA: ACEEE, August 22-7, 1982.

<sup>8</sup>See Appendix "A" for details.

<sup>9</sup>Portland General Electric. The Water Heater Incentive Program. Portland: PGE, Dec. 1980.

<sup>10</sup>Northwest Natural Gas. Conservation Incentive Program: Residential Water Heating Program Description. Portland: NNG, Dec. 1980.

<sup>11</sup>Ibid, p. 3.

<sup>12</sup>Source: Monthly and quarterly reports to PUC by each of the five companies.\*

**NORTHWEST NATURAL GAS COMPANY**

SCHEDULE 28  
CONSERVATION INCENTIVE PROGRAM  
- RESIDENTIAL WATER HEATING -

RECEIVED  
OPUC  
SALEM

**General:**  
This program provides an incentive for energy conservation by encouraging the use in residences of highly efficient gas water heating systems, thereby reducing the energy demand for residential water heating and minimizing the gas requirement for such use.

**Available:**  
The program is available in all territory served by the Company under the tariff of which this schedule is a part.

**Applicable:**  
This program applies to residential dwelling units with a functional gas service line (with or without a meter), where gas water heating conforming to conservation standards replaces electric water heating, or where solar water heating is installed assisted by gas water heating conforming to conservation standards.

**Incentive Allowance:**  
The Company will provide an incentive allowance for a gas conservation water heater installed in a residential dwelling unit coming within the "Applicable" provisions of this schedule. The incentive allowance will be in one of two forms at the customer's option, but not both: (1) \$150 cash; or (2) on approved credit, zero-interest financing in the principal amount of the customer's actual total cost of purchasing and installing the water heater, not to exceed \$400, repayable to the Company at not less than \$10 per month over a period not to exceed 48 months. Such incentive allowance shall be provided to the person or entity financially responsible for the installation.

**Special Conditions:**  
1. To qualify under this program, a gas water heating system must, as a minimum, conform to the energy conservation standards specified under ASHRAE Standard 90-75 as effective January 1, 1977.

Issued May 7, 1982 Effective with service on and after May 10, 1982

*(Signature)*

NORTHWEST NATURAL GAS COMPANY  
1900 200 NW Lee Street, Portland, Oregon 97201

8. Appendices

A. Sample IOU Tariffs

Portland General Electric Company First Revision of Sheet No. 220-1  
P.U.C. Ore. No. E-12 Cancelling Original Sheet No. 220-1

WATER HEAT INCENTIVE PROGRAM

PURPOSE

The Water Heat Incentive Program is designed to reduce domestic usage of electricity for water heating. The Company will provide a lump sum payment to residential customers converting their electric water heating systems to solar-assisted water heaters or water heater heat pumps. Customers installing a solar-assisted unit may choose instead to receive a no-interest advance of their Federal and state income tax credits.

AVAILABLE

In all territories served by the Company. Provisions of this tariff will not be available to dwellings not served by the Company on or before June 12, 1980, or to dwellings converted to electric water heating subsequent to June 12, 1980.

APPLICABLE

To residential dwellings where electricity is the primary source of domestic water heating and which serve as principal residences.

SERVICES PROVIDED

Qualifying units under this tariff refer to either solar-assisted water heaters or water heater heat pumps. The Company will, at the request of a qualifying customer, perform an analysis of the potential energy savings resulting from the installation of qualifying units. The Company shall also offer to assist in arranging the installation and/or financing of qualifying units.

FINANCIAL INCENTIVE

Customers who install a qualifying unit under this program may elect to receive the following financial incentives:

1. A lump sum payment of \$300, or
2. For solar-assisted water heater installations, an advance, at no interest, of the expected tax credits (60 percent of the installed cost) up to a maximum of \$2,400 until July 1 of the next year.

Note: Federal (40 percent) and state (25 percent) income tax credits are calculated at the nominal amount of 65 percent; however, when combined, the actual tax credit for many people will be 61 percent because of the effect of Federal tax upon the state tax calculations.

*(Signature)*  
Issued December 1, 1981  
C. L. Heinrich, Senior Vice President

Effective for service rendered on and after January 1, 1982



B. Key Contacts

- CP NATIONAL: Richard Jarrett  
1355 Willow Way, Concord, CA 94520  
415-680-7700
- CASCADE NG: D.E. Bennett  
222 Fairview North, Seattle, WA 98109  
206-624-3900
- NORTHWEST NG: Bruce DeBolt  
123 NW Flanders, Portland, OR 97209  
503-226-4211
- PACIFIC POWER: John Melnichuk  
920 SW 6th, Portland, OR 97204  
503-243-4601
- PORTLAND GENERAL: Roy Josi  
121 SW Salmon, Portland, OR 97204  
503-226-8333
- OREGON DEPT. OF ENERGY: Dave Philbrick (Renewables) 503-378-6063  
John Kaufmann (Solar) 503-378-5268  
102 Labor & Industries Bldg., Salem, OR 97310
- OREGON PUC: Al Jasso (Gas) 503-378-6115  
Barbara Combs (Renewables) 503-378-6190  
330 Labor & Industries Bldg., Salem, OR 97310

\* TABLE 5. IOU WATER HEATER CONVERSIONS AND FINANCING

	2nd Q 1982		FYD	
	\$	%	\$	%
<b>I. Electric to Solar, Heatpump</b>				
CP National <sup>1</sup>	0	0	1	150
PP&L <sup>2</sup>	70*	13,763*	167*	35,674*
PGE <sup>3</sup>	397	375,291	3,122	2,345,514
	467	\$389,054	3,290	\$2,381,338
<b>II. Electric to Gas</b>				
NNG <sup>4</sup>	831	124,650	7,277	1,091,550
Cascade <sup>5</sup>	32	4,800	261	39,150
CP National <sup>1</sup>	33	4,950	225	33,750
	896	\$134,400	7,803	\$1,170,450

Footnotes: 1. Began March 15, 1981. Rebate only.  
2. Began October 8, 1980. Rebate per KWH only.  
3. Began October 1, 1980. Rebate and low-interest loans.  
4. Began January 7, 1981. Rebate only. Some solar back-up.  
5. Began March 30, 1981. Rebate only.

\*Rested First Quarter Results