SAVEnergy Action Plan

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center
Seattle, Washington

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May 1995

Prepared for
the U.S. Department of Energy
Federal Energy Management Program
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington

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Preface

The SAVEnergy Program provides direct assistance to Federal agencies in identifying and implementing energy and water conservation measures. The Energy Policy Act of 1992 and the Executive Order 12902 require that Federal agencies reduce the energy consumed in Federal buildings. The Executive Order increased the goal to a 30% reduction by 2005 compared to 1985 levels. In addition, agencies are required, to the maximum extent possible, to install all energy and water conservation measures with paybacks of less than 10 years.

To help meet these goals, the U.S. Department of Energy's (DOE's) Office of Federal Energy Management Programs (FEMP) has initiated the SAVEnergy program. The SAVEnergy program approach has three key elements:

- The Action Plan with recommended conservation actions and complete proposals on how the agency can implement them.
- The Action Team to implement the SAVEnergy Action Plan.
- A project-tracking database to evaluate the SAVEnergy program and record progress toward conservation goals.

The SAVEnergy Action Plan enables facility energy managers to identify and implement cost-effective projects, using the full spectrum of resources available through the agency. FEMP, utilities, and other sources. It gives energy managers a detailed description of how they can translate specific energy conservation measures into real projects, including budget requirements and potential financing options.

The Action Plan starts with an energy and water conservation audit of the facility. In addition to collecting data on energy and water use, the auditors develop and evaluate conservation alternatives, using a fuel-neutral approach. The auditors also provide a report to help the agency and FEMP follow up on the project.

The SAVEnergy Action Plan has several components. The Plan

- Lists several low- or no-cost operation and maintenance changes that will generate immediate savings.
- Lists the top projects recommended for implementation based on less than 10-year simple payback and Federal life-cycle costing.
- Suggests funding sources to complete these projects. The funding sources could include agency funds, FEMP's Federal Energy Efficiency Fund, or leveraging of non-Federal financial incentives, such as utility demand-side management (DSM) programs.
- Lists other resources necessary for starting these projects to make it easier for the facility manager to start and complete a project.

Energy and Water Conservation Action Plan

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Executive Summary

On December 20 and 21, 1994, the Pacific Northwest Laboratory (PNL)[a] conducted a SAVEnergy Audit of the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service, Northwest Fisheries Science Center in Seattle, Washington. The objectives of this study were to evaluate the performance of all energy-consuming equipment in the facility, to estimate energy consumption and demand by end-use and to recommend energy conservation measures (ECMs) and water conservation measures (WCMs) to reduce costs pursuant to the Executive Order 12902, the Energy Policy Act of 1992 and the Code of Federal Regulations (10 CFR 436).

Energy conservation measures recommended in this SAVEnergy report and summarized in Table S.1 and S.2 below could save an estimated 3,050 million Btu's each year, or 14% of the facility's fiscal year 1994 (FY94) energy consumption. The annual reduction in energy costs amounts to approximately $20,944, or 12% of FY94 energy costs. In addition to energy savings, operations and maintenance costs are estimated to be reduced by approximately $5,446. Full implementation of the two energy conservation measures recommended in this report is estimated to save $26,390/yr with a net cost of $132,808. The simple payback is 5.3 years. The results of the life-cycle cost analysis for full implementation indicate a net-present value (NPV) of $355,038 with a savings-to-investment ratio (SIR) of 3.6. The life-cycle cost analysis was performed over a 25-year period.

In addition to recommending the full implementation of the two energy conservation measures, ECM 1: Upgrade Lighting Systems and ECM 2: Install Run-Around Heat Recovery Coil System, this report also makes the following recommendations:

- Complete and submit the funding proposal located in Appendix F to the Federal Energy Efficiency Fund.
- Complete and submit the rebate request forms located in Appendix D to Seattle City Light.
- Perform periodic energy and water conservation surveys in-house.
- Routinely review, recalculate, and inspect utility bills and rate schedules.
- Communicate and encourage staff to turn off lighting when not required.
- Specify premium efficiency motors when ordering new motors.
- Purchase a copy of *Motor Master* from the Washington State Energy Office.
- Specify high-efficiency refrigeration units when replacing exisiting units.
- Specify high-efficiency air-conditioning units when replacing or upgrading existing equipment.

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[a] Pacific Northwest Laboratory is a multiprogram national laboratory operated for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830 by Battelle Memorial Institute.

Table S.1. Summary of Potential Energy Savings

Energy Conservation Measure	Electric				Natural Gas			Net Energy	
	kWh/yr	kW	million Btu/yr	$/yr	therm/yr	million Btu/yr	$/yr	million Btu/yr	$/yr
1 Upgrade Lighting	419,686	80	1,432	15,389	0	0	0	1,432	15,389
2 Heat Recovery	(65,718)		(224)	(2,609)	18,421	1,842	8,164	1,618	5,555
Total	353,968	80	1,208	12,780	18,421	1,842	8,164	3,050	20,944
Percentage (FY94)	13.0%	16.5%		13.7%	15.2%		10.8%	14.3%	12.4%

Table S.2. Summary of Life-Cycle Cost Analysis

Energy Conservation Measure	Savings			Implementation			Simple	Life-Cycle Cost	
	Energy ($/yr)	O&M ($/yr)	Total ($/yr)	Cost ($)	Rebate ($)	Net Cost ($)	Payback (yr)	NPV ($)	SIR
1 Upgrade Lighting	15,389	5,446	20,835	151,580	37,772	113,808	5.5	249,065	3.2
2 Heat Recovery	5,555	0	5,555	19,000	0	19,000	3.4	111,975	6.9
Total	20,944	5,446	26,390	176,580[b]	37,772	138,810[b]	5.3	355,038	3.6

[b] Includes $6,000 agency dollar equivalent funds.

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1.0 Overview

1.1 Introduction

On December 20 and 21, 1994, the Pacific Northwest Laboratory (PNL) conducted a SAVEnergy Audit of the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service, Northwest Fisheries Science Center in Seattle, Washington. The objectives of this study were to evaluate the performance of all energy-consuming equipment in the facility, to estimate energy consumption and demand by end-use and to recommend energy conservation measures (ECMs) and water conservation measures (WCMs) to reduce costs pursuant to the Executive Order 12902, the Energy Policy Act of 1992 and the Code of Federal Regulations (10 CFR 436).

This section describes the facility and the systems encountered during the visit by the audit team. It also presents a summary of energy conservation measures. Section 2 shows energy consumption and costs for electricity, natural gas and water. A breakdown of energy consumed by end-use is also presented. Recommended energy conservation measures are presented in Section 3. Section 4 contains a discussion of operations and maintenance issues and other energy measures that can be implemented on a replace-on-failure basis rather than replacing immediately. Appendix A contains a three-year history of consumption, demand and cost for electric, natural gas and water utilities. Appendix B contains information on local weather data correlated to utility billing periods. A brief summary on Federal life-cycle costing is located in Appendix C along with the life-cycle cost analyses summaries for the energy and water conservation measures detailed in this report. Information on the rebate program sponsored by Seattle City Light, the electric utility, is located in Appendix D. Sample information for water-efficient equipment is located in Appendix E. Appendix F contains submittal forms to the Federal Energy Efficiency Fund for the energy conservation measures recommended in Section 3 of this report. A glossary of terms and abbreviations used in this report is located in Appendix G.

1.2 Building and Systems Description

The Fisheries complex consists of seven buildings including three primary buildings. The West building is a three-story structure constructed around 1931-32 and contains administration facilities. The West building has around 18,663 square feet total area. The East building is a four-story structure with a basement constructed around 1963 and contains the laboratory and research facilities. The East building has approximately 65,604 square feet total area. The main heating plant is located in the basement of the East building. Between these two facilities is a three-story building called the Center building also constructed around 1963. The Center building has approximately 10,260 square feet total area and contains the auditorium and a research library. In addition to these three main facilities, there are the Pilot Plant building, the Pilot Plant addition, the Aquaculture Laboratory, the Butler Complex, and the Refer building. These other facilities have approximately 20,550 square feet of floor space total. A diagram of the Fisheries complex is shown in Figure 1.1. A new facility to support research efforts is currently under construction beside the Aquaculture Laboratory.

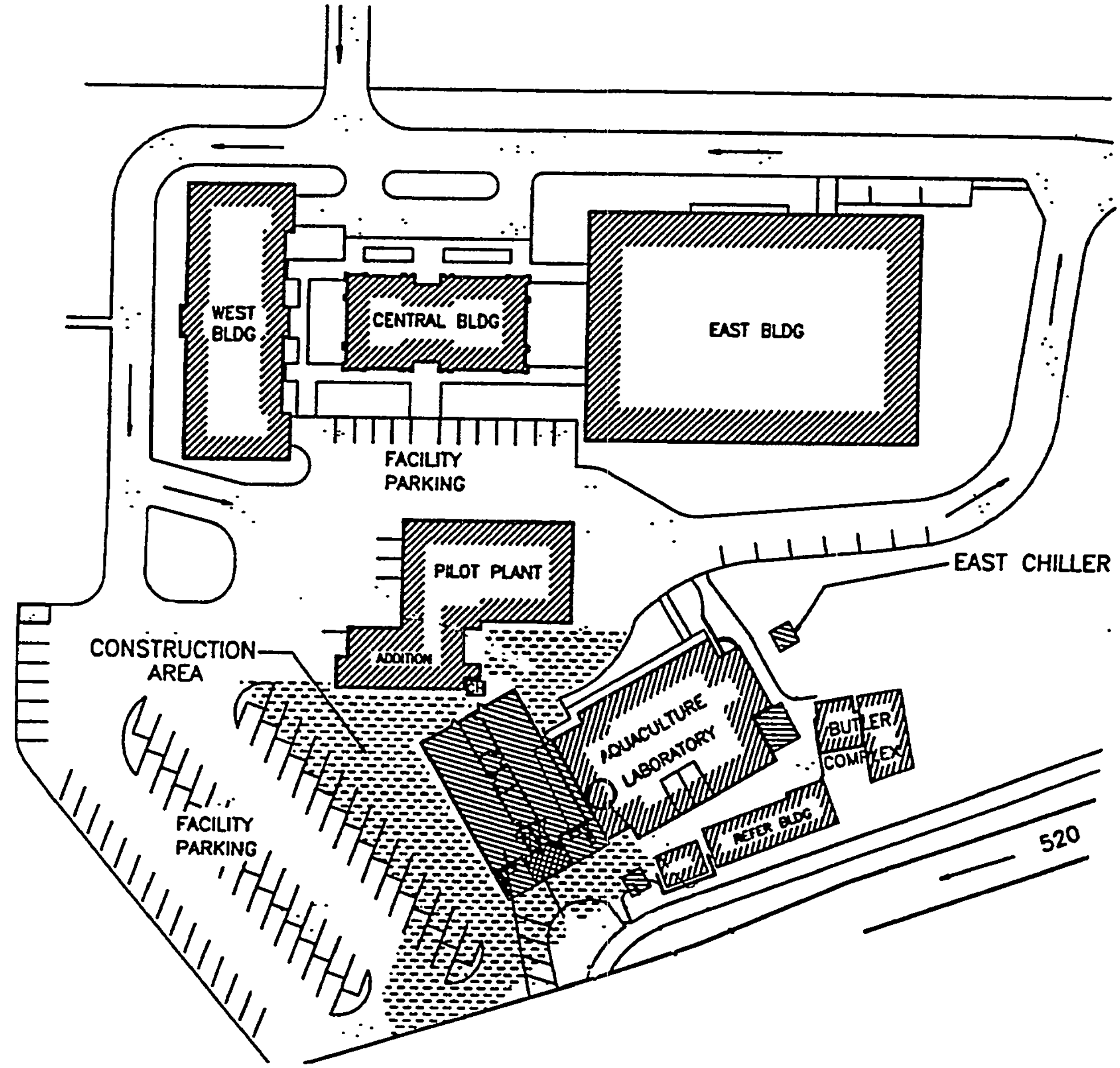

Figure 1.1. NOAA National Marine Fisheries Service Northwest Fisheries Science Center

Most of the buildings are occupied approximately 12 to 14 hours per day, 5 days per week, with the exception of the East building. Occupancy of the East building fluctuates greatly because of the nature of the laboratory environment.

Low-pressure steam is generated by a fire-tube boiler located in the basement of the East building. The steam is used to provide heat to the East, Center and West buildings. The West building uses steam radiators, whereas the Center and East buildings have forced-air ventilation systems. The boiler also provides heat energy to the central hot water system. The boiler operates most of the year but is typically down during August for maintenance and inspection. Natural gas-fired water heaters are rented from the natural gas utility to provide hot water needs in the Butler Complex, Pilot Plant, and Pilot Plant addition. There is also a rented water heater located in the boiler room to provide supplemental hot water to the central system.

The average load factors for the boilers and domestic water heaters are low, as will be demonstrated in the end-use consumption breakdown later in Section 2.5. Load factor is defined as the average load divided by capacity and is typically expressed as a percentage. Therefore, load factor is influenced by both usage (energy) and demand (capacity). Load factors are generally low on seasonal equipment and water heaters. Although a low load factor is one indicator of potentially oversized equipment, oversizing could not be verified.

Combustion efficiency tests are performed annually at the facility by a local contractor. A review of the previous efficiency test of the main boiler taken November 8, 1994, documented a combustion efficiency of 83.7% at high fire with a stack temperature of 290°F and 85.1% at low fire with a stack temperature of 247°F. The excess air level for the test was 47%. Although the excess air level is excessive, the extremely low stack temperature resulted in a high net efficiency. An optimal excess air rate for a natural gas boiler is between 8 and 15%. However, a limited visual inspection of the burner did not indicate this low level of excess air could be achieved or maintained.

Cooling is provided by a series of window air-conditioning units and split-systems. There are 20 window air-conditioning units installed in the West building, 25 in the East building, and 2 in the Pilot Plant. There are also 7 split-system air-conditioning units installed in the East building. The facility is expected to continue installing window air-conditioning units until each office in the East and West buildings is air conditioned.

1.3 Recommendations

Energy conservation measures (ECM) recommended in this report and summarized in Table 1.1 and 1.2 below could save an estimated 3,050 million Btu's each year, or 14% of the facility's fiscal year 1994 (FY94) energy consumption. The annual reduction in energy costs amount to approximately $20,944, or 12% of FY94 energy costs. In addition to energy savings, operations and maintenance costs are estimated to be reduced by approximately $5,446. Full implementation of the two energy conservation measures recommended in this report is estimated to save $26,390/yr with a net cost of $132,808. The simple payback is 5.3 years. The results of the life-cycle cost analysis for full implementation, including agency dollar equivalent funds, indicate a net-present value (NPV) of $355,038. The life-cycle cost analysis was performed over a 25-year period. The savings-to-investment ratio (SIR) is 3.6. A brief summary of life-cycle costing is located in Appendix C. A copy of the output from Building Life-Cycle Cost (BLCC) software[a] version 4.11 is included in Appendix C, Table C.4.

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[a] BLCC software was developed by the National Institute of Standards and Technology (NIST).

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In addition to recommending the full implementation of the two energy conservation measures, ECM 1: Upgrade Lighting Systems and ECM 2: Install Run-Around Heat Recovery Coil System, this report also make the following recommendations:

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- Routinely review, recalculate, and inspect utility bills and rate schedules.
- Communicate and encourage staff to turn off lighting when not required.
- Specify premium efficiency motors when ordering new motors.
- Purchase a copy of *Motor Master* from the Washington State Energy Office.
- Specify high-efficiency refrigeration units when replacing exisiting units.
- Specify high-efficiency air-conditioning units when replacing or upgrading existing equipment.

1.4 Energy Management

Energy management is an ongoing and continuous effort. The recommendations presented in this report are based on the findings and experience of the SAVEnergy Audit team but are also based on only a short period spent at the facility. While there are advantages to audits performed by unbiased parties such as the SAVEnergy Audit team, there is no substitute for local experience and familiarity. Energy audits and surveys should be performed on a regular basis by the facility staff. The local staff are in the best position to see opportunities to save energy, particularly opportunities that may not show themselves during formal energy surveys or visits from outside agencies. Periodic energy surveys need not be as formalized as the SAVEnergy Audit. Energy surveys may consist of special analyses of specific opportunities, measures, or technologies. Energy surveys may also consist of periodic inspections or checklist-type audits. Assistance in performing energy surveys can be found through local utilities and the state energy office, which sometimes offer this service at no cost.

It is also important to remember that specific energy and water conservation measures should periodically be re-evaluated. The savings potential of any measure is dependent on (1) the demand and load on the system, (2) the efficiency of the existing system and proposed alternative, and (3) the unit cost of the energy or water. Each of these parameters may change over time, thereby affecting the potential life-cycle cost effectiveness of the alternative. The cost of implementing the energy or water conservation measure may also change, in some cases actually becoming less expensive as energy-efficient and water-efficient technologies replace what was once conventional.

Energy and water conservation efforts are also supported by thorough inspection and review of the utility bills and familiarity with utility billing practices and rate schedules. The electric utility billing reviewed as part of this audit was relatively straightforward, however, little reasoning for the second electric meter could be identified. The second electric meter is on a more expensive billing structure and is also subject to minimum billing charges (in effect, a monthly penalty costing about $20 to $40 per year). The natural gas bill is less straightforward. The billing structure for natural gas includes a fixed[c] demand charge, which is currently $22,284/yr, approximately 30% of the annual natural gas bill. The rate of the demand charge increased approximately 330% in October 1993. The contracted demand amount should periodically be reviewed and discussed with the local utility. The natural gas bill is also subject to a minimum monthly charge. In the past, this has not been a concern; however, the facility was charged $570 in minimum charges during the last 2 months of FY94. The implication may be that energy conservation efforts may result in an increase in the minimum charge penalty and full energy cost reductions may not be realized. The facility should plot and follow utility consumption and billed amounts and anomalies should be reviewed and explanations sought.

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[c] *fixed* implies the rate is constant each month based on a contracted rate and not dependent on actual metered demand or rate of consumption.

1.5 Audit Information

Dates Audit Performed:	December 20-21, 1994
Performed by:	Pacific Northwest Laboratory
Auditor Type:	National Laboratory
Project Leader:	Steven A. Parker
Telephone:	(509) 375-6366
Facsimile:	(509) 375-3614
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Type Audit Performed:	Complete Building

Renewables Screening Completed: yes
Water Conservation Screening Completed: yes

Building Type Audited:	Office, R&D
Age of Facility:	West building 63 years old East building 32 years old
Number of Buildings Audited:	7

Total Square Footage Audited:

East bldg.	65,604 sq.ft.	
Center bldg.	10,260 sq.ft.	
West bldg.	18,663 sq.ft.	
Pilot Plant	7,360 sq.ft	
Aquaculture Lab	7,311 sq.ft.	(Behavior Lab section)
Aquaculture Lab	3,500 sq.ft.	
Aqua. Lab Annex	1,150 sq.ft.	
Butler Complex	1,230 sq.ft.	
Refer bldg.	n/a	
Total	115,078 sq.ft.	

2.0 Facility Energy, Water and End-Use Analysis

To properly evaluate opportunities for conserving energy or water, it is first necessary to analyze current energy and water consumption and cost. The resulting profile serves as a basis for evaluating and quantifying savings opportunities. This section provides a summary of the facility's energy and water consumption, demand and cost.

2.1 Electric

The electric utility for the site is Seattle City Light. There are two electric service accounts for the site. However, the vast majority of the consumption and demand is accountable through one meter billed under rate schedule 34. The secondary meter is billed under rate schedule 31. Rate schedule 31 is a consumption only charge, whereas rate schedule 34 charges for both consumption and demand. Because of the low consumption readings on the second meter, it is sometimes subject to a minimum billing charge.

Electricity consumption during FY94 was 2,724,330 kWh (9,295.4 million Btus) for the main electric meter and 4,470 kWh (15.3 million Btus) for the secondary meter. The peak demand for the year was 544 kW and the cumulative peak demand over FY94 was 5,813 kW. The total cost of electric service for FY94 was $93,214. A three-year history of electric consumption, demand and cost is shown in Appendix A, Table A.1. Weather data correlated to the electric billing period is located in Appendix B.

2.2 Natural Gas

The natural gas utility for the site is Washington Natural Gas Company. There is only one natural gas meter for the site and the account is subject to rate schedule 85. This rate schedule charges for energy consumption and demand. Energy consumption is determined using energy content correction factors applied to a volumetric meter reading. The consumption charge is subject to a monthly minimum charge. The monthly minimum charge is a ratchet clause identifying that the minimum charge is a function of the previous peak consumption rate. The minimum consumption charge under rate schedule 85 is 25% of the peak consumption in the previous 12 months or 2,500 therms, whichever is largest. The demand charge is a contracted rate rather than a metered demand. The natural gas bill also contains a rental charge for four domestic water heaters. The natural gas bill is also subject to Seattle city and Washington state taxes.

Natural gas consumption for the facility during FY94 was 120,970 therms (12,097.0 million Btus). There is a contracted fixed demand charge of 1,238 therms. All natural gas consumption and charges are on a single account. The total cost of natural gas services for FY94 was $75,703. A three-year history of natural gas consumption, demand and cost is shown in Appendix A, Table A.2. Weather data correlated to the natural gas billing period is located in Appendix B.

2.3 Water

The City of Seattle is the water utility for the site. Water is currently billed on two metered accounts. Total water consumption for the facility during FY94 was 128,073 ccf (100 cubic feet) with 64,263 ccf metered on one account and 63,810 ccf metered on the other account. Both metered accounts are on the same rate schedule. Wastewater charges are only applied to one of these accounts. Total wastewater metered for FY94 was 5,982 ccf. The total cost of water service to the site for FY94 was $113,971. A three-year history of water consumption, wastewater discharge and cost is shown in Appendix A, Table A.3.

The vast majority of the water consumed at the site goes to the site's function — supporting the fish. There is no submetering at the site; therefore, it was impossible for the audit team to develop an end-use profile for water consumption. The facility has significantly reduced water consumption over the past three years as can readily be seen in Appendix A, Table A.3. Most water systems in the fishery currently use once-through cycles. The site is currently constructing a new process that will allow a significant amount of water used at the site to be recycled and reused, thereby further reducing water consumption.

2.4 Unit Costs of Energy and Water

The per unit cost of energy and water are very important factors in determining energy and water costs and potential energy and water cost savings. The incremental cost of energy is the correct cost to use in determining savings rather than the average cost of energy. The incremental cost of energy is defined as the cost associated with consuming one unit (more or less) than the current consumption level. The same concept applies to electricity, electric demand, natural gas, and water. The unit costs of energy and water are summarized as follows:

Electric:	Summer (Mar-Oct)	Winter (Nov-Feb)
Consumption (rate 34)	$0.0285 /kWh	$0.0427 /kWh
Consumption (rate 31)	$0.0339 /kWh	$0.0451 /kWh
Demand (rate 34)	$1.30 /kW-month	$2.27 /kW-month

Natural Gas:	
Consumption	$0.4432 /therm

Water:	Summer (Jun-Sep)	Winter (Oct-May)
Water	$1.51 /ccf	$0.53 /ccf
Wastewater	$3.37 /ccf	$3.37 /ccf

2.5 End-Use Consumption Breakdowns

Most of the electric energy consumed is for lighting. Other major energy-consuming equipment include fan motors, refrigeration systems, and air-conditioning systems. Table 2.1 presents a breakdown of electric consumption and demand by building and end-use category. The electric consumption end-use breakdown is illustrated in Figure 2.1.

Most of the natural gas consumed is for heating and is consumed in the main boiler located in the East building. The second largest natural gas consumer is the boiler located in the Pilot Plant. This boiler provides building heat and high-pressure steam to an autoclave. The other natural gas consumers consist of the four identified water heaters. Table 2.2 presents a breakdown of natural gas consumption by end-use equipment. The natural gas consumption end-use breakdown is illustrated in Figure 2.2.

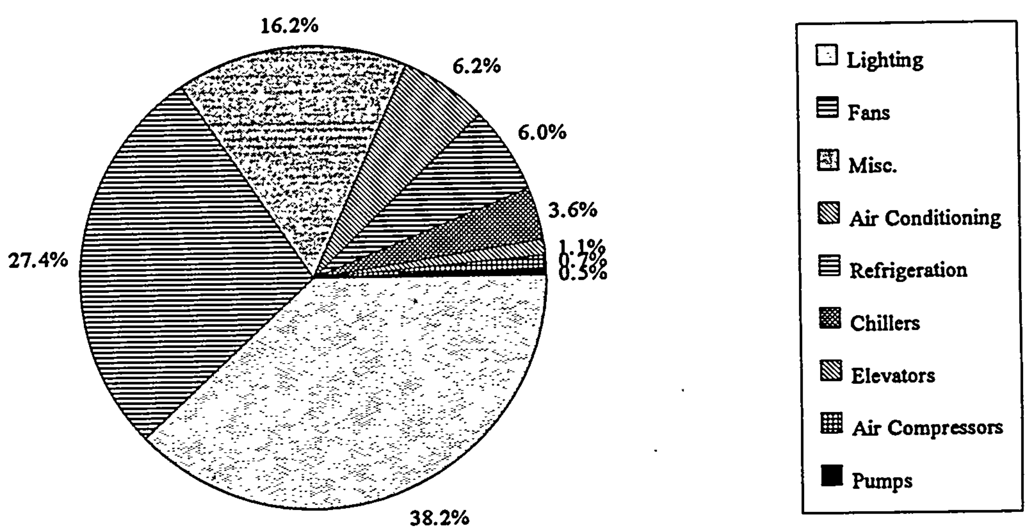


Figure 2.1. Electric Consumption End-Use Breakdown

Table 2.1. Electric Consumption by Building and End-Use Category

Item No.	Building	End-Use Category	Qty	Load (kW)	Load Factor	Operation (h/yr)	Demand (kW)	Energy (kWh/yr)
1	Aquaculture	Chiller	1	37.6	60%	0	0	0
2	Aquaculture	Lighting	90	16.8	100%	3,000	17	50,256
3	Aquaculture	Lighting - Night	4	0.5	100%	4,000	1	2,100
4	Aquaculture	Motor - Air Compressor	1	3.5	80%	876	4	3,075
5	Butler Complex	Lighting	8	0.8	100%	3,000	1	2,352
6	Butler Complex	Lighting - Night	1	0.2	100%	4,000	0	600
7	Center bldg	Lighting	315	20.7	100%	various	21	62,181
8	Center bldg	Motor - Fan - Exhaust	2	0.7	60%	8,760	1	6,127
9	Center bldg	Motor - Fan - Supply	2	2.3	70%	8,760	2	20,013
10	East bldg	Air Conditioning	32	64.4	various	various	64	118,134
11	East bldg	Lighting	1,341	129.8	100%	various	130	810,854
12	East bldg	Lighting - Night	6	1.1	100%	4,000	1	4,200
13	East bldg	Motor - Air Compressor	2	10.4	80%	1,752	10	18,237
14	East bldg	Motor - Boiler - Fan	1	5.3	80%	1,750	5	9,215
15	East bldg	Motor - Boiler - Pump	1	1.4	80%	1,050	1	1,474
16	East bldg	Motor - Elevator	1	31.7	80%	876	32	27,779
17	East bldg	Motor - Fan - Exhaust	37	15.7	60%	8,760	16	137,234
18	East bldg	Motor - Fan - Exhaust - Main	1	9.2	75%	8,760	9	80,789
19	East bldg	Motor - Fan - Supply - Main	1	59.2	75%	8,760	59	518,648
20	East bldg	Motor - Pump - HW	3	2.2	70%	6,000	2	12,901
21	East bldg	Refrigeration - Air Dryer	1	0.7	50%	8,760	1	3,264
22	East bldg	Refrigeration	8	18.5	60%	8,760	18	97,207
23	East Chiller	Chiller	1	42.7	60%	4,000	43	102,372
24	Exterior	Lighting - Night	4	0.7	100%	4,000	0	2,704
25	Pilot Plant	Air Conditioning	2	3.6	50%	3,000	4	5,400
26	Pilot Plant	Lighting	80	8.5	100%	3,000	8	25,416
27	Pilot Plant	Lighting - Night	5	0.8	100%	4,000	1	3,000
28	Pilot Plant	Motor - Fan - Exhaust	5	1.7	60%	8,760	2	15,030
29	Pilot Plant	Refrigeration	3	5.8	60%	8,760	6	30,546
30	Refer bldg	Refrigeration	2	8.1	60%	8,760	8	42,496
31	West bldg	Air Conditioning	20	36.2	50%	3,000	36	54,300
32	West bldg	Lighting	182	34.9	100%	various	35	131,210
33	West bldg	Lighting - Night	5	0.5	100%	4,000	0	1,800
34	West bldg	Motor - Elevator	1	5.3	80%	876	5	4,613
35	All	Misc. plug loads	lot	81.6	65%	8,760	82	464,460
	Total	Est. Electric Consumption					625	2,869,989
	Total	Billing Data FY94					544	3,120,000
	Total	Billing Data FY93					624	3,033,600
	Total	Billing Data FY92					624	2,724,330

Table 2.2. Natural Gas Consumption by End-Use Equipment

Item No.	Building	End-Use Category	Input (Btu/h)	Load Factor	Operation (h/yr)	Natural Gas (therm/yr)
1	East bldg.	Boiler 1 High Fire	10,461,000	8%	7,500	62,766.0
	East bldg.	Boiler 1 Low Fire	2,615,250	25%	7,500	49,035.9
2	Pilot Plant	Boiler 3 High Fire	700,000	3%	8,000	1,680.0
	Pilot Plant	Boiler 3 Low Fire	350,000	10%	8,000	2,800.0
3	East bldg.	Water Heater	197,000	8%	6,000	945.6
4	Pilot Plant	Water Heater	120,000	8%	8,760	841.0
5	Pilot Plant-add	Water Heater	120,000	0%	8,760	0.0
6	Butler Complex	Water Heater	197,000	5%	8,760	862.9
	Total	Est. Gas Consumption				118,931.4
	Total	Billing Data FY94				120,970.0
	Total	Billing Data FY93				135,845.0
	Total	Billing Data FY92				104,911.0

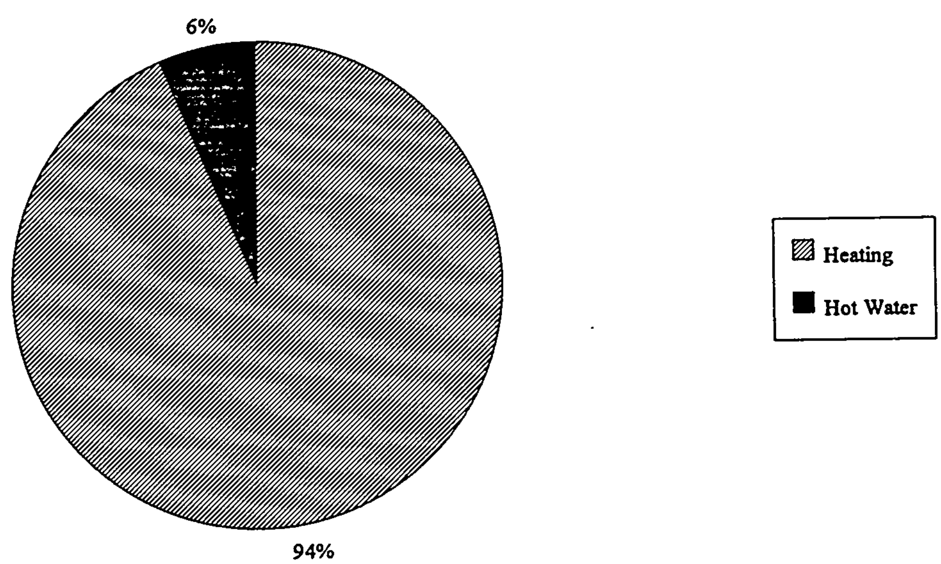


Figure 2.2. Natural Gas Consumption End-Use Breakdown

3.0 Energy and Water Conservation Measures

The results of the energy conservation measure analysis are presented within two primary categories, lighting and heat recovery. Both energy measures are cost effective and recommended for full implementation. One water conservation measure is also included for review. Although the water conservation measure is life-cycle cost effective, the payback is notably long (over 12 years) and therefore not included in the overall project recommendations.

A narrative description of each measure is provided, including information on the present end-use energy consumption, proposed alternative measure, alternative end-use energy consumption, estimated implementation cost, and life-cycle cost analysis. Summary tables included in each measure present the estimated operational performance of end-use equipment before and after the implementation of each measure.

3.1 ECM 1: Upgrade Lighting Systems

Description:

The efficiency of lighting systems has advanced significantly since the design and installation of the lighting systems at the NOAA National Marine Fisheries Service facilities. This energy measure recommends upgrading the lighting systems identified in Tables 3.1 through 3.3.

In general, Tables 3.1 through 3.3 recommend and itemize the following changes:

- Replace all 4-foot fluorescent lamps (F40T12 and FB40T12 U-lamp) with high-efficiency T-8 fluorescent lamps (F32T8 and FB31T8).

- Replace all 8-foot fluorescent lamps (F96T12) with energy-saving fluorescent lamps (F96T12/ES).

- Convert all fluorescent luminaries by replacing all standard and energy-efficient ballasts with electronic ballasts. This recommendation includes all 4-foot and 8-foot fluorescent lamp luminaries.

- Tandem wire ballasts wherever possible. Tandem wiring uses one 4-lamp ballast to operate two 2-lamp luminaries instead of two 2-lamp ballasts or using one 2-lamp ballast to operate two 1-lamp luminaries when possible instead of two 1-lamp ballasts. Tandem wiring ballasts increases energy efficiency while reducing operation and implementation costs.

- Convert the 4-lamp 8-foot fluorescent luminaries by installing specular reflectors and converting the luminaries to hold 3 lamps instead of 4 lamps. This also includes replacing the exiting ballast with electronic ballasts.

- Replace all 1-lamp 8-foot fluorescent luminaries with 2-lamp 4-foot luminaries equipped with F32T8 lamps and electronic ballasts.

- Replace all 2-foot fluorescent lamps (F20T12) with high-efficiency T8 fluorescent lamps (F17T8). Another alternative to consider is to eliminate the need for the 2-foot luminaries in all areas by improving the general lighting layout.

- Replace 75-watt incandescent lamps with 20-watt compact fluorescent lamps.

- Replace 150-watt incandescent exterior floodlights and 300-watt quartz exterior lights with 70-watt high-pressure sodium exterior floodlights.

- Replace the non-dimmable 200-watt incandescent luminaries in the Aquaculture Laboratory with fluorescent luminaries using 2-lamp F032T8 lamps with electronic ballasts. This alternative should also be considered to replace the dimmable 200 watt incandescent luminaries.

- Replace incandescent exit lights with light-emitting diode (LED) exit lights.

Energy and Cost Savings:

Energy consumption associated with upgrading the lighting system is estimated to be reduced by 419,686 kWh/yr. Peak electric demand is estimated to be reduced by 80.1 kW. The value of the electric energy savings is $15,389/yr.

Operations and Maintenance:

Operations and maintenance costs associated with the lamp and ballasts cost will decrease from an estimated $17,420/yr to $11,974/yr for a savings of $5,446/yr. The recommended alternatives will also reduce the number of spare parts required to be stocked by the maintenance department. Furthermore, in the case of the incandescent lamp replacements, maintenance time required for lamp replacement will be significantly reduced.

It may be noted that certain line items identified in Table 3.3 have negative net present values. Although this would indicate that these line items may not be life-cycle cost effective individually, they are recommended for implementation because of their impact on the entire lighting system. Full implementation will eliminate all inefficient lamps from required parts storage, specifically all F40T12 lamps. This will eliminate the opportunity to mis-apply the old inefficient lamps in the retrofit fixtures, thereby simplifying maintenance requirements and reducing overall parts storage.

Budget Implications:

The cost to upgrade all the lighting systems, as identified in Table 3.3, is $151,580. This includes all recommended conversions and replacements.

Seattle City Light, the electric utility, currently offers rebates for upgrading lighting systems in the amount of $0.09/kWh saved annually for conversions, components and retrofits and $0.14/kWh saved annually for new lighting fixtures and controls. There are certain limitations on the funding and the availability of funding should be confirmed with Seattle City Light and applications submitted before construction begins. Based on the estimated electric energy savings of 419,686 kWh/yr, the utility rebate is estimated to be $37,772. Therefore, the net cost of upgrading the lighting system is estimated to be $113,808. The simple payback for this energy conservation measure is 5.5 years.

Life-Cycle Cost Analysis:

The results of the life-cycle cost analysis indicate that implementing the proposed lighting changes will reduce the life-cycle cost from $991,542 to $742,477 for a net-present value of $249,065. The SIR for this energy measure is 3.2. A copy of the output from BLCC version 4.11 is included in Appendix C, Table C.1.

Table 3.1. Summary of Existing Lighting Systems

Item No.	Building	Existing System Descriptor	Location	Qty	Watts (W/fix)	Total (kW)	Operation (h/yr)	Demand (kW)	Energy kWh/yr)
1	West	2x4 4F40T12	hall	17	196	3.332	8,760	3.3	29,188
2	West	2x4 4F40T12	office	123	196	24.108	3,000	24.1	72,324
3	West	1x8 4F96T12	office	2	350	0.700	3,000	0.7	2,100
4	West	1x4 1F40T12 wall	hall	2	49	0.098	8,760	0.1	858
5	West	2x8 F96T12	hall	1	175	0.175	8,760	0.2	1,533
6	West	75 W inc.	stair/storage	5	75	0.375	8,760	0.4	3,285
7	West	1x8 2F96T12 surface	restroom	3	175	0.525	8,760	0.5	4,599
8	West	2x2 2F40T12U	hall	1	98	0.098	8,760	0.1	858
9	West	2x4 4F40T12 inset	graphics	20	196	3.920	3,000	3.9	11,760
10	West	2x4 4F40T12 inset	misc.	8	196	1.568	3,000	1.6	4,704
11	East	2x4 2F40T12 inset	hall	4	98	0.392	8,760	0.4	3,434
12	East	1x4 2F40T12 surface	hall	8	98	0.784	8,760	0.8	6,868
13	East	2x4 4F40T12 inset	cafeteria	12	196	2.352	8,760	2.4	20,604
14	East	1x4 2F40T12 wall	stair	16	98	1.568	8,760	1.6	13,736
15	East	exit 2-25 W inc.	hall	18	50	0.900	8,760	0.9	7,884
16	East	1x4 2F40T12 surface	hall	114	98	11.172	8,760	11.2	97,867
17	East	1x4 2F40T12 inset	labs	527	98	51.646	5,800	51.6	299,547
18	East	1x4 2F40T12 inset	office	444	98	43.512	5,800	43.5	252,370
19	East	1x4 2F40T12 yellow	labs	75	98	7.350	5,800	7.4	42,630
20	East	1x4 2F40T12 surface	restrooms	30	98	2.940	8,760	2.9	25,754
21	East	1x4 2F40T12 surface	first aid	2	98	0.196	5,800	0.2	1,137
22	East	1x2 2F20T12 inset	office	24	56	1.344	5,800	1.3	7,795
23	East	1x4 1F40T12 wall	hall	4	49	0.196	8,760	0.2	1,717
24	East	1x4 2F40T12 inset	computer room	46	98	4.508	5,800	4.5	26,146
25	East	1x4 2F40T12 inset	lunchroom	5	98	0.490	8,760	0.5	4,292
26	East	1x4 2F40T12 inset	conference	12	98	1.176	3,000	1.2	3,528
27	Center	1x4 1F40T12 surface	exterior	120	49	5.880	4,000	5.9	23,520
28	Center	1x4 2F40T12 surface	stair	7	98	0.686	8,760	0.7	6,009
29	Center	1x8 1F96T12 indirect high ceiling	library	30	95	2.850	3,000	2.9	8,550
30	Center	1x4 2F40T12 surface	library stacks	44	98	4.312	3,000	4.3	12,936
31	Center	2x4 2F40T12 inset	auditorium	12	98	1.176	1,500	1.2	1,764
32	Center	1x4 1F40T12 indirect	auditorium	28	49	1.372	1,500	1.4	2,058
33	Center	1x4 1F40T12 indirect high	auditorium	28	49	1.372	1,500	1.4	2,058
34	Center	1x4 1F40T12 surface	auditorium	28	49	1.372	1,500	1.4	2,058
35	Center	1x4 2F40T12 surface	audit. restroom	10	98	0.980	1,500	1.0	1,470
36	Center	1x4 2F40T12 surface	audit. restroom	6	98	0.588	1,500	0.6	882
37	Center	exit 2-25 W inc.	auditorium	2	50	0.100	8,760	0.1	876
38	Butler Complex	1x4 2F40T12 weatherproof	main area	8	98	0.784	3,000	0.8	2,352
39	Pilot Plant	2x4 2F40T12 inset	Biohazard room	10	98	0.980	3,000	1.0	2,940
40	East	300 W inc. quartz (night)	perimeter	1	300	0.300	4,000	0.0	1,200
41	East	150 W inc. flood (night)	perimeter	5	150	0.750	4,000	0.0	3,000
42	West	150 W inc. flood (night)	perimeter	1	150	0.150	4,000	0.0	600
43	West	75 W inc. (night)	perimeter	4	75	0.300	4,000	0.0	1,200
44	Pilot Plant	150 W inc. flood (night)	perimeter	5	150	0.750	4,000	0.0	3,000
45	Aquaculture	75 W inc. (2 lamp fixtures) (night)	perimeter	3	150	0.450	4,000	0.0	1,800
46	Aquaculture	75 W inc. (1 lamp fixtures) (night)	perimeter	1	75	0.075	4,000	0.0	300
47	Butler Complex	150 W inc. flood (night)	perimeter	1	150	0.150	4,000	0.0	600
48	Pilot Plant	2x4 4F40T12 inset	all	9	196	1.764	3,000	1.8	5,292
49	Pilot Plant	2x4 2F40T12		49	98	4.802	3,000	4.8	14,406
50	Pilot Plant	1F96T12 industrial strip		2	88	0.176	3,000	0.2	528
51	Pilot Plant	75 W inc.	various	10	75	0.750	3,000	0.8	2,250
52	Aquaculture	2F40T12	offices	5	98	0.490	3,000	0.5	1,470
53	Aquaculture	4F40T12 inset	various	22	196	4.312	3,000	4.3	12,936
54	Aquaculture	2F96T12 waterproof	Dechlor. rm	6	175	1.050	3,000	1.1	3,150
55	Aquaculture	75 W inc.	various	4	75	0.300	3,000	0.3	900
56	Aquaculture	200 W inc.	various	20	200	4.000	3,000	4.0	12,000
	Total							205.5	1,078,624

Table 3.2. Proposed Lighting System Recommendations

Item No.	Existing System Descriptor	Proposed Lighting System: Proposed System Descriptor	Qty	Watts (W/fix)	Demand (kW)	Energy (kWh)	Savings: Demand (kW)	Savings: Energy (kWh/yr)
1	2x4 4F40T12	4F32T8 ELC4	17	110	1.9	16,381	1.5	12,807
2	2x4 4F40T12	4F32T8 ELC4	123	110	13.5	40,590	10.6	31,734
3	1x8 4F96T12	3F96T12/ES ELC1,2 REF	2	165	0.3	990	0.4	1,110
4	1x4 1F40T12 wall	1F32T8 ELC	2	35	0.1	613	0.0	245
5	2x8 F96T12	2F96T12/ES ELC	1	105	0.1	920	0.1	613
6	75 W inc.	CFL 20	5	20	0.1	876	0.3	2,409
7	1x8 2F96T12 surface	2F96T12/ES ELC	3	105	0.3	2,759	0.2	1,840
8	2x2 2F40T12U	2FB31T8 U ELC2	1	62	0.1	543	0.0	315
9	2x4 4F40T12 inset	4F32T8 ELC4	20	110	2.2	6,600	1.7	5,160
10	2x4 4F40T12 inset	4F32T8 ELC4	8	110	0.9	2,640	0.7	2,064
11	2x4 2F40T12 inset	2F32T8 ELC2	4	62	0.2	2,172	0.1	1,261
12	1x4 2F40T12 surface	2F32T8 ELC2	8	62	0.5	4,345	0.3	2,523
13	2x4 4F40T12 inset	4F32T8 ELC4	12	110	1.3	11,563	1.0	9,040
14	1x4 2F40T12 wall	2F32T8 ELC2	16	62	1.0	8,690	0.6	5,046
15	exit 2-25 W inc.	LED exit	18	5	0.1	788	0.8	7,096
16	1x4 2F40T12 surface	2F32T8 ELC2	114	62	7.1	61,916	4.1	35,951
17	1x4 2F40T12 inset	2F32T8 ELC2	527	62	32.7	189,509	19.0	110,038
18	1x4 2F40T12 inset	2F32T8 ELC2	444	62	27.5	159,662	16.0	92,707
19	1x4 2F40T12 yellow	2F32T8 ELC2	75	71	5.3	30,885	2.0	11,745
20	1x4 2F40T12 surface	2F32T8 ELC2	30	62	1.9	16,294	1.1	9,461
21	1x4 2F40T12 surface	2F32T8 ELC2	2	62	0.1	719	0.1	418
22	1x2 2F20T12 inset	2F17T8 ELC2	24	39	0.9	5,429	0.4	2,366
23	1x4 1F40T12 wall	1F32T8 ELC	4	35	0.1	1,226	0.1	491
24	1x4 2F40T12 inset	2F32T8 ELC2	46	62	2.9	16,542	1.7	9,605
25	1x4 2F40T12 inset	2F32T8 ELC2	5	62	0.3	2,716	0.2	1,577
26	1x4 2F40T12 inset	2F32T8 ELC2	12	62	0.7	2,232	0.4	1,296
27	1x4 1F40T12 surface	1F32T8 ELC2 tandem ballast	120	31	3.7	14,880	2.2	8,640
28	1x4 2F40T12 surface	2F32T8 ELC2	7	62	0.4	3,802	0.3	2,208
29	1x8 1F96T12 indirect high ceiling	1F96T12/ES ELC2 tandem ballast	30	53	1.6	4,725	1.3	3,825
30	1x4 2F40T12 surface	2F32T8 ELC2	44	62	2.7	8,184	1.6	4,752
31	2x4 2F40T12 inset	2F32T8 ELC2	12	62	0.7	1,116	0.4	648
32	1x4 1F40T12 indirect	1F32T8 ELC tandem if possible	28	35	1.0	1,470	0.4	588
33	1x4 1F40T12 indirect high	1F32T8 ELC tandem if possible	28	35	1.0	1,470	0.4	588
34	1x4 1F40T12 surface	1F32T8 ELC tandem if possible	28	35	1.0	1,470	0.4	588
35	1x4 2F40T12 surface	2F32T8 ELC2	10	62	0.6	930	0.4	540
36	1x4 2F40T12 surface	2F32T8 ELC2	6	62	0.4	558	0.2	324
37	exit 2-25 W inc.	LED exit	2	5	0.0	88	0.1	788
38	1x4 2F40T12 weatherproof	2F32T8 ELC2	8	62	0.5	1,488	0.3	864
39	2x4 2F40T12 inset	2F32T8 ELC2	10	62	0.6	1,860	0.4	1,080
40	300 W inc. quartz	HPS 70 W	1	94	0.0	376	0.0	824
41	150 W inc. flood	HPS 70 W	5	94	0.0	376	0.0	2,624
42	150 W inc. flood	HPS 70 W	1	94	0.0	376	0.0	224
43	75 W inc.	CFL 20	4	20	0.0	80	0.0	1,120
44	150 W inc. flood	HPS 70 W	5	94	0.0	376	0.0	2,624
45	75 W inc. (2 lamp fixtures)	2CFL 20	3	40	0.0	160	0.0	1,640
46	75 W inc. (1 lamp fixtures)	CFL 20	1	20	0.0	80	0.0	220
47	150 W inc. flood	HPS 70 W	1	94	0.0	376	0.0	224
48	2x4 4F40T12 inset	4F32T8 ELC4	9	110	1.0	2,970	0.8	2,322
49	2x4 2F40T12	2F32T8 ELC2	49	62	3.0	9,114	1.8	5,292
50	1F96T12 industrial strip	2F32T8 ELC2	2	62	0.1	372	0.1	156
51	75 W inc.	CFL 20	10	20	0.2	600	0.6	1,650
52	2F40T12	2F32T8 ELC2	5	62	0.3	930	0.2	540
53	4F40T12 inset	4F32T8 ELC4	22	110	2.4	7,260	1.9	5,676
54	2F96T12 waterproof	2F96T12/ES ELC2	6	105	0.6	1,890	0.4	1,260
55	75 W inc.	CFL 20	4	20	0.1	240	0.2	660
56	200 W inc.	2F32T8 ELC2	20	62	1.2	3,720	2.8	8,280
Total			2,004		125.5	658,938	80.1	419,686

Table 3.3. Summary of Lighting Energy Measure Non-Energy Costs

Item No.	Proposed System Descriptor	Qty	Existing O&M Cost ($/fix-yr)	Existing O&M Cost ($/yr)	Proposed O&M Cost ($/fix-yr)	Proposed O&M Cost ($/yr)	Installation Cost ($/fix)	Installation Cost ($)
1	4F32T8 ELC4	17	22.86	389	18.88	321	103.56	1,761
2	4F32T8 ELC4	123	6.88	846	3.66	450	103.56	12,738
3	3F96T12/ES ELC1,2 REF	2	13.02	26	7.61	15	236.03	472
4	1F32T8 ELC	2	10.17	20	8.85	18	64.91	130
5	2F96T12/ES ELC	1	23.60	24	22.99	23	93.27	93
6	CFL 20	5	30.15	151	19.02	95	21.90	110
7	2F96T12/ES ELC	3	23.60	71	22.99	69	93.27	280
8	2FB31T8 U ELC2	1	26.84	27	25.85	26	71.57	72
9	4F32T8 ELC4	20	6.88	138	3.66	73	103.56	2,071
10	4F32T8 ELC4	8	6.88	55	3.66	29	103.56	828
11	2F32T8 ELC2	4	13.81	55	11.53	46	71.57	286
12	2F32T8 ELC2	8	13.81	110	11.53	92	71.57	573
13	4F32T8 ELC4	12	22.86	274	18.88	227	103.56	1,243
14	2F32T8 ELC2	16	13.81	221	11.53	184	71.57	1,145
15	LED exit	18	13.81	242	0.00	0	162.07	2,917
16	2F32T8 ELC2	114	13.81	1,574	11.53	1,314	71.57	8,159
17	2F32T8 ELC2	527	8.86	4,669	6.62	3,489	71.57	37,717
18	2F32T8 ELC2	444	8.86	3,934	6.62	2,939	71.57	31,777
19	2F32T8 ELC2	75	8.86	665	6.62	497	58.24	4,368
20	2F32T8 ELC2	30	13.81	414	11.53	346	71.57	2,147
21	2F32T8 ELC2	2	8.86	18	6.62	13	71.57	143
22	2F17T8 ELC2	24	8.86	213	6.62	159	93.11	2,235
23	1F32T8 ELC	4	10.17	41	8.85	35	64.91	260
24	2F32T8 ELC2	46	8.86	408	6.62	305	71.57	3,292
25	2F32T8 ELC2	5	13.81	69	11.53	58	71.57	358
26	2F32T8 ELC2	12	4.12	49	2.02	24	71.57	859
27	1F32T8 ELC2 tandem ballast	120	4.26	511	1.83	219	64.91	7,789
28	2F32T8 ELC2	7	13.81	97	11.53	81	71.57	501
29	1F96T12/ES ELC2 tandem ballast	30	5.27	158	2.43	73	46.64	1,399
30	2F32T8 ELC2	44	4.12	181	2.02	89	71.57	3,149
31	2F32T8 ELC2	12	1.48	18	0.46	6	71.57	859
32	1F32T8 ELC tandem if possible	28	1.03	29	0.23	6	64.91	1,817
33	1F32T8 ELC tandem if possible	28	1.03	29	0.23	6	64.91	1,817
34	1F32T8 ELC tandem if possible	28	1.03	29	0.23	6	64.91	1,817
35	2F32T8 ELC2	10	1.48	15	0.46	5	71.57	716
36	2F32T8 ELC2	6	1.48	9	0.46	3	71.57	429
37	LED exit	2	13.43	27	0.00	0	162.07	324
38	2F32T8 ELC2	8	4.12	33	2.02	16	71.57	573
39	2F32T8 ELC2	10	4.12	41	2.02	20	71.57	716
40	HPS 70 W	1	17.42	17	11.51	12	173.85	174
41	HPS 70 W	5	38.29	191	11.51	58	173.85	869
42	HPS 70 W	1	38.29	38	11.51	12	173.85	174
43	CFL 20	4	13.75	55	7.41	30	21.90	88
44	HPS 70 W	5	38.29	191	11.51	58	173.85	869
45	2CFL 20	3	27.50	83	14.82	44	21.90	66
46	CFL 20	1	13.75	14	7.41	7	21.90	22
47	HPS 70 W	1	38.29	38	11.51	12	173.85	174
48	4F32T8 ELC4	9	6.88	62	3.66	33	103.56	932
49	2F32T8 ELC2	49	4.12	202	2.02	99	71.57	3,507
50	2F32T8 ELC2	2	5.27	11	2.02	4	148.02	296
51	CFL 20	10	10.30	103	4.98	50	21.90	219
52	2F32T8 ELC2	5	4.12	21	2.02	10	71.57	358
53	4F32T8 ELC4	22	6.88	151	3.66	81	103.56	2,278
54	2F96T12/ES ELC2	6	7.31	44	4.86	29	93.27	560
55	CFL 20	4	10.30	41	4.98	20	21.90	88
56	2F32T8 ELC2	20	13.98	280	2.02	40	143.38	2,968
	Total	2,004		17,420		11,974		151,580

3.2 ECM 2: Install Run-Around Heat Recovery Coil System

Description:

A run-around heat recovery system consists of two fin-tube heat exchanger coils and a pump circulating water, or some other heat recovery fluid, between the two coils. One heat recovery coil is installed in the exhaust air ventilation system, while the other coil is installed in the outside make-up air system, as illustrated in Figure 3.1. During the winter, exhaust air passes over the heat recovery coil, the heat recovery fluid picks up the heat, the solution is pumped to the preheat coil, and the heat is transferred to the cool make-up air. The pump then circulates the cool heat transfer fluid back to the exhaust side to repeat the cycle.

A run-around heat recovery coil can also be used to pre-cool make-up air by transferring the heat from the outside make-up air to the exhaust ventilation air in the same fashion. Because the majority of the East building is not currently air conditioned, no savings from this activity are claimed.

Efficiencies, also referred to as effectiveness, of these systems vary from 50 to 75% depending on design. The efficiency of each system varies widely, depending on the size, ductwork layout, equipment type, and inside and outside air temperatures. For the purpose of this analysis, a heat exchanger effectiveness of 50% is assumed.

Energy savings will result in less energy consumed by the boiler during the heating months. There will be an increase in electricity consumption and electric demand because of the recirculation pump. There will also be an increase in the supply and exhaust fan motor energy consumption because of the increased pressure differential resulting from the installation of the heat recovery coils. The amount of the increased pressure differential is dependent on the design of the heat recovery coils.

Energy and Cost Savings:

Natural gas consumption associated with installing the heat recovery system is estimated to be reduced by 18,421 therm/yr. Electricity consumption is estimated to increase 65,718 kWh/yr because of the increased fan loads and added recirculation pump. The net energy savings is estimated to be 1,618 million Btu/yr. The value of the energy savings is $5,555/yr.

Operations and Maintenance:

There will be some increase in operations and maintenance requirements. These requirements include periodic maintenance of the recirculation pump and cleaning of the two heat recovery coils. These requirements can be performed by existing maintenance personnel, therefore, no cost impact is included in the life-cycle cost analysis.

Budget Implications:

The cost estimated to install the heat recovery system, as identified in Table 3.4, is $19,000. The simple payback for this energy conservation measure is 3.4 years.

Life-Cycle Cost Analysis:

The results of the life-cycle cost analysis indicate that implementing the proposed heat recovery system reduces the life-cycle cost from $1,492,318 to $1,380,342 for a net-present value of $111,976. The life-cycle cost analysis was performed over a 25-year period. The SIR is 6.9. A copy of the output from BLCC version 4.11 is included in Appendix C, Table C.2.

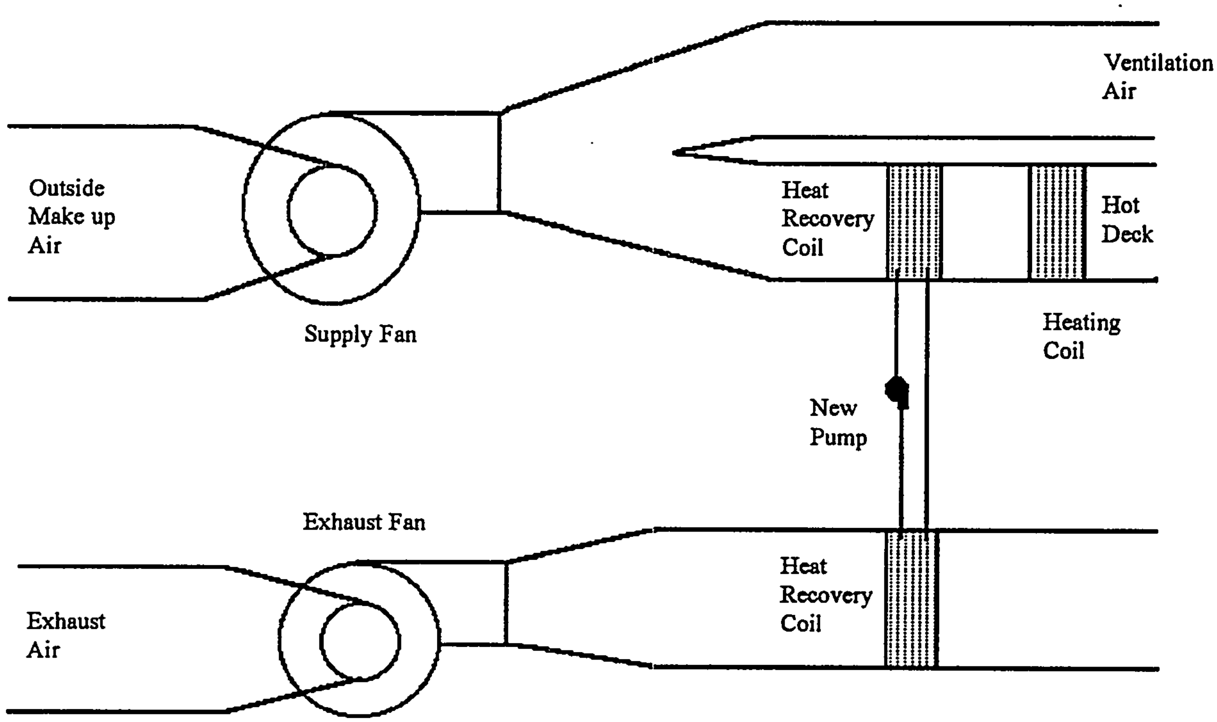


Figure 3.1. Run-Around Heat Recovery Coil

Table 3.4. Heat Recovery Analysis

<u>Assumptions</u>:

Exhaust air temperature	68	°F
Heat exchanger effectiveness	50%	
Outside air flow rate (hot deck)	31,000	cfm (assume 50% in heat duct, 50% in ventilation duct)
Exhaust air flow rate	20,000	cfm
Boiler efficiency	80%	
Recovery pump size	1	hp
Natural gas cost	$0.4432	/therm
Electricity cost	$0.0397	/kWh (demand weighted)

<u>Summary of Results</u>:

Heat recovery	1,474	million Btu/yr	
Natural gas energy savings	18,421	therm/yr	(1,842.1 million Btu/yr)
Natural gas cost savings	$8,164	/yr	
Electricity consumption increase:	65,718	kWh/yr	(224.2 million Btu/yr)
- Main supply fan	51,865	kWh/yr	(177.0 million Btu/yr)
- Main exhaust fan	8,079	kWh/yr	(27.6 million Btu/yr)
- Recirculation pump	5,774	kWh/yr	(19.7 million Btu/yr)
Electricity cost	$2,609	/yr	
Net energy savings	1,618	million Btu/yr	
Net energy cost savings	$5,555	/yr	
Installed cost estimate	$19,000		
Simple payback	3.3	years	

<u>Analysis</u>:

Outside Air Temp. Bin (°F)	Bin Hours (h/yr)	Heat Recovered (Btu/hr)	Heat Recovered (mil. Btu/yr)	Energy Savings (therm/yr)	Preheat Air Temp. (°F)	New Exhaust Air Temp. (°F)
57	1,332	118,800	158	1,978	60.5	62.5
52	1,415	172,800	245	3,056	57.2	60.0
47	1,573	226,800	357	4,459	53.8	57.5
42	1,258	280,800	353	4,416	50.4	55.0
37	687	334,800	230	2,875	47.0	52.5
32	214	388,800	83	1,040	43.6	50.0
27	57	442,800	25	315	40.2	47.5
22	25	496,800	12	155	36.8	45.0
17	15	550,800	8	103	33.5	42.5
12	3	604,800	2	23	30.1	40.0
7	0	0	0	0		
Total	6,579		1,474	18,421		

3.3 WCM 1: Upgrade Domestic Water Systems

Description:

This water conservation measure recommends upgrading the domestic water systems to meet current Washington state water use efficiency standards. In general, implementing this measure includes:

- Replacing all water closets with a model that consumes 1.6 gallons per flush (gpf).
- Replacing all urinals with a model designed for 1.0 gpf. This includes equipping the urinal with an electronic sensor activated flushometer also designed for 1.0 gpf.
- Replacing all lavatory faucets with commercial low-flow sensor faucets rated at 0.5 gallons per minute (gpm).
- Installing aerators rated at 0.5 gpm in all other faucets.
- Replacing all showerheads with low-flow showerheads rated at 2.5 gpm or less.

A sample of water-efficient equipment meeting the specifications above is included in Appendix E. These are included only as a reference; no recommendation or endorsement of the manufacturer is implied.

Assumptions:

The function of the facility results in a considerable amount of water consumption. Because water consumption within the facility is not submetered, it is impossible to separate domestic water consumption from process water consumption. For this reason, this conservation measure is based on the standard assumptions listed below to estimate domestic water consumption.

- Facility staffing is approximately 150 people. Assume 60% male, 40% female.
- Domestic water flow rate associated with water closets is assumed to be 5.0 gpf.
- Domestic water flow rate associated with urinals is assumed to be 2.5 gpf.
- Domestic water flow rate associated with faucets is assumed to be 2.5 gpm.
- Domestic water consumption associated with water closets is assumed to be 3 times the number of female staff members per day and 1 times the number of male staff members per day.
- Domestic water consumption associated with urinals is assumed to be 2 times the number of male staff members per day.

- Domestic water consumption associated with faucets is assumed to be 4 times the number of female staff members and 3 times the number of male staff members per day. The average faucet run time is assumed to be 10 seconds.

- Domestic water consumption is estimated based on an average 251 working days per year. No domestic water consumption is assumed during weekends and holidays.

- Although one shower was identified during the site audit from the facility plans, no water consumption is estimated for its use.

Water and Cost Savings:

Water consumption associated with the domestic water systems is estimated to be 506,200 gal/yr. Upgrading the domestic water systems as recommended in this water conservation measure is estimated to reduce water consumption to 164,500 gal/yr for a savings of 341,700 gal/yr. The value of the water savings, including the wastewater cost savings, is $1,931/yr.

Although there is the potential for energy savings associated with a reduction in domestic hot water consumption of the lavatory faucets and the one shower identified, because of the lack of hot water consumption identified during the audit, no hot water energy savings are being claimed as part of this water conservation measure.

Operations and Maintenance:

No change to operations and maintenance activities or costs is included in the life-cylce cost analysis, although training may be required on the electronic sensors.

Budget Implications:

The equipment listed in Table 3.5 was identified during the site survey. The total cost to install this water conservation measure is estimated to be $23,684. With the water cost reduction estimated to be $1,931/yr, the simple payback for this measure is 12.3 years.

Life-Cycle Cost Analysis:

The results of the life-cycle cost analysis indicate that implementing the proposed water conservation measures will reduce the life-cycle cost from $49,251 to $39,682 for a net-present value of $9,569. The life-cycle cost analysis was performed over a 25-year period. The SIR is 1.40. A copy of the output from BLCC version 4.11 is included in Appendix C, Table C.3.

Table 3.5. Domestic Water-Consuming Equipment

			Implementation Cost			
Location	Description	Qty	Removal ($/unit)	Equipment ($/unit)	Installation ($/unit)	Total[d] ($)
East Bldg.	Faucet - lavatory	10	0	228	25	2,910
East Bldg.	Aerator - janitor sink	1	0	10	25	40
East Bldg.	Water closets	14	40	150	75	4,267
East Bldg.	Urinal - wall mount	6	50	350	125	3,623
East Bldg.	Shower	1	0	20	25	52
Center Bldg.	Faucet - lavatory	4	0	228	25	1,164
Center Bldg.	Water closets	5	40	150	75	1,524
Center Bldg.	Urinal - wall mount	3	50	350	125	1,811
West Bldg.	Faucet - lavatory	6	0	228	25	1,746
West Bldg.	Water closets	6	40	150	75	1,829
West Bldg.	Urinal - floor mount	4	80	666	150	4,122
Aquaculture Lab.	Faucet - lavatory	1	0	228	25	291
Aquaculture Lab.	Water closet	1	40	150	75	305
Total						23,684

[d] Includes 15% contractor overhead.

4.0 Operations and Maintenance Measures

The results of the site audit and inspection did not reveal many opportunities to reduce energy consumption through operations and maintenance (O&M) practices. In general, the systems are well maintained and the staff demonstrate a high degree of professional responsibility. There are, however, a few O&M opportunities that the facility should review. The first O&M measure, Section 4.1, is truly an operations issue and can be implemented immediately. The remaining O&M measures, Sections 4.2 through 4.4, are recommended practices that deal with replace-on-failure of existing equipment. These recommendations are energy measures that can be implemented over time as old equipment is regularly scheduled for replacement or upgrade or failed equipment is replaced. Implementation of energy measures in this category do not qualify for funding under the Federal Energy Efficiency Fund.

4.1 Turn Off Lights When Not Required

In general, the facility has a good practice of turning off lights in unoccupied rooms. During the site visit, however, the audit team noted there was still room for improvement. This was most evident during the after-hours inspection. During the after-hours inspection the lights were off in almost all of the facilities except the East building. Over one-third of the perimeter rooms had the lights on with no occupancy during an after-hours inspection of the East building. This was reflected in the estimate of the operating hours for the end-use electric load estimate (Table 2.1) and the lighting energy conservation measure (ECM 1).

The audit team considered recommending occupancy sensor-type lighting controls, but the capital measure was not cost effective based on the limited observations and the low electric energy cost. For this reason, it is recommended that management and maintenance staff communicate to the facility occupants the need to turn off lights when leaving the room. This type of communication should occur on a regular basis and be highly endorsed by the local management for it to be effective and enduring.

The best practice to follow is for the occupant to turn off the lights whenever the occupant expects to be away for more than 1 minute. Although a true life-cycle cost analysis would reveal a somewhat longer time period. Our experience reveals that most people underestimate how long they expect to be away, or get "caught-in-the-hall" for a discussion that kept them away longer than anticipated.

The potential energy savings from this O&M energy measure is difficult to estimate. Based on the observations of the audit team and the success of implementing this O&M recommendation, electric energy savings could be as high as 300,000 kWh/yr with a value of about $9,970/yr.

4.2 Specify Premium-Efficiency Motors

Motors are the second largest electric energy consumer at the Northwest Fisheries Science Center. Excluding the boiler and elevators, which use specialty-type motors, the 17 motors greater than 1 hp identified in Table 2.1 account for almost 722,000 kWh/yr, or 25%, of the facility's electric energy consumption. Although motors are inherently efficient devices, design improvements have increased their efficiency. Many motor manufacturers today offer *energy-efficient* and even *premium-efficiency* motors from 1 hp to over 500 hp in both open drip-proof (ODP) and totally enclosed fan-cooled (TEFC) enclosures. Premium-efficiency motors have a lower slip than standard motors, therefore they operate at a slightly higher rpm. Because they are more efficient, premium-efficiency motors generally run cooler, which results in a longer motor life. Premium-efficiency motors typically cost around $25/hp more than standard-efficiency motors but can offer savings from 2 to 8%.

It is recommended that the facility implement a practice of specifying premium-efficiency motors when replacing any failed motor. To assist in identifying the performance specifications and model availability, it is also recommended that the maintenance staff obtain a copy of *Motor Master* from the Washington State Energy Office[(e)]. *Motor Master* is a user friendly software package developed by the Washington State Energy Office and contains an extensive database on commercially available, commonly used, motors from 1 hp to 500 hp. The cost of the software is around $50.

The audit team considered recommending replacing the facility motors immediately as a capital project, but the measure was not cost effective. It is cost effective to upgrade the motors using a replace-on-failure implementation strategy. The potential savings from fully implementing this O&M energy measure is approximately 13,640 kWh/yr with a value of about $480/yr. This measure, however, will not be fully implemented until all motors 1 hp and greater identified in Table 2.1 have been replaced.

4.3 Specify High-Efficiency Refrigeration Units

The audit team noted 13 refrigeration units located throughout the complex. The smaller units (less than 1-ton nominal size) are generally hermetically sealed compressors and the larger units (mostly 1- to 3-tons nominal size) are bolted hermetic compressors. Most systems use either R-12 or R-502 as a refrigerant (both are CFCs) and one unit has been converted to R-401A (a non-CFC). New compressor models are available today that offer higher efficiency. Most manufacturers of refrigeration equipment offer *scroll-type* compressors, and one manufacturer, Copeland[(f)], offers both *scroll-type* and *discus-type* compressors. The scroll and discus compressor types can be 10 to 20% more efficient than standard hermetic compressors. It is recommended that the facility consider system efficiency when replacing or repairing failed refrigeration compressors.

[(e)] Washington State Energy Office, P.O. Box 43165, Olympia, Washington 98504-3165. Telephone (360) 956-2115. Facsimile (360) 956-2229.

[(f)] Copeland is one of the largest manufacturers of refrigeration compressors in this size and application range and is noted because all of the existing units at the facility were manufactured by Copeland.

4.4 Specify High-Efficiency Air Conditioning Units

Most of the complex is not air conditioned but that is changing. During the site survey, the audit team identified 54 air-conditioning systems (7 split-systems and 47 window units). The East building is slowly being retrofit with additional window air conditioning units. Although installing window air-conditioning units is not an optimal design strategy, energy savings alone will not economically justify replacing the window air-conditioning units with a central air-conditioning system.

The window air-conditioning units identified during the site visit have cooling energy-efficiency ratios (EERs) between 7.0 and 9.0 (the unit of measure for EER is Btu/watt-hour). The split-system air-conditioning units, located on the roof of the East building and used to cool certain core rooms, have EER ratings between 9.0 and 10.0. Higher-efficiency units are available with EER ratings between 10.0 and 16.0 at a slightly higher cost.

It is recommended that the facility consider system efficiency when replacing or repairing failed air-conditioning systems. Replacing the existing window air-conditioning units with units rated with an EER of 10.0 and replacing the split-system air-conditioning units with units rated with an EER of 15.0 is estimated to save up to 54,800 kWh/yr at a value of $1,780/yr. This measure may also be subject to a rebate of as much as $12,750 from the electric utility, depending on utility restrictions (estimate based on a current rebate of $0.233/kWh for the first year electricity savings).

4.5 Specify Energy-Efficient Cogged V-Belts or Synchronous Belt Drives

Many of the motors systems at the facility utilize v-belt drive systems. V-belts are a common method of transferring drivepower and are relatively efficient. Mechanical efficiencies of standard v-belts typically range from 90% to 95%. Lower figures result from belt slippage and from energy dissipated in belt flexing; both of these inefficiencies increase with smaller pulley sizes.

Most manufacturers have introduced more efficient belt systems such as cogged v-belts and synchronous belts. Cogged v-belts, sometimes called energy-efficient belts, are direct replacements for standard v-belts thereby requiring little or no modifications to the drive system. Energy savings resulting from the application of cogged v-belts vary depending on how well the belt system is maintained and the respective pulley sizes, but are typically estimated to be around 2% of the motor energy. In addition to the energy savings, there is also a potential for maintenance savings. Because the belts are more flexible there is reduced slippage and the belts run cooler. This frequently results in longer belt life. Some manufacturers claim that energy-efficient belts have up to twice the life of standard v-belts. The cost of cogged v-belts is usually around 50% greater than the cost of standard v-belts.

Synchronous belts require replacing the existing v-belt pulleys with geared (toothed) pulleys. Alignment of the drive pulleys is more important with synchronous belts than it is with v-belts. Synchronous drives have zero slip and are more efficient that cogged v-belts. Energy savings resulting from the application of synchronous belt drives also vary depending on how well the previous system was maintained and the respective pulley sizes but are typically estimated to be around 2% to 6% of the motor energy. The cost of synchronous belts is usually around twice the cost of standard v-belts, plus there is the cost of the new pulleys and installation.

The audit team identified 16 belt-driven systems with integral horsepower motors, mostly fans and the air compressors, totalling 154 hp and 34 belt-driven systems with fractional horsepower motors, all exhaust fans, totalling 17 hp. The potential energy savings from replacing the standard v-belts with cogged v-belts on all these systems is approximately 16,100 kWh/yr with a value of $644/yr, using the run-time and load assumptions identified in Table 2.1 and assuming a 2% reduction in energy consumption. During the site visit, the audit team was not able to get a good accounting of the belt sizes used at the facility; therefore, an accurate estimate of the implementation cost can not be provided. However, cogged v-belts are usually good investments and are, therefore, recommended.

5.0 Funding Recommendations

Although several energy and water conservation measures were evaluated as part of this analysis, only a few were found to be cost effective. Because of the results of the life-cycle cost analysis, only the first two energy measures included in Section 3 are recommended for full implementation. The full cost for implementation of these measures is estimated to be $170,580, plus the Northwest Fisheries Science Center estimates around $6,000 for the value of agency time associated with developing the request-for-proposal, proposal evaluation, contract management and coordination.

The lighting conservation measure qualifies for a rebate from the electric utility. The value of this rebate is estimated to be $37,772. However, the rebate is subject to utility approval and the final rebate amount may be dependent on energy savings verified after project implementation. It is recommended that the site begin negotiating with Seattle City Light using the SAVEnergy Audit report as a reference document.

The results of the life-cycle cost analysis indicate that implementing the two proposed energy conservation measures (ECM 1 and ECM 2) will result in a net-present value of $355,038. The life-cycle cost analysis was performed over a 25-year period. The SIR is 3.6. A copy of the output from BLCC version 4.11 is included in Appendix C, Table C.4.

The avenues available for funding are limited to the Northwest Fisheries Science Center. It was concluded during the site visit by the audit team that no agency funding would be available to support implementation of any energy or water conservation measures. The only other source of funding identified is in the form of a rebate from the electric utility for the results of the lighting energy conservation measure (ECM 1). For this reason, the audit team recommends pursuing funding from the U.S. Department of Energy, Federal Energy Efficiency Fund (FEEF) leveraged with the utility rebate. The agency should also count the value of personnel time anticipated to develop the request-for-proposal, evaluate bid responses, contract management and oversight. The value of this personnel time can be included in the FEEF request as *agency dollar equivalent funds* (see Form D-6 in Appendix F). This will result in additional leveraging of funds, thereby improving the value of the proposal to FEEF.

A copy of the proposal forms for Federal Energy Efficiency Funds is included in Appendix F. These forms should be completed and submitted to the Office of Federal Energy Management Programs, DOE.

Another potential funding alternative is Energy Savings Performance Contracting (ESPC). In ESPC, a third party provides long-term financing of the energy conservation measures, which the agency repays to the third party in a payment determined as a percentage of the energy savings. Although this funding option may be pursued, the overall economics are not likely significant enough to interest potential financiers.

Appendix A

Utility Billing Data

Table A.1. Electric Billing Data

Month	Billing Season	Billing Period From	Billing Period To	No. Days	Meter Number 1 Electricity (kWh)	Electricity ($)	Demand (kW)	Demand ($)	L.F. (%)	Total ($)
Oct	s	9/25/91	10/24/91	29	279,600	6,514.68	588.0	517.44	68	7,032.12
Nov	w	10/24/91	11/25/91	32	280,800	6,542.64	552.0	485.76	66	7,028.40
Dec	w	11/25/91	12/27/91	32	243,600	8,142.33	516.0	954.76	61	9,097.09
Jan	w	12/27/91	1/28/92	32	231,600	8,175.48	480.0	974.40	63	9,149.88
Feb	w	1/28/92	2/28/92	31	218,400	7,709.52	492.0	998.76	60	8,708.28
Mar	s	2/28/92	3/30/92	31	198,000	6,989.40	456.0	925.68	58	7,915.08
Apr	s	3/30/92	4/28/92	29	226,800	5,378.29	468.0	430.40	70	5,808.69
May	s	4/28/92	5/28/92	30	248,400	5,787.72	540.0	475.20	64	6,262.92
Jun	s	5/28/92	6/26/92	29	261,600	6,095.28	576.0	506.88	65	6,602.16
Jul	s	6/26/92	7/28/92	32	309,600	7,213.68	612.0	538.56	66	7,752.24
Aug	s	7/28/92	8/26/92	29	313,200	7,297.56	624.0	549.12	72	7,846.68
Sep	s	8/26/92	9/25/92	30	308,400	7,776.82	612.0	584.46	70	8,361.28
Oct	s	9/25/92	10/26/92	31	308,400	7,895.04	624.0	605.28	66	8,500.32
Nov	w	10/26/92	11/25/92	30	315,600	11,550.96	600.0	1,212.00	73	12,762.96
Dec	w	11/25/92	12/29/92	34	260,400	10,103.52	492.0	1,097.16	65	11,200.68
Jan	w	12/29/92	1/29/93	31	252,000	9,777.60	504.0	1,123.92	67	10,901.52
Feb	w	1/29/93	3/1/93	31	229,200	8,795.36	468.0	1,024.61	66	9,819.97
Mar	s	3/1/93	3/30/93	29	217,200	5,560.32	456.0	442.32	68	6,002.64
Apr	s	3/30/93	4/28/93	29	198,000	5,068.80	444.0	430.68	64	5,499.48
May	s	4/28/93	5/27/93	29	212,400	5,773.62	480.0	586.26	64	6,359.88
Jun	s	5/27/93	6/28/93	32	254,400	6,945.12	492.0	610.08	67	7,555.20
Jul	s	6/28/93	7/28/93	30	259,200	7,076.16	516.0	639.84	70	7,716.00
Aug	s	7/28/93	8/26/93	29	256,800	7,010.64	504.0	624.96	73	7,635.60
Sep	s	8/26/93	9/27/93	32	270,000	7,371.00	504.0	624.96	70	7,995.96
Oct	s	9/27/93	10/26/93	29	244,800	6,683.04	492.0	610.08	71	7,293.12
Nov	w	10/26/93	11/29/93	34	253,200	9,482.35	480.0	939.11	65	10,421.46
Dec	w	11/29/93	12/28/93	29	214,800	8,420.16	456.0	948.48	68	9,368.64
Jan	w	12/28/93	1/28/94	31	214,800	8,420.16	457.4	951.39	63	9,371.55
Feb	w	1/28/94	2/28/94	31	131,800	5,166.56	474.7	987.38	37	6,153.94
Mar	s	2/28/94	3/29/94	29	214,750	5,626.45	465.1	553.47	66	6,179.92
Apr	s	3/29/94	4/27/94	29	213,720	5,599.46	465.1	553.47	66	6,152.93
May	s	4/27/94	5/26/94	29	216,080	5,661.30	446.8	531.69	69	6,192.99
Jun	s	5/26/94	6/27/94	32	209,900	5,906.72	482.4	618.83	57	6,525.55
Jul	s	6/27/94	7/27/94	30	283,250	8,072.63	543.8	706.94	72	8,779.57
Aug	s	7/27/94	8/25/94	29	254,790	7,261.52	532.8	692.64	69	7,954.16
Sep	s	8/25/94	9/26/94	32	272,440	7,764.54	516.9	671.97	69	8,436.51
FY92				366	3,120,000	83,623.40	6,516.0	7,941.42	65	91,564.82
FY93				367	3,033,600	92,928.14	6,084.0	9,022.07	68	101,950.21
FY94				364	2,724,330	84,064.89	5,813.0	8,765.45	64	92,830.34

s summer
w winter

Table A.1. Electric Billing Data, contd.

Month	Billing Season	Billing Period From	Billing Period To	No. Days	Meter 2 Electricity (kWh)	Meter 2 Electricity ($)	Minimum Charge ($)	Flood Light ($)	Total Charge ($)
Oct	s	9/25/91	10/24/91	29	2	0.00	4.11	28.78	7,065.01
Nov	w	10/24/91	11/25/91	32	8	0.00	4.53	28.78	7,061.71
Dec	w	11/25/91	12/27/91	32	278	10.81	0.00	28.78	9,136.68
Jan	w	12/27/91	1/28/92	32	979	40.24	0.00	28.78	9,218.90
Feb	w	1/28/92	2/28/92	31	0	0.00	4.39	28.78	8,741.45
Mar	s	2/28/92	3/30/92	31	108	4.44	0.00	27.82	7,947.34
Apr	s	3/30/92	4/28/92	29	48	0.00	4.11	28.78	5,841.58
May	s	4/28/92	5/28/92	30	55	0.00	4.25	28.78	6,295.95
Jun	s	5/28/92	6/26/92	29	61	0.00	4.11	28.78	6,635.05
Jul	s	6/26/92	7/28/92	32	67	0.00	4.53	28.78	7,785.55
Aug	s	7/28/92	8/26/92	29	12	0.00	4.11	28.78	7,879.57
Sep	s	8/26/92	9/25/92	30	29	0.00	4.61	28.78	8,394.67
Oct	s	9/25/92	10/26/92	31	31	0.00	4.84	32.42	8,537.58
Nov	w	10/26/92	11/25/92	30	59	0.00	4.68	32.42	12,800.06
Dec	w	11/25/92	12/29/92	34	105	0.00	5.30	32.42	11,238.40
Jan	w	12/29/92	1/29/93	31	568	25.67	0.00	32.42	10,959.61
Feb	w	1/29/93	3/1/93	31	276	12.33	0.00	32.42	9,864.72
Mar	s	3/1/93	3/30/93	29	192	5.64	0.00	32.42	6,040.70
Apr	s	3/30/93	4/28/93	29	145	0.00	4.52	32.42	5,536.42
May	s	4/28/93	5/27/93	29	235	7.57	0.00	15.12	6,382.57
Jun	s	5/27/93	6/28/93	32	47	0.00	5.55	15.10	7,575.85
Jul	s	6/28/93	7/28/93	30	2	0.00	5.20	15.10	7,736.30
Aug	s	7/28/93	8/26/93	29	0	0.00	5.03	15.10	7,655.73
Sep	s	8/26/93	9/27/93	32	51	0.00	5.55	15.10	8,016.61
Oct	s	9/27/93	10/26/93	29	54	0.00	5.03	15.10	7,313.25
Nov	w	10/26/93	11/29/93	34	910	39.34	0.00	14.54	10,475.34
Dec	w	11/29/93	12/28/93	29	1,089	49.11	0.00	14.52	9,432.27
Jan	w	12/28/93	1/28/94	31	259	11.68	0.00	14.52	9,397.75
Feb	w	1/28/94	2/28/94	31	1,065	48.03	0.00	14.52	6,216.49
Mar	s	2/28/94	3/29/94	29	401	12.47	0.00	14.52	6,206.91
Apr	s	3/29/94	4/27/94	29	259	8.05	0.00	14.52	6,175.50
May	s	4/27/94	5/26/94	29	242	7.53	0.00	14.52	6,215.04
Jun	s	5/26/94	6/27/94	32	163	0.00	5.73	15.69	6,546.97
Jul	s	6/27/94	7/27/94	30	14	0.00	5.45	15.82	8,800.84
Aug	s	7/27/94	8/25/94	29	0	0.00	5.27	15.82	7,975.25
Sep	s	8/25/94	9/26/94	32	14	0.00	5.81	15.82	8,458.14
FY92				366	1,647	55.49	38.75	344.40	92,003.46
FY93				367	1,711	51.21	40.67	302.46	102,344.55
FY94				364	4,470	176.21	27.29	179.91	93,213.75

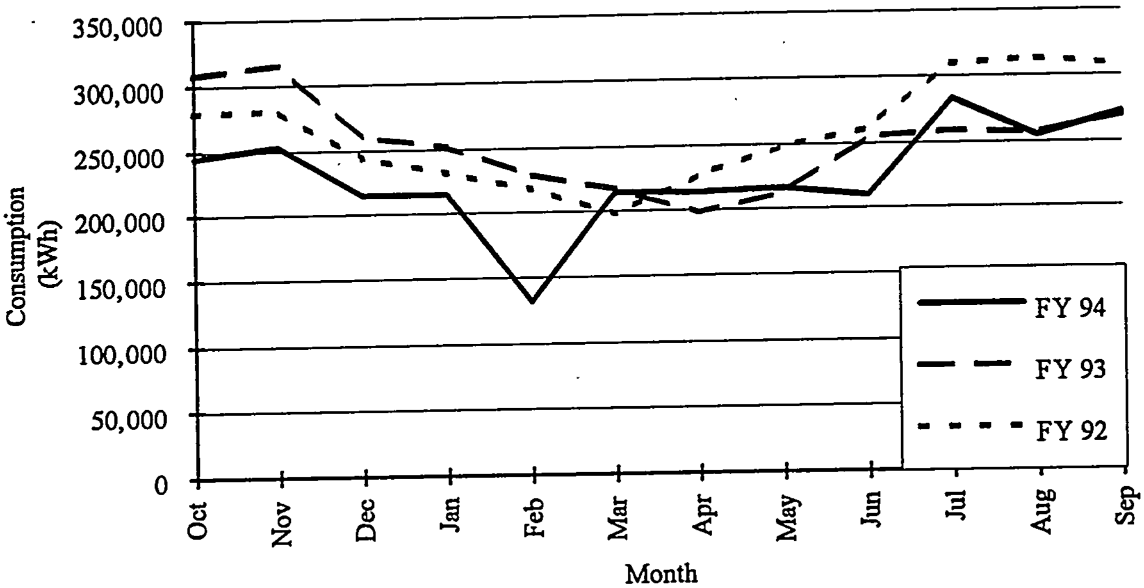


Figure A.1. Electricity Consumption

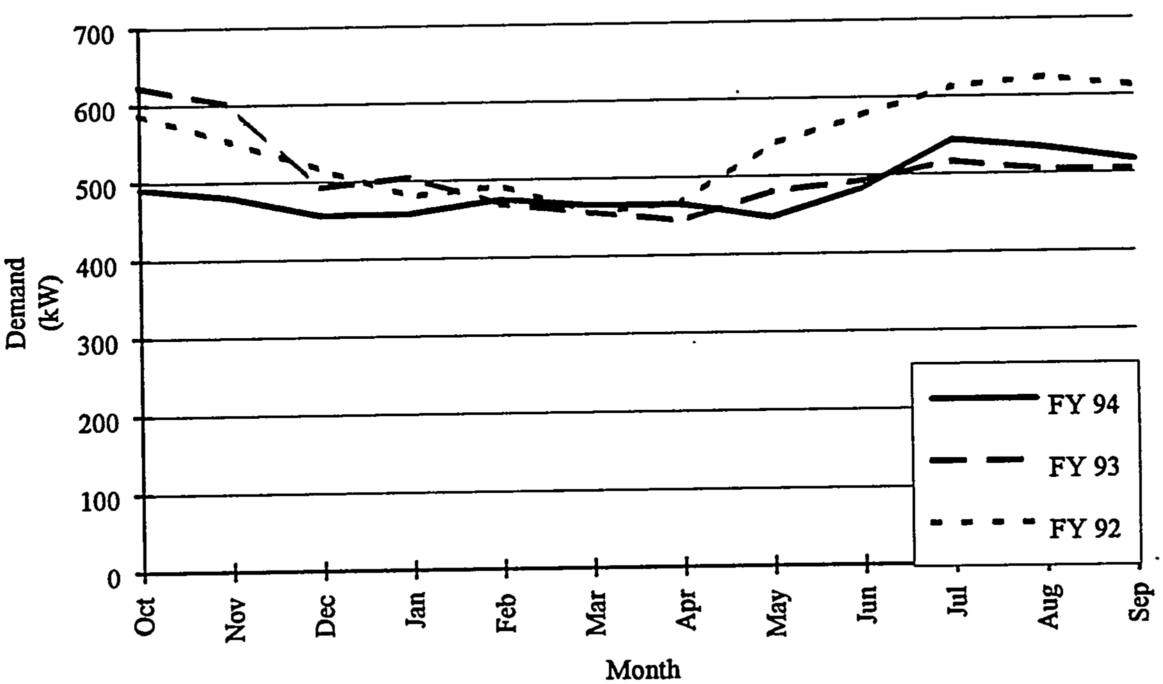


Figure A.2. Electric Demand

Table A.2. Natural Gas Billing Data

Month	Billing Period From	Billing Period To	No. Days	Natural Gas (therms)	Natural Gas ($)	Contract Demand ($)	Heater Rental ($)	Seattle Tax ($)	Min. Charge ($)	Total Charge ($)
Sep	8/27/91	9/26/91	30	1,006.0	350.26	567.10	69.26	62.69	0.00	1,045.15
Oct	9/26/91	10/25/91	29	4,687.6	1,632.08	567.10	69.26	144.47	0.00	2,408.75
Nov	10/25/91	11/25/91	31	14,698.8	5,117.68	567.10	69.26	366.85	0.00	6,116.73
Dec	11/25/91	12/27/91	32	18,981.1	6,608.65	567.10	69.26	467.97	0.00	7,702.82
Jan	12/27/91	1/28/92	32	19,082.1	6,643.81	567.10	69.26	464.22	0.00	7,740.23
Feb	1/28/92	2/27/92	30	16,257.8	5,660.48	567.10	69.26	401.48	0.00	6,694.16
Mar	2/27/92	3/27/92	29	12,960.3	4,512.39	567.10	69.26	328.23	0.00	5,472.82
Apr	3/27/92	4/27/92	31	9,816.7	3,417.88	567.10	69.26	258.40	0.00	4,308.48
May	4/27/92	5/27/92	30	5,137.2	1,788.62	567.10	69.26	154.45	0.00	2,575.27
Jun	5/27/92	6/26/92	30	1,192.3	415.12	567.10	69.26	66.82	0.00	1,114.14
Jul	6/26/92	7/29/92	33	724.1	252.11	567.10	69.26	62.54	0.00	1,042.74
Aug	7/29/92	8/27/92	29	367.1	127.81	567.10	69.26	62.54	0.00	1,042.74
Sep	8/27/92	9/28/92	32	2,952.1	1,027.83	567.10	69.26	105.92	0.00	1,765.95
Oct	9/28/92	10/27/92	29	6,902.0	2,403.07	567.10	69.26	193.66	0.00	3,228.93
Nov	10/27/92	11/25/92	29	13,280.9	4,624.01	567.10	69.26	335.35	0.00	5,591.56
Dec	11/25/92	12/30/92	35	23,675.7	8,243.17	567.10	69.26	566.25	0.00	9,441.62
Jan	12/30/92	1/29/93	30	22,028.5	8,033.38	567.10	69.26	552.87	0.00	9,218.45
Feb	1/29/93	3/3/93	33	23,596.9	8,618.77	567.10	69.26	590.22	0.00	9,841.19
Mar	3/3/93	3/31/93	28	15,927.1	5,817.37	567.10	69.26	411.49	0.00	6,861.06
Apr	3/31/93	4/29/93	29	14,059.8	5,135.34	567.10	69.26	367.97	0.00	6,135.51
May	4/29/93	5/27/93	28	6,670.7	2,436.47	567.10	69.26	195.79	0.00	3,264.46
Jun	5/27/93	6/29/93	33	3,762.7	1,374.33	567.10	69.26	128.02	0.00	2,134.55
Jul	6/29/93	7/29/93	30	2,206.0	912.35	567.10	69.26	98.55	0.00	1,643.10
Aug	7/29/93	8/30/93	32	782.9	325.09	567.10	69.26	62.54	0.00	1,042.74
Sep	8/30/93	9/29/93	30	2,158.0	896.09	567.10	69.26	97.51	0.00	1,625.80
Oct	9/29/93	10/28/93	29	7,308.1	2,980.63	1,456.74	84.75	288.19	0.00	4,805.22
Nov	10/28/93	11/30/93	33	18,412.0	7,448.21	1,857.00	86.54	598.87	0.00	9,985.43
Dec	11/30/93	12/30/93	30	18,799.2	7,604.84	1,857.00	86.54	608.86	0.00	10,152.05
Jan	12/30/93	1/31/94	32	17,148.7	6,937.16	1,857.00	86.54	566.26	0.00	9,441.77
Feb	1/31/94	3/3/94	31	19,597.6	7,927.82	1,857.00	86.54	629.46	0.00	10,495.63
Mar	3/3/94	3/31/94	28	14,052.2	5,684.54	1,857.00	86.54	486.34	0.00	8,109.23
Apr	3/31/94	4/29/94	29	10,716.8	4,335.27	1,857.00	86.54	400.26	0.00	6,673.88
May	4/29/94	5/31/94	32	7,572.1	3,063.14	1,857.00	86.54	319.10	0.00	5,320.59
Jun	5/31/94	6/29/94	29	3,942.9	1,637.66	1,857.00	86.54	228.15	0.00	3,804.16
Jul	6/29/94	7/29/94	30	730.1	304.15	1,857.00	86.54	158.61	243.50	2,644.61
Aug	7/29/94	8/30/94	32	532.3	221.75	1,857.00	86.54	158.61	325.90	2,644.61
FY92			366	104,911.1	36,526.90	6,805.20	831.12	2,840.66	0.00	47,264.03
FY93			368	135,845.3	48,951.18	6,805.20	831.12	3,608.63	0.00	60,169.12
FY94			365	120,970.0	49,041.25	20,593.84	1,019.41	4,540.22	569.40	75,702.98

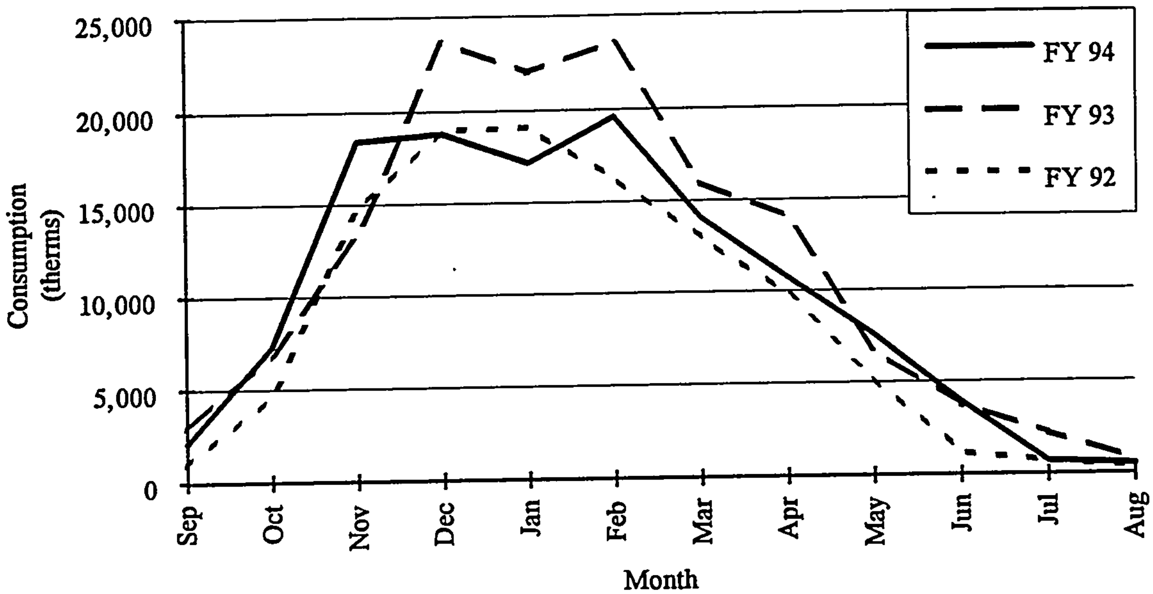


Figure A.3. Natural Gas Consumption

Table A.3. Water Billing Data

		Billing Period			Meter 1					
Month	Billing Season	From	To	No. Days	Water (ccf)	Cost ($)	Wastewater (ccf)	Cost ($)	Penalty ($)	Total ($)
Oct*	w	8/30/91	10/1/91	32	6,240	3,341.96	689	1,743.17	0.00	5,085.13
Nov	w	10/1/91	11/13/91	43	8,000	4,314.00	2,299	5,816.47	0.00	10,130.47
Dec	w	11/13/91	12/16/91	33	8,293	4,428.00	1,513	3,827.89	0.00	8,255.89
Jan	w	12/16/91	1/22/92	37	7,000	3,744.00	1,567	3,998.98	(41.00)	7,701.98
Feb	w	1/22/92	2/21/92	30	16,167	8,593.34	1,238	3,284.48	0.00	11,877.82
Mar	w	2/21/92	3/20/92	28	2,410	1,315.89	821	2,101.76	0.00	3,417.65
Apr	w	3/20/92	4/17/92	28	5,380	2,887.02	2,333	5,972.48	0.00	8,859.50
May	w	4/17/92	5/15/92	28	9,700	5,172.30	1,737	4,446.72	0.00	9,619.02
Jun	s	5/15/92	6/12/92	28	11,240	10,668.27	1,618	4,142.08	10.00	14,820.35
Jul	s	6/12/92	7/15/92	33	5,790	7,625.90	1,496	3,829.76	0.00	11,455.66
Aug	s	7/15/92	8/14/92	30	6,250	8,228.50	1,580	4,044.80	0.00	12,273.30
Sep	s	8/14/92	9/17/92	34	9,680	8,690.28	3,527	9,029.12	0.00	17,719.40
Oct	w	9/17/92	10/15/92	28	260	178.54	2,188	5,601.28	0.00	5,779.82
Nov	w	10/15/92	11/13/92	29	7,500	4,008.50	3,280	8,396.80	0.00	12,405.30
Dec	w	11/13/92	12/16/92	33	8,293	4,428.00	1,999	5,117.44	0.00	9,545.44
Jan	w	12/16/92	1/13/93	28	8,000	4,262.80	1,099	2,978.19	0.00	7,240.99
Feb	w	1/13/93	2/16/93	34	8,000	4,256.00	1,717	4,824.77	0.00	9,080.77
Mar*	w	2/16/93	3/17/93	29	8,630	4,589.27	1,333	3,745.73	0.00	8,335.00
Apr	w	3/17/93	4/12/93	26	7,110	3,785.19	1,566	4,400.46	0.00	8,185.65
May	w	4/12/93	5/13/93	31	8,000	4,256.00	1,554	4,366.74	0.00	8,622.74
Jun	s	5/13/93	6/16/93	34	6,860	5,957.48	1,887	5,302.47	0.00	11,259.95
Jul	s	6/16/93	7/15/93	29	5,790	6,734.61	941	2,644.21	0.00	9,378.82
Aug*	s	7/15/93	8/17/93	33	7,693	8,940.19	767	2,155.27	0.00	11,095.46
Sep	s	8/17/93	9/20/93	34	6,530	4,987.23	552	1,551.12	0.00	6,538.35
Oct	w	9/20/93	10/18/93	28	6,301	3,357.23	573	1,610.13	0.00	4,967.36
Nov	w	10/18/93	11/16/93	29	5,590	2,981.11	560	1,573.60	0.00	4,554.71
Dec	w	11/16/93	12/16/93	30	5,909	3,149.86	574	1,612.94	0.00	4,762.80
Jan	w	12/16/93	1/20/94	35	6,784	3,612.73	139	439.87	0.00	4,052.60
Feb	w	1/20/94	2/16/94	27	5,359	2,858.91	164	552.68	0.00	3,411.59
Mar	w	2/16/94	3/18/94	30	4,805	2,565.85	1,313	4,424.81	0.00	6,990.66
Apr	w	3/18/94	4/18/94	31	8,103	4,334.49	471	1,587.27	0.00	5,921.76
May	w	4/18/94	5/17/94	29						2,547.18
Jun	s	5/17/94	6/17/94	31	7,349	7,724.81	350	1,179.50	0.00	8,904.31
Jul	s	6/17/94	7/19/94	32	4,549	6,856.60	540	1,819.80	0.00	8,676.40
Aug	s	7/19/94	8/17/94	29	4,555	6,865.61	594	2,001.78	0.00	8,867.39
Sep	s	8/17/94	9/20/94	34	4,959	4,416.23	704	2,372.48	0.00	6,788.71
FY92				384	96,150	69,009.46	20,418	52,237.71	(31.00)	121,216.17
FY93				368	82,666	56,383.81	18,883	51,084.48	0.00	107,468.29
FY94				365	64,263	48,723.43	5,982	19,174.86	0.00	67,898.29

Table A.3. Water Billing Data, contd.

	Billing Period			Meter 2			
Month	From	To	No. Days	Water (ccf)	Water ($)	Penalty ($)	Total ($)
Oct	8/30/91	10/1/91	32	7,652	4,071.31	5.00	4,076.31
Nov	10/1/91	11/13/91	43	12,475	6,646.08	5.00	6,651.08
Dec	11/13/91	12/16/91	33	3,920	2,097.08	0.00	2,097.08
Jan	12/16/91	1/20/92	35	5,439	2,900.63	(23.40)	2,877.23
Feb	1/20/92	2/21/92	32	8,597	4,571.21	10.00	4,581.21
Mar	2/21/92	3/20/92	28	12,180	6,466.62	0.00	6,466.62
Apr	3/20/92	4/17/92	28	14,964	7,939.36	0.00	7,939.36
May	4/17/92	5/15/92	28	16,745	8,881.51	0.00	8,881.51
Jun	5/15/92	6/12/92	28	13,908	13,173.41	(70.00)	13,103.41
Jul	6/12/92	7/20/92	38	13,665	17,924.55	0.00	17,924.55
Aug	7/20/92	8/18/92	29	8,402	11,030.02	0.00	11,030.02
Sep	8/18/92	9/17/92	30	10,933	9,791.62	0.00	9,791.62
Oct	9/17/92	10/19/92	32	11,827	6,279.88	0.00	6,279.88
Nov	10/19/92	11/17/92	29	15,359	8,148.31	0.00	8,148.31
Dec	11/17/92	12/16/92	29	13,127	6,967.58	0.00	6,967.58
Jan	12/16/92	1/19/93	34	13,214	7,007.96	10.00	7,017.96
Feb	1/19/93	2/16/93	28	18,591	9,848.64	10.00	9,858.64
Mar	2/16/93	3/17/93	29	14,193	7,522.10	0.00	7,522.10
Apr	3/17/93	4/16/93	30	17,081	9,049.85	0.00	9,049.85
May	4/16/93	5/18/93	32	17,606	9,327.57	0.00	9,327.57
Jun	5/18/93	6/17/93	30	12,839	11,119.44	0.00	11,119.44
Jul	6/17/93	7/19/93	32	8,134	9,441.31	0.00	9,441.31
Aug	7/19/93	8/17/93	29	7,057	8,193.06	0.00	8,193.06
Sep	8/17/93	9/20/93	34	5,870	4,475.62	0.00	4,475.62
Oct	9/20/93	10/18/93	28	5,356	2,847.32	10.00	2,857.32
Nov	10/18/93	11/16/93	29	5,068	2,694.97	10.00	2,704.97
Dec	11/16/93	12/16/93	30	7,083	3,760.91	0.00	3,760.91
Jan	12/16/93	1/20/94	35	5,587	2,969.52	0.00	2,969.52
Feb	1/20/94	2/16/94	27	5,574	2,962.65	0.00	2,962.65
Mar	2/16/94	3/18/94	30	6,000	3,188.00	0.00	3,188.00
Apr	3/18/94	4/18/94	31	6,345	3,370.51	0.00	3,370.51
May	4/18/94	5/17/94	29	4,924	2,618.80	0.00	2,618.80
Jun	5/17/94	6/17/94	31	3,056	3,216.61	0.00	3,216.61
Jul	6/17/94	7/19/94	32	3,269	4,924.04	0.00	4,924.04
Aug	7/19/94	8/17/94	29	5,262	7,917.52	0.00	7,917.52
Sep	8/17/94	9/20/94	34	6,286	5,582.06	0.00	5,582.06
FY92			384	128,880	95,493.40	(73.40)	95,420.00
FY93			368	154,898	97,381.32	20.00	97,401.32
FY94			365	63,810	46,052.91	20.00	46,072.91

Table A.3. Water Billing Data, contd.

Month	Both Meters Water (ccf)	Water ($)	Wastewater (ccf)	Wastewater ($)	Penalty ($)	Total ($)
Oct	13,892	7,413.27	689	1,743.17	5.00	9,161.44
Nov	20,475	10,960.08	2,299	5,816.47	5.00	16,781.55
Dec	12,213	6,525.08	1,513	3,827.89	0.00	10,352.97
Jan	12,439	6,644.63	1,567	3,998.98	(64.40)	10,579.21
Feb	24,764	13,164.55	1,238	3,284.48	10.00	16,459.03
Mar	14,590	7,782.51	821	2,101.76	0.00	9,884.27
Apr	20,344	10,826.38	2,333	5,972.48	0.00	16,798.86
May	26,445	14,053.81	1,737	4,446.72	0.00	18,500.53
Jun	25,148	23,841.68	1,618	4,142.08	(60.00)	27,923.76
Jul	19,455	25,550.45	1,496	3,829.76	0.00	29,380.21
Aug	14,652	19,258.52	1,580	4,044.80	0.00	23,303.32
Sep	20,613	18,481.90	3,527	9,029.12	0.00	27,511.02
Oct	12,087	6,458.42	2,188	5,601.28	0.00	12,059.70
Nov	22,859	12,156.81	3,280	8,396.80	0.00	20,553.61
Dec	21,420	11,395.58	1,999	5,117.44	0.00	16,513.02
Jan	21,214	11,270.76	1,099	2,978.19	10.00	14,258.95
Feb	26,591	14,104.64	1,717	4,824.77	10.00	18,939.41
Mar	22,823	12,111.37	1,333	3,745.73	0.00	15,857.10
Apr	24,191	12,835.04	1,566	4,400.46	0.00	17,235.50
May	25,606	13,583.57	1,554	4,366.74	0.00	17,950.31
Jun	19,699	17,076.92	1,887	5,302.47	0.00	22,379.39
Jul	13,924	16,175.92	941	2,644.21	0.00	18,820.13
Aug	14,750	17,133.25	767	2,155.27	0.00	19,288.52
Sep	12,400	9,462.85	552	1,551.12	0.00	11,013.97
Oct	11,657	6,204.55	573	1,610.13	10.00	7,824.68
Nov	10,658	5,676.08	560	1,573.60	10.00	7,259.68
Dec	12,992	6,910.77	574	1,612.94	0.00	8,523.71
Jan	12,371	6,582.25	139	439.87	0.00	7,022.12
Feb	10,933	5,821.56	164	552.68	0.00	6,374.24
Mar	10,805	5,753.85	1,313	4,424.81	0.00	10,178.66
Apr	14,448	7,705.00	471	1,587.27	0.00	9,292.27
May						5,165.98
Jun	10,405	10,941.42	350	1,179.50	0.00	12,120.92
Jul	7,818	11,780.64	540	1,819.80	0.00	13,600.44
Aug	9,817	14,783.13	594	2,001.78	0.00	16,784.91
Sep	11,245	9,998.29	704	2,372.48	0.00	12,370.77
FY92	225,030	164,502.86	20,418	52,237.71	(104.40)	216,636.17
FY93	237,564	153,765.13	18,883	51,084.48	20.00	204,869.61
FY94	128,073	94,776.34	5,982	19,174.86	20.00	113,971.20

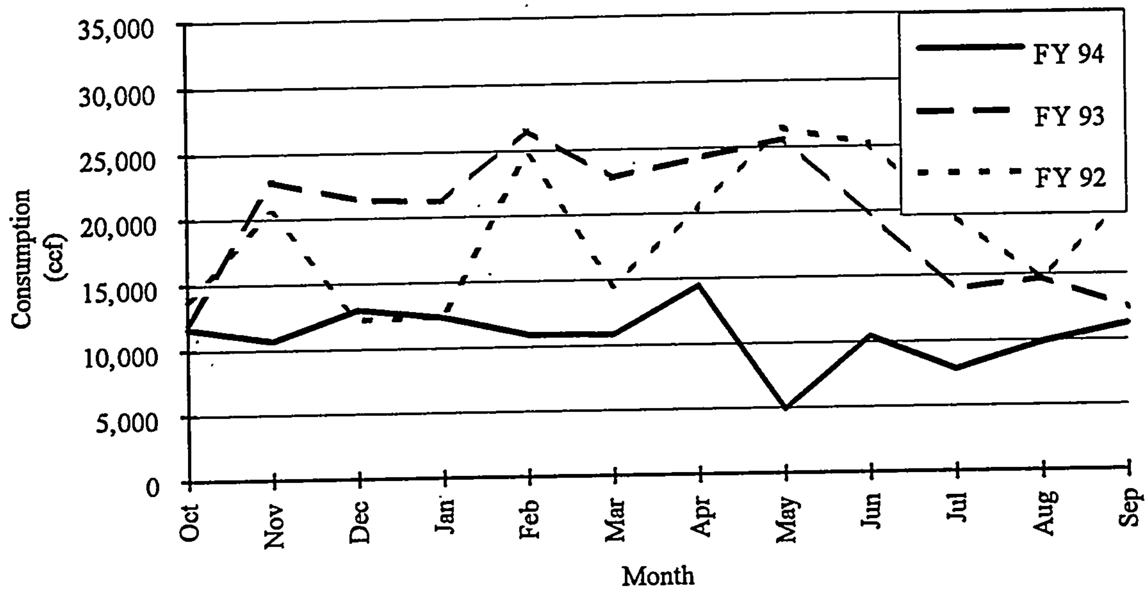


Figure A.4. Water Consumption

Appendix B

Weather Data Correlated to Utility Billing Periods

Table B.1. Weather Data Correlated to Electric Billing Period

Month	Billing Period From	Billing Period To	No. of Days	Meter 1 Electricity (kWh)	Degree-Days Cooling (base 55°F)	Degree-Days Cooling (base 60°F)	Degree-Days Cooling (base 65°F)	Degree-Days Heating (base 65°F)
Sep								
Oct	9/25/91	10/24/91	29	279,600				
Nov	10/24/91	11/25/91	32	280,800				
Dec	11/25/91	12/27/91	32	243,600				
Jan	12/27/91	1/28/92	32	231,600				
Feb	1/28/92	2/28/92	31	218,400	0	0	0	547
Mar	2/28/92	3/30/92	31	198,000	2	0	0	457
Apr	3/30/92	4/28/92	29	226,800	50	13	0	349
May	4/28/92	5/28/92	30	248,400	145	56	14	198
Jun	5/28/92	6/26/92	29	261,600	281	145	64	73
Jul	6/26/92	7/28/92	32	309,600	341	183	56	35
Aug	7/28/92	8/26/92	29	313,200	377	232	104	17
Sep	8/26/92	9/25/92	30	308,400	175	62	11	138
Oct	9/25/92	10/26/92	31	308,400	83	20	4	271
Nov	10/26/92	11/25/92	30	315,600	0	0	0	537
Dec	11/25/92	12/29/92	34	260,400	0	0	0	852
Jan	12/29/92	1/29/93	31	252,000	0	0	0	872
Feb	1/29/93	3/1/93	31	229,200	0	0	0	697
Mar	3/1/93	3/30/93	29	217,200	0	0	0	494
Apr	3/30/93	4/28/93	29	198,000	7	2	0	430
May	4/28/93	5/27/93	29	212,400	134	54	8	194
Jun	5/27/93	6/28/93	32	254,400	183	55	8	145
Jul	6/28/93	7/28/93	30	259,200	180	41	0	120
Aug	7/28/93	8/26/93	29	256,800	300	157	65	55
Sep	8/26/93	9/27/93	32	270,000	226	103	35	132
Oct	9/27/93	10/26/93	29	244,800	90	28	1	227
Nov	10/26/93	11/29/93	34	253,200	0	0	0	730
Dec	11/29/93	12/28/93	29	214,800	0	0	0	683
Jan	12/28/93	1/28/94	31	214,800	0	0	0	616
Feb	1/28/94	2/28/94	31	131,800	0	0	0	773
Mar	2/28/94	3/29/94	29	214,750	4	0	0	497
Apr	3/29/94	4/27/94	29	213,720	19	0	0	369
May	4/27/94	5/26/94	29	216,080				
Jun	5/26/94	6/27/94	32	209,900				
Jul	6/27/94	7/27/94	30	283,250				
Aug	7/27/94	8/25/94	29	254,790				
Sep	8/25/94	9/26/94	32	272,440				

Table B.2. Weather Data Correlated to Natural Gas Billing Period

Month	Billing Period From	Billing Period To	No. of Days	Natural Gas Consumption (therms)	Heating Degree-Days (base 65°F)
Sep	8/27/91	9/26/91	30	1,006.0	
Oct	9/26/91	10/25/91	29	4,687.6	
Nov	10/25/91	11/25/91	31	14,698.8	
Dec	11/25/91	12/27/91	32	18,981.1	
Jan	12/27/91	1/28/92	32	19,082.1	
Feb	1/28/92	2/27/92	30	16,257.8	534
Mar	2/27/92	3/27/92	29	12,960.3	443
Apr	3/27/92	4/27/92	31	9,816.7	373
May	4/27/92	5/27/92	30	5,137.2	195
Jun	5/27/92	6/26/92	30	1,192.3	79
Jul	6/26/92	7/29/92	33	724.1	35
Aug	7/29/92	8/27/92	29	367.1	17
Sep	8/27/92	9/28/92	32	2,952.1	161
Oct	9/28/92	10/27/92	29	6,902.0	261
Nov	10/27/92	11/25/92	29	13,280.9	524
Dec	11/25/92	12/30/92	35	23,675.7	879
Jan	12/30/92	1/29/93	30	22,028.5	845
Feb	1/29/93	3/3/93	33	23,596.9	738
Mar	3/3/93	3/31/93	28	15,927.1	470
Apr	3/31/93	4/29/93	29	14,059.8	427
May	4/29/93	5/27/93	28	6,670.7	180
Jun	5/27/93	6/29/93	33	3,762.7	152
Jul	6/29/93	7/29/93	30	2,206.0	119
Aug	7/29/93	8/30/93	32	782.9	62
Sep	8/30/93	9/29/93	30	2,158.0	121
Oct	9/29/93	10/28/93	29	7,308.1	255
Nov	10/28/93	11/30/93	33	18,412.0	719
Dec	11/30/93	12/30/93	30	18,799.2	715
Jan	12/30/93	1/31/94	32	17,148.7	634
Feb	1/31/94	3/3/94	31	19,597.6	736
Mar	3/3/94	3/31/94	28	14,052.2	481
Apr	3/31/94	4/29/94	29	10,716.8	375
May	4/29/94	5/31/94	32	7,572.1	
Jun	5/31/94	6/29/94	29	3,942.9	
Jul	6/29/94	7/29/94	30	730.1	
Aug	7/29/94	8/30/94	32	532.3	
Sep					

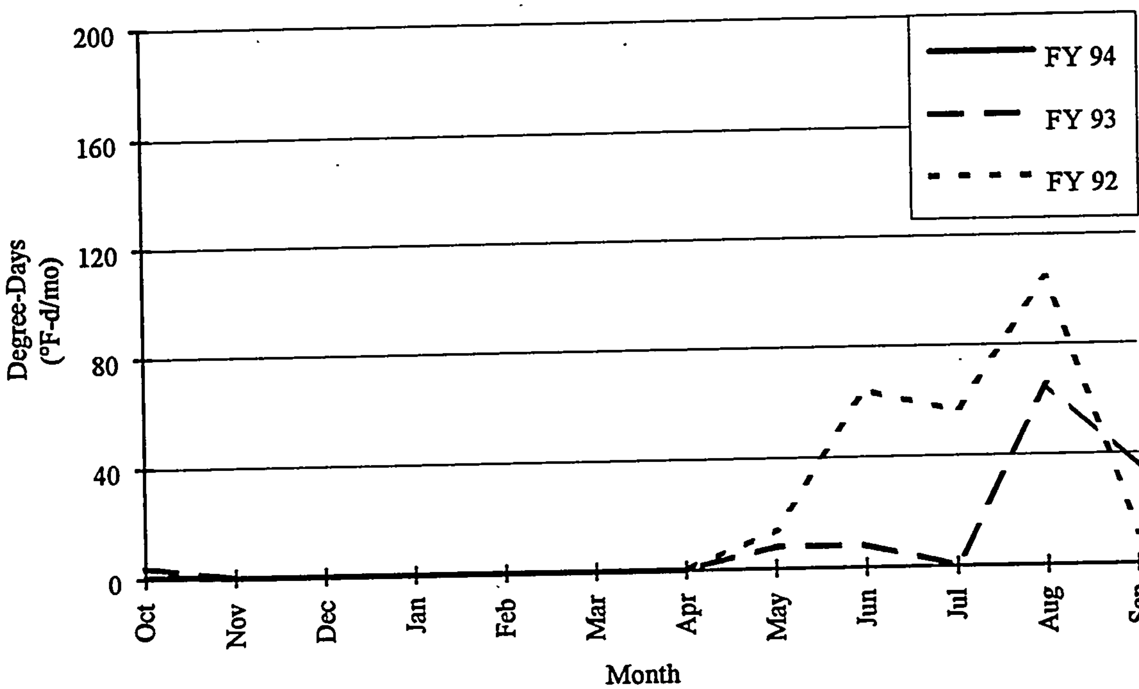


Figure B.1. Cooling Degree-Days
(base 65°F - corresponding to electric billing period)

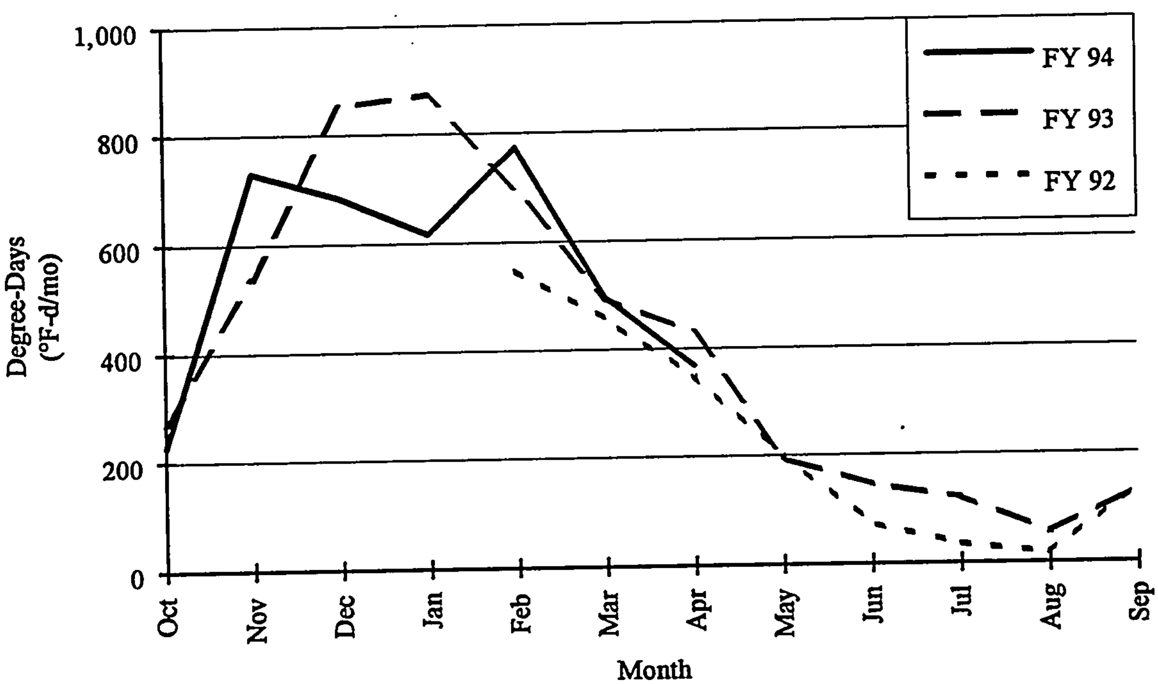


Figure B.2. Heating Degree-Days
(base 65°F - corresponding to electric billing period)

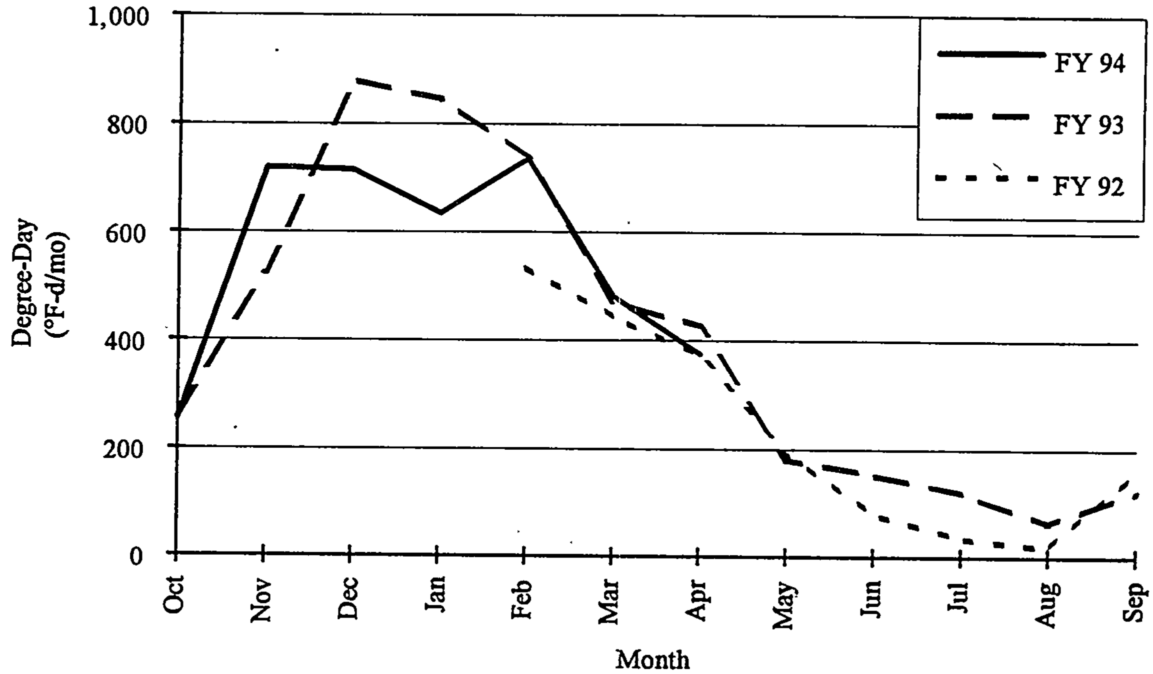


Figure B.3. Heating Degree-Days
(base 65°F - corresponding to natural gas billing period)

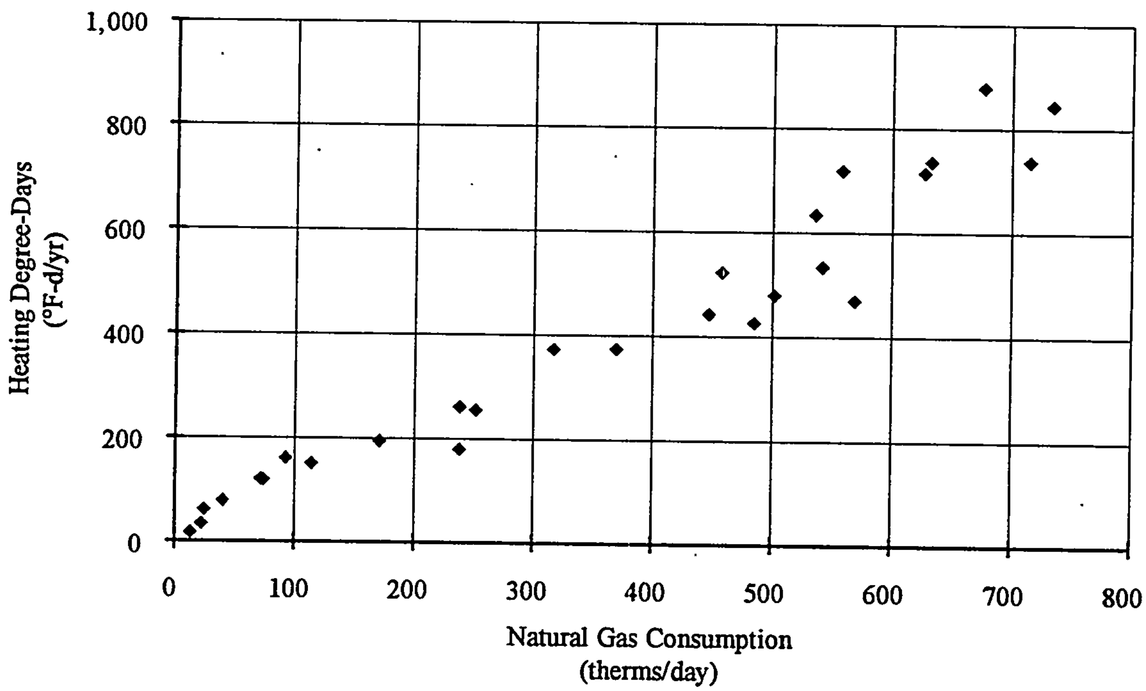


Figure B.4. Weather Data Correlation
(natural gas consumption and heating degree-days)

Appendix C

BLCC Life-Cycle Cost Analyses

Federal Life-Cycle Costing Procedures and the BLCC Software

Federal agencies are required to evaluate energy-related investments on the basis of minimum life-cycle costs (10 CFR Part 436). A life-cycle cost evaluation computes the total long-run costs of a number of potential actions, and selects the action that minimizes the long-run costs. When considering retrofits, sticking with the existing equipment is one potential action, often called the *baseline* condition. The life-cycle cost (LCC) of a potential investment is the present value of all of the costs associated with the investment over time.

The first step in calculating the LCC is the identification of the costs. *Installed Cost* includes cost of materials purchased and the labor required to install them (for example, the price of an energy-efficient lighting fixture, plus cost of labor to install it). *Energy Cost* includes annual expenditures on energy to operate equipment. (For example, a lighting fixture that draws 100 watts and operates 2,000 hours annually requires 200,000 watt-hours (200 kWh) annually. At an electricity price of $0.10 per kWh, this fixture has an annual energy cost of $20.) *Nonfuel Operations and Maintenance* includes annual expenditures on parts and activities required to operate equipment (for example, replacing burned out light bulbs). *Replacement Costs* include expenditures to replace equipment upon failure (for example, replacing an oil furnace when it is no longer usable).

Because LCC includes the cost of money, periodic and aperiodic maintenance (O&M) and equipment replacement costs, energy escalation rates, and salvage value, it is usually expressed as a present value, which is evaluated by

$$LCC = PV(IC) + PV(EC) + PV(OM) + PV(REP)$$

where PV(x) denotes "present value of cost stream x"
IC is the installed cost
EC is the annual energy cost
OM is the annual nonenergy O&M cost
REP is the future replacement cost

Net present value (NPV) is the difference between the LCCs of two investment alternatives, e.g., the LCC of an energy-saving or energy-cost-reducing alternative and the LCC of the existing, or baseline, equipment. If the alternative's LCC is less than the baseline's LCC, the alternative is said to have a positive NPV, i.e., it is cost effective. NPV is thus given by

$$NPV = PV(EC_0) - PV(EC_1)) + PV(OM_0) - PV(OM_1)) + PV(REP_0) - PV(REP_1)) - PV(IC)$$

or

$$NPV = PV(ECS) + PV(OMS) + PV(REPS) - PV(IC)$$

where subscript 0 denotes the existing or baseline condition
subscript 1 denotes the energy cost saving measure
IC is the installation cost of the alternative
(note that the IC of the baseline is assumed zero)
ECS is the annual energy cost savings

OMS is the annual nonenergy O&M savings
REPS is the future replacement savings

Levelized energy cost (LEC) is the breakeven energy price (blended) at which a conservation, efficiency, renewable, or fuel-switching measure becomes cost effective (NPV > = 0). Thus, a project's LEC is given by

$$PV(LEC*EUS) = PV(OMS) + PV(REPS) - PV(IC)$$

where EUS is the annual energy-use savings (energy units/yr). Savings-to-investment ratio (SIR) is the total (PV) savings of a measure divided by its installation cost:

$$SIR = [PV(ECS) + PV(OMS) + PV(REPS)]/PV(IC).$$

Some of the tedious effort of life-cycle cost calculations can be avoided by using the Building Life-Cycle Cost software, BLCC, developed by NIST. For copies of BLCC, call the FEMP Help Desk at (800) 566-2877.

Table C.1. BLCC 4.0: Comparative Economic Analysis - Upgrade Lighting

BASE CASE: NOAA-Light1
ALTERNATIVE: NOAA-Light2

PRINCIPAL STUDY PARAMETERS:

ANALYSIS TYPE:	Federal Analysis--Energy Conservation Projects
STUDY PERIOD:	25.00 YEARS (JAN 1995 THROUGH DEC 2019)
DISCOUNT RATE:	3.1% Real (exclusive of general inflation)
BASE CASE LCC FILE:	NOAALIT1.LCC
ALTERNATIVE LCC FILE:	NOAALIT2.LCC

COMPARISON OF PRESENT-VALUE COSTS

	BASE CASE: NOAA-Light1	ALTERNATIVE: NOAA-Light2	SAVINGS FROM ALT.
Initial Investment Item(s):			
Cash requirements as of service date	$0	$113,808	-$113,808
Subtotal	$0	$113,808	-$113,808
Future cost items:			
Annual and non-an. recurring costs	$299,985	$206,201	$93,784
Energy Expenditures	$691,557	$422,468	$269,089
Subtotal	$991,542	$628,669	$362,873
Total P.V. Life-Cycle Cost	$991,542	$742,477	$249,065

NET SAVINGS
from alternative NOAA-Light2 compared to alternative NOAA-Light1

Net Savings =	P.V. of non-investment savings	$362,873
	- Increased total investment	$113,808
	Net Savings:	$249,065

Note: the SIR and AIRR computations include differential initial costs, capital replacement costs, and resale value (if any) as investment costs, per NIST Handbook 135 (Federal and MILCON analyses only).

SAVINGS-TO-INVESTMENT RATIO (SIR)
for alternative NOAA-Light2 compared to alternative NOAA-Light1

$$\text{SIR} = \frac{\text{P.V. of non-investment savings}}{\text{Increased total investment}} = 3.19$$

ADJUSTED INTERNAL RATE OF RETURN (AIRR)
for alternative NOAA-Light2 compared to alternative NOAA-Light1
(Reinvestment rate = 3.10%; Study period = 25 years)

AIRR = 7.99%

ESTIMATED YEARS TO PAYBACK

Simple Payback occurs in year	6
Discounted Payback occurs in year	7

ENERGY SAVINGS SUMMARY

Energy type	Units	---Annual Consumption--- Base Case	Alternative	Energy Savings
Electricity	kWh	1,078,624	658,938	419,686

Table C.2. BLCC 4.0: Comparative Economic Analysis - Heat Recovery

BASE CASE: NOAA-Base
ALTERNATIVE: NOAA-ht rec.

PRINCIPAL STUDY PARAMETERS:

ANALYSIS TYPE:	Federal Analysis--Energy Conservation Projects
STUDY PERIOD:	25.00 YEARS (JAN 1995 THROUGH DEC 2019)
DISCOUNT RATE:	3.1% Real (exclusive of general inflation)
BASE CASE LCC FILE:	NOAA-1.LCC
ALTERNATIVE LCC FILE:	NOAA-2.LCC

COMPARISON OF PRESENT-VALUE COSTS

	BASE CASE: NOAA-Base	ALTERNATIVE: NOAA-ht rec.	SAVINGS FROM ALT.
Initial Investment Item(s):			
Cash requirements as of service date	$0	$19,000	-$19,000
Subtotal	$0	$19,000	-$19,000
Future cost items:			
Energy Expenditures	$1,492,318	$1,361,342	$130,976
Subtotal	$1,492,318	$1,361,342	$130,976
Total P.V. Life-Cycle Cost	$1,492,318	$1,380,342	$111,976

NET SAVINGS
from alternative NOAA-ht rec. compared to alternative NOAA-Base

Net Savings =	P.V. of non-investment savings	$130,976
	- Increased total investment	$19,000
	Net Savings:	$111,976

Note: the SIR and AIRR computations include differential initial costs, capital replacement costs, and resale value (if any) as investment costs, per NIST Handbook 135 (Federal and MILCON analyses only).

SAVINGS-TO-INVESTMENT RATIO (SIR)
for alternative NOAA-ht rec. compared to alternative NOAA-Base

$$SIR = \frac{\text{P.V. of non-investment savings}}{\text{Increased total investment}} = 6.89$$

ADJUSTED INTERNAL RATE OF RETURN (AIRR)
for alternative NOAA-ht rec. compared to alternative NOAA-Base
(Reinvestment rate = 3.10%; Study period = 25 years)

AIRR = 11.38%

ESTIMATED YEARS TO PAYBACK

Simple Payback occurs in year	4
Discounted Payback occurs in year	4

ENERGY SAVINGS SUMMARY

Energy type	Units	---Annual Consumption--- Base Case	Alternative	Energy Savings
Electricity	kWh	599,437	665,155	-65,718
Natural Gas	Therm	111,802	93,381	18,421

Table C.3. BLCC 4.0: Comparative Economic Analysis - Water Conservation

BASE CASE: NOAA-Base
ALTERNATIVE: NOAA-Water

PRINCIPAL STUDY PARAMETERS:

ANALYSIS TYPE:	Federal Analysis--Energy Conservation Projects
STUDY PERIOD:	25.00 YEARS (JAN 1995 THROUGH DEC 2019)
DISCOUNT RATE:	3.1% Real (exclusive of general inflation)
BASE CASE LCC FILE:	NOAAWTR1.LCC
ALTERNATIVE LCC FILE:	NOAAWTR2.LCC

COMPARISON OF PRESENT-VALUE COSTS

	BASE CASE: NOAA-Base	ALTERNATIVE: NOAA-Water	SAVINGS FROM ALT.
Initial Investment Item(s):			
Cash requirements as of service date	$0	$23,684	-$23,684
Subtotal	$0	$23,684	-$23,684
Future cost items:			
Annual and non-an. recurring costs	$49,251	$15,998	$33,253
Subtotal	$49,251	$15,988	$33,253
Total P.V. Life-Cycle Cost	$49,251	$39,682	$9,569

NET SAVINGS
from alternative NOAA-Water compared to alternative NOAA-Base

Net Savings =	P.V. of non-investment savings	$33,253
	- Increased total investment	$23,684
	Net Savings:	$9,569

Note: the SIR and AIRR computations include differential initial costs, capital replacement costs, and resale value (if any) as investment costs, per NIST Handbook 135 (Federal and MILCON analyses only).

SAVINGS-TO-INVESTMENT RATIO (SIR)
for alternative NOAA-Water compared to alternative NOAA-Base

$$SIR = \frac{\text{P.V. of non-investment savings}}{\text{Increased total investment}} = 1.40$$

ADJUSTED INTERNAL RATE OF RETURN (AIRR)
for alternative NOAA-ht rec. compared to alternative NOAA-Base
(Reinvestment rate = 3.10%; Study period = 25 years)

AIRR = 4.51%

ESTIMATED YEARS TO PAYBACK

Simple Payback occurs in year 13
Discounted Payback occurs in year 16

ENERGY SAVINGS SUMMARY

Energy type	Units	---Annual Consumption--- Base Case	Alternative	Energy Savings
Other	gallon	0	0	0

Table C.4. BLCC 4.0: Comparative Economic Analysis - All Energy Conservation Measures

BASE CASE: NOAA-Present
ALTERNATIVE: NOAA-Proposed

PRINCIPAL STUDY PARAMETERS:

ANALYSIS TYPE: Federal Analysis--Energy Conservation Projects
STUDY PERIOD: 25.00 YEARS (JAN 1995 THROUGH DEC 2019)
DISCOUNT RATE: 3.1% Real (exclusive of general inflation)
BASE CASE LCC FILE: NOAA-ALL.LCC
ALTERNATIVE LCC FILE: NOAA-ECM.LCC

COMPARISON OF PRESENT-VALUE COSTS

	BASE CASE: NOAA-Present	ALTERNATIVE: NOAA-Proposed	SAVINGS FROM ALT.
Initial Investment Item(s):			
Cash requirements as of service date	$0	$138,810	-$138,810
Subtotal	$0	$138,810	-$138,810
Future cost items:			
Annual and non-an. recurring costs	$299,985	$206,201	$93,784
Energy Expenditures	$3,112,831	$2,712,767	$400,064
Subtotal	$3,412,816	$2,918,968	$493,848
Total P.V. Life-Cycle Cost	$3,412,816	$3,057,778	$355,038

NET SAVINGS
from alternative NOAA-Proposed compared to alternative NOAA-Present

Net Savings =	P.V. of non-investment savings	$493,848
	- Increased total investment	$138,810
	Net Savings:	$355,038

Note: the SIR and AIRR computations include differential initial costs, capital replacement costs, and resale value (if any) as investment costs, per NIST Handbook 135 (Federal and MILCON analyses only).

SAVINGS-TO-INVESTMENT RATIO (SIR)
for alternative NOAA-Proposed compared to alternative NOAA-Present

$$\text{SIR} = \frac{\text{P.V. of non-investment savings}}{\text{Increased total investment}} = 3.56$$

ADJUSTED INTERNAL RATE OF RETURN (AIRR)
for alternative NOAA-Light2 compared to alternative NOAA-Light1
(Reinvestment rate = 3.10%; Study period = 25 years)

AIRR = 8.47%

ESTIMATED YEARS TO PAYBACK

Simple Payback occurs in year 6
Discounted Payback occurs in year 6

ENERGY SAVINGS SUMMARY

Energy type	Units	---Annual Consumption--- Base Case	Alternative	Energy Savings
Electricity	kWh	3,120,000	2,766,032	353,968
Natural Gas	therm	120,970	102,549	18,421

Appendix D

Seattle City Light Rebate Program Information

Seattle City Light
Energy Management Services

FACILITY INFORMATION

Please complete all items on both sides of this form

Facility Name: ______________________________

Contact Person: ______________________________
Name *Phone*
____
Title / Relationship to the facility
____
Street address
____
City *State* *Zip*

Building Occupancy (please check):

- ☐ Lease ☐ Owner occupied
- ☐ Federal ☐ State ☐ City/County
- ☐ Multi-sited - Chain
- ☐ Multi-sited - Franchise
- ☐ Multi-sited - other ______________

Year constructed: ______________

Facility gross square feet: ______________

Gross sq.ft. heated/cooled: ______________

Sq.ft. affected by project: ______________

Annual electrical consumption (kWh) of the facility: ______________

Primary facility use (please check):

- ☐ Offices ☐ Grocery ☐ Retail
- ☐ Full-service restaurant (incl. bars and lounges)
- ☐ Fast-food restaurant
- ☐ Apartment, condo ☐ Single family residential
- ☐ Other residential, hotel/motel, nursing home, etc.
- ☐ Laundry ☐ School ☐ Warehouse
- ☐ Assembly - regular use (theaters, etc.)
- ☐ Assembly - sporadic use (church, auditorium)
- ☐ Manufacturing - type: ______________
- ☐ Other use: ______________
- ☐ Mixed use (please check primary use above)

Fuel source/system (please check):	Space (air) Heating		Space (air) Cooling		Water Heating	
	primary	secondary	primary	secondary	primary	secondary
Electricity	☐	☐	☐	☐	☐	☐
Natural gas	☐	☐	☐	☐	☐	☐
Oil	☐	☐	☐	☐	☐	☐
Heat pump	☐	☐	☐	☐	☐	☐
Purchased steam	☐	☐	☐	☐	☐	☐
None	☐	☐	☐	☐	☐	☐
Other, please specify: ________	☐	☐	☐	☐	☐	☐

Please specify any large industrial loads at the site:

____

____

After completing this form, please mail to:
Seattle City Light; Commercial/Industrial Energy Management Services;
1015 Third Avenue Room 804; Seattle, Washington 98104-1198.
For more information or assistance in filling out this form, please phone (206) 684-3254.

01/21/94

Seattle City Light
Energy Management Services
APPLICATION

Please complete all items on both sides of this form

Company Name: ______________________________

Facility Name: ______________________________

Facility Address: ______________________________

____
City   State   Zip

Are you considering any specific projects which may impact electrical use? ☐ Yes ☐ No

If yes, please describe the projects under consideration:

- Lighting systems: ______________________________
- Heating, cooling, ventilation: ______________________________
- Domestic hot water: ______________________________
- Industrial processes: ______________________________
- other projects: ______________________________

Type of project: ☐ New construction ☐ Addition to existing facility ☐ Remodel ☐ Equipment replacement

Do you have capital funds available for making improvements to your facility? ☐ Yes ☐ No

At what stage is your project?

Design work has been contracted	☐ Yes	☐ No
Design work is complete	☐ Yes	☐ No
Contractors have been contacted	☐ Yes	☐ No
Bids have been received	☐ Yes	☐ No

If bids have been received, what is the approximate total cost of the proposed project? ______________

If your project is operating under specific deadlines, please indicate the dates below:

______________ *Design work must be complete by*   ______________ *Equipment must be ordered by*   ______________ *Installation must start by*

Seattle City Light Account Numbers - you will find these on the top line of your billing statement(s):

___-____-________-___-___-_   ___-____-________-___-___-_

___-____-________-___-___-_   ___-____-________-___-___-_

The information shown on this sheet is accurate to the best of my knowledge.

______________ *Print Name*   ______________ *Title / Relationship to facility*

______________ *Please sign*   ______________ *Phone*   ______________ *Date*

After completing this form, please mail to:
Seattle City Light; Commercial/Industrial Energy Management Services; 1015 Third Avenue Room 804; Seattle, Washington 98104-1198.
For more information or assistance in filling out this form, please phone (206) 684-3254.

01/21/94

ENERGY SMART DESIGN

Program Overview

Energy Smart Design is a program sponsored by the Bonneville Power Administration and administered by Seattle City Light. The goal of Seattle City Light's Energy Smart Design program is to aid the utility's commercial customers in using electricity as efficiently as possible. Efficiency improvements benefit both the commercial customer and Seattle City Light since the customer pays less on electricity bills and Seattle City Light is able to defer investment in costly new generation capacity.

Through Energy Smart Design, Seattle City Light will pay a **cash incentive** to the customer to help defray the costs of "stepping up" to the most energy-efficient electrical technologies and designs. The amount of the Seattle City Light funding is **directly related to the reduction in electricity consumption** that will be achieved at the customer's facility if the customer installs energy-efficient electrical equipment or otherwise modifies the facility. In general, the greater the electricity savings, the greater the amount of the Seattle City Light funding.

Energy Smart Design works **alongside the normal business relationship between the customer and private sector services**. The customer chooses a contractor, engineer, etc. to manage the project and/or perform the installation work. In Seattle City Light's Energy Management programs, the firm or individual providing these services to the customer is called the "trade ally". Along with the usual agreement for services between the customer and trade ally, the customer with assistance from the trade ally applies for funding for the project from Seattle City Light by completing a proposal to Seattle City Light. Seattle City Light staff, the customer, and the trade ally work as a team to obtain a project design which meets the goals of all three parties.

Other services are available to Seattle City Light customers. Seattle City Light provides **technical assistance** and literature to customers on a broad range of conservation topics. Seattle City Light also operates and co-sponsors the **Lighting Design Lab**, a demonstration facility dedicated to the promotion of excellence in lighting design and energy efficiency.

For more information about Energy Smart Design or other energy management services offered by Seattle City Light, please call (206) 684-3254.

Energy Smart Design provides funding through four different paths:

- **Lighting Incentives**

  T8 Fluorescent Fixtures with Electronic Ballasts
  Compact Fluorescent Fixtures
  Metal Halide Fixtures
  High Pressure Sodium Fixtures
  Motion Sensors
  Other lamp and control types (with certain exceptions)

- **Standard Incentives**

  Chillers
  Air Conditioners
  Air-to-Air and Hydronic Heat Pumps
  Package Terminal Air Conditioners and Heat Pumps
  Variable Speed Drives for Variable Air Volume System Fans
  High-Efficiency Motors

- **Custom Incentives**

  Seattle City Light can also provide funding for electrical modifications not eligible for Lighting or Standard Incentives. Typical examples are:

  Building Envelope modifications such as new windows or insulation.
  Energy Management Control Systems
  Refrigeration Systems
  HVAC systems not covered by the Standard Incentives
  Variable Speed Drives (except on VAV fan motors)

- **Design Assistance**

  For some facilities, the analysis required to calculate the potential electrical energy savings can be very complex and time-consuming. Seattle City Light can provide funding for the customer to hire an engineer or design firm to perform the analysis and provide the documentation needed to obtain funding from Seattle City Light for the modifications. **Design Assistance is available only for (1) analysis of modifications not eligible for Lighting or Standard Incentives and (2) major new or remodel projects where the potential for energy savings is considerable.**

For more information on Energy Smart Design funding, please see the documentation on the appropriate funding path.

ENERGY SMART DESIGN

Reimbursement Schedule for Lighting Incentives and Standard Incentives

The following rates may be used when estimating Seattle City Light funding for Lighting Incentives or Standard Incentives. Please see the appropriate literature for futher information on the calculation procedures.

Effective October 1, 1994. These rates are subject to change without notice.

Lighting Equipment	Lighting Fixtures	$0.14 per kWh saved annually
	Lighting Controls	$0.14 per kWh saved annually
	Retrofit Kits	$0.09 per kWh saved annually
	Components	$0.09 per kWh saved annually
HVAC Equipment	Chiller	$0.285 per kWh saved annually
	Air Conditioner	$0.233 per kWh saved annually
	Air-to-Air Heat Pump	$0.233 per kWh saved annually
	Hydronic Heat Pump	$0.275 per kWh saved annually

Limitations on Funding

- *New Construction or Major Remodel of an Existing Facility*

  Seattle City Light funding = Annual kWh Savings x funding rate, limited to 70% of the cost of the Energy Conservation Measure (ECM) cost (see definition below). For lighting projects where bid alternates are not available, funding is limited to 50% of the ECM materials cost.

- *Project at Existing Facility Not Considered a Major Remodel*

  Seattle City Light funding = Annual kWh Savings x funding rate, limited to 70% of the ECM cost (see definition below).

Energy Conservation Measure (ECM) Cost

- *New Construction or Major Remodel of an Existing Facility*

  The incremental cost, defined as the difference in cost between a common practice installation and the proposed installation.

- *Existing Facility Not Considered a Major Remodel*

  The installation cost of equipment that increases electrical energy efficiency and results in electrical energy savings as determined from a suitable baseline.

Steps to Participate in Energy Smart Design

The following steps must be followed in order to complete a project with Seattle City Light (SCL). More details are provided in the sections covering specific funding paths.

- **Application** - The customer (facility owner, facility manager, etc.) should fill out the Application/Facility Information form on both sides and send it to Seattle City Light at the address listed on the form. Application/Facility Information forms are available from Seattle City Light. The Application/Facility Information form provides Seattle City Light with the information necessary to initiate and track the project.

- **Assignment** - Once Seattle City Light has received the Application/Facility Information form, a SCL analyst will be assigned to the project. The analyst will contact the customer to discuss the project and decide on the next steps to take.

- **Scoping** - A "scoping" meeting will be scheduled between the customer, SCL analyst, trade ally(s), and any other members of the project management team. Discussions will center around the potential energy modifications to be analyzed or installed, energy savings and funding formulas, and the requirements of the Energy Smart Design program.

- **Proposal** - Once eligibility for the project has been confirmed by SCL and the scoping has been completed, a proposal will be assembled by the customer and/or customer's representative and submitted to Seattle City Light for review. The exact contents of the proposal depend upon the type of path used to obtain funding.

- **Contract** - Once the proposal has been approved by Seattle City Light, Seattle City Light will offer a contract to the customer. The contract will state the amount of funding that Seattle City Light will provide for the project and terms of the agreement. The customer signs the contract and returns it to Seattle City Light.

- **Contract Execution** - Seattle City Light signs (executes) the contract and returns the executed contract to the customer. Work on the project should not begin until the contract has been executed by Seattle City Light. **Projects commenced prior to contract execution may not be eligible for funding, even if funding was offered in the contract.**

- **Final Inspection and Payment** - Once the project is complete, Seattle City Light will inspect the work to verify completion of the contract requirements. Once the completed project and final documentation have been approved by Seattle City Light, Seattle City Light will issue a check for the contract amount to the customer.

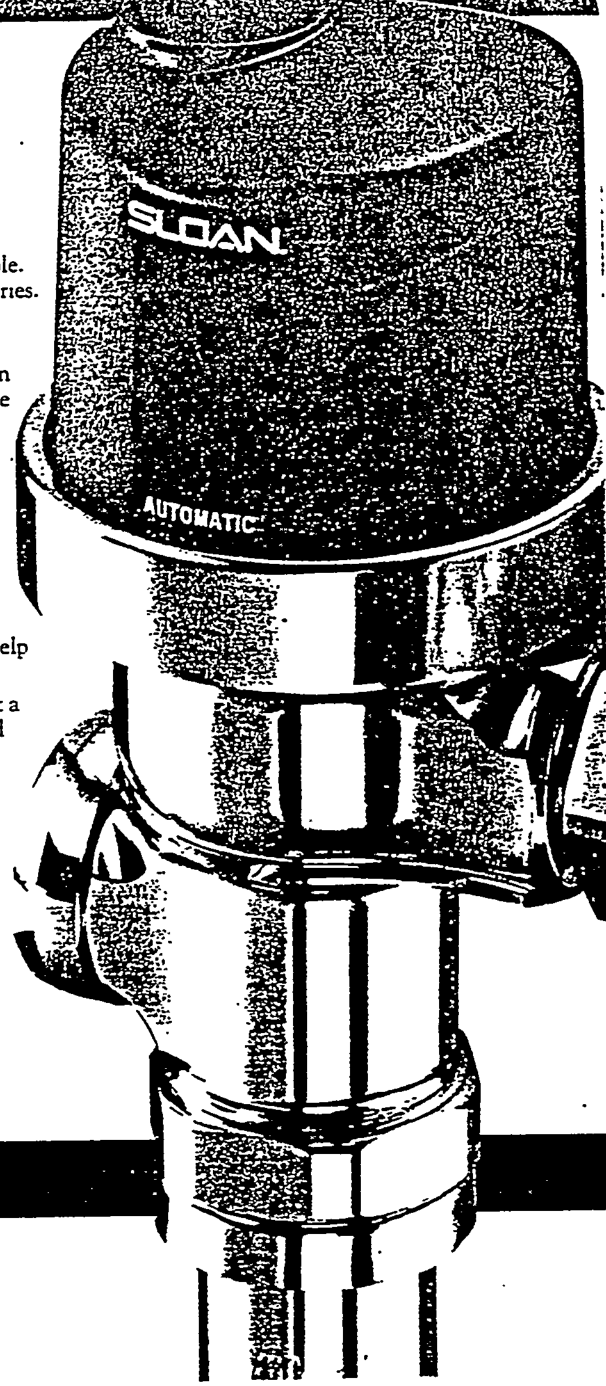
Appendix E

Sample Water Conservation Equipment

When you change your Sloan Royal® Flushometers into

Optima Plus®

some remarkable other changes take place



- IMPROVED HYGIENE – people will be more comfortable. Optima Plus is electronic and runs on four AA Duracell® batteries. No more hygiene problems.
- REDUCED ODOR – makes the restroom visit a more pleasant visit. Optima Plus® flushes *automatically* after each use. On closet models, our over-ride button gives the users the convenience of manual operation. Restrooms stay cleaner, longer!
- USER SATISFACTION – people will appreciate the clean condition of the restroom. Optima Plus meets all A.D.A. requirements.
- ELIMINATES CHEMICALS – you'll save money by not having to use them to "cover up". Optima Plus is the most efficient way to keep restrooms sanitary.
- WATER CONSERVATION – electronics don't waste water... everything is controlled using infrared sensors. You'll help preserve our most precious resource.
- HIGH-TECH IMAGE – Optima Plus will help you project a positive image. Optima Plus looks sharp, is vandal resistant and will say "we care" to users.

Sloan's Optima Plus® battery-operated Flushometers can turn your restrooms into odorless, highly hygienic places. They retrofit on all existing Sloan Royal® or most other diaphragm valves quickly and easily. And, Optima Plus eliminates the possibility of transferring disease because users don't have to touch the valve to activate it. Optima Plus "senses" the presence or absence of the user, and responds accordingly.

For more information on how Optima Plus can significantly improve your restrooms, call:

1-800-745-0800 EXT. 114

SLOAN.

Sloan Valve Company
10500 Seymour Avenue
Franklin Park, IL 60131

Here are the new water efficiency standards for plumbing fixtures in new and remodeled buildings

Fixture	Standard
Tank-type toilet*	1.6 gal. (6.0 liters) per flush
Flushometer-valve toilets*	1.6 gal. (6.0 liters) per flush
Flushometer-tank toilets*	1.6 gal. (6.0 liters) per flush
Electromechancial hydraulic toilets*	1.6 gal (6.0 liters) per flush
Urinals	1.0 gal. (3.78 liters) per flush
Showerheads	2.5 gal. (9.5 liters) per minute
Lavatory Faucets	2.5 gal. (9.5 liters) per minute
Kitchen Faucets	2.5 gal. (9.5 liters) per minute
Public Lavatory Faucets (other than self-closing)*	0.5 gal. (1.89 liters) per minute
Replacement Aerators	2.5 gal. (9.5 liters) per minute

* Some exceptions are made for fixtures intended for use for certain purposes. Contact your local building official for additional information.

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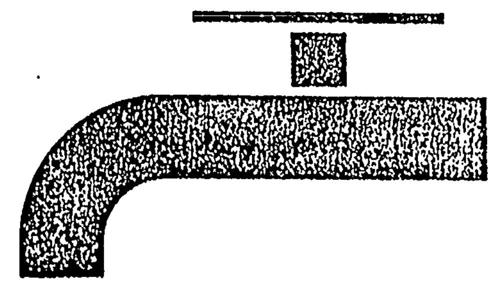
Washington State
Department of
Community Development
State Building Code Council
906 Columbia SW
PO BOX 48300
Olympia, WA 98504

Washington State
Department of
Community Development

Water Use Efficiency Standards for Plumbing Fixtures



A new standards law becomes effective July 1, 1993

While Washington may be thought of as a rainy state, new water resources are in short supply.

Fish runs, wildlife habitat, and water based recreation all compete with new residential, commercial, and industrial development for existing water resources.

In order to help ensure that there is enough water for all users, the Legislature directed the State Building Code Council to adopt water efficiency requirements for plumbing fixtures installed in all new and remodeled buildings. In order to give plumbing manufacturers, retailers, and installers adequate time to gear up for the new water efficiency requirements, the Council was directed to adopt the standards in two phases. The first phase became effective July 1, 1991.

The second phase requirements become effective July 1, 1993, and take advantage of a whole new generation of water conserving plumbing products that are now commercially available. The date of application for a building or plumbing permit determines which water use standard apply. If the building or plumbing permit application is received prior to July 1, 1993, the existing requirements apply. All building and plumbing permits applied for after July 1, 1993, must comply with the new requirements.

These new plumbing fixtures and fittings ensure the efficient use of water in new and remodeled buildings. Fixtures and fittings that do not meet the new water use standards are prohibited from sale, distribution, offer of sale, importation, installation, and approval for installation in Washington State.

This brochure was created to help you identify these new fixtures and determine whether the fixture meets the new standards.

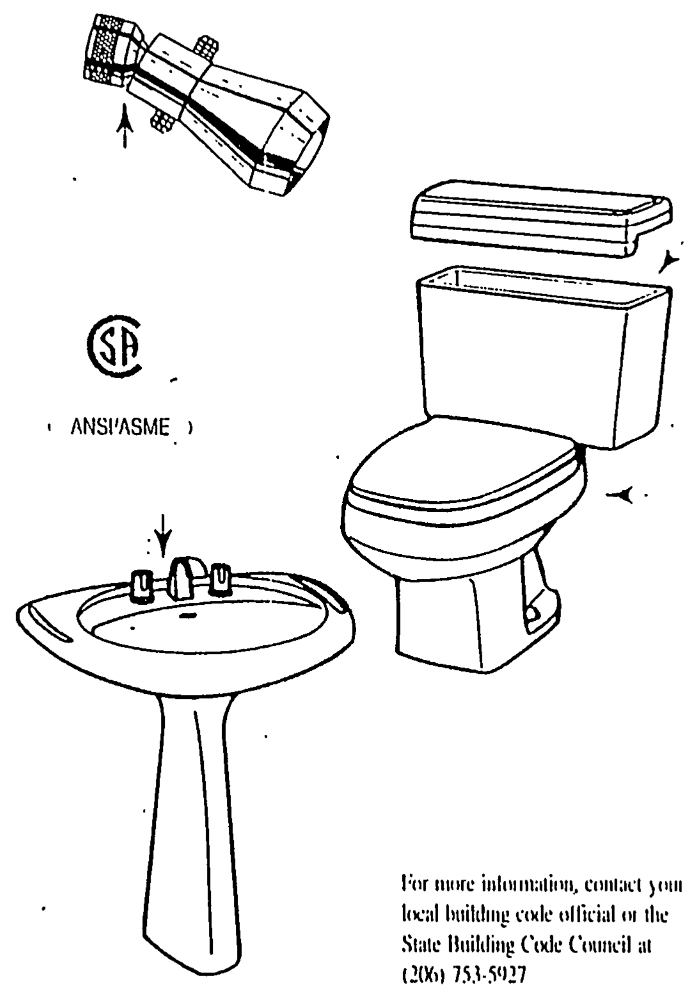
How to tell if a product meets the water consumption standards?

New fixtures should be labelled with either a permanent marking or a removable label which states the standard the fixture meets and/or information on the maximum amount of water consumed by the fixture. Water use information will also be found on the packaging.

Vitreous china fixtures (toilets and urinals) will be labelled as meeting either ANSI/ASME A112.19.2M-1990 & A112.19.6-1990 or CSA B45. Marking may be inside of the tank.

All other fixtures and fittings will be labelled as meeting either ANSI/ ASME A112.18.1M-1989 or CSA B125.

This illustration shows where you would typically find the identifying marks on different types of fixtures.



For more information, contact your local building code official or the State Building Code Council at (206) 753-5927

Appendix F

Federal Energy Efficiency Fund Forms

Submit to:

The Office of Federal Energy Management Programs
Mr. John P. Archibald
Code EE-44
Department of Energy
1000 Independence Avenue
Washington, D.C. 20585

Proposal for the Federal Energy Efficiency Fund

PROJECT DATA SHEET

FORM D-2

Date: March 1995

Project Title: Upgrade Lighting and Install Ventilation Heat Recovery System

Project Location: National Marine Fisheries Service, Northwest Fisheries Science Center

2725 Montlake Boulevard, East

Seattle, WA 98112-2097

Agency: Department of Commerce, National Oceanic and Atmospheric Administration

Point of Contact: Dr. Linda Jones, Deputy Director

Telephone: (206) 860-3202 FAX: (206) 860-3217

Address: 2725 Montlake Boulevard, East

Seattle, WA 98112-2097

Type of Conservation Project: _X_ Energy Efficiency

____ Water Conservation

Is an Energy Saving Performance Contract proposed? No

Summary of Project: (Provide a brief summary of the project)

This proposal involves two energy measures. The first energy measure is a complete upgrade of the lighting systems throughout the complex to the most energy-efficient and life-cycle cost-effective systems. This includes electronic ballasts, high-efficiency T-8 lamps, compact fluorescents, and high-pressure sodium lamps. The second energy measure is the installation of a run-around heat recovery system recovering heat energy between the exhaust and make-up air systems in the facilities largest bulding.

Schedule information:

Date funds are desired: __________

Critical date for reciept of funds: _________
(Provide explanation in Description of the Project. See next page.)

Work Start Date: _________ (estimate if not known)

Date Initial Cost and Energy or Water Savings Will Occur:

Cost ___/___/___ Energy or water: ___/___/___ (mm/dd/yy)
(estimate if not know)

Funds requested: $132,810

Proposal for the Federal Efficiency Fund

ENERGY EFFICIENCY PROPOSALS
FORM D-4A

COST EFFECTIVENESS CALCULATION WORKSHEET
FOR PROJECTS WITHOUT ENERGY SAVINGS PERFORMANCE CONTRACTS

(1) Calculated Net Savings — $ 355,038

[as calculated by BLCC computer program] — Enter on Form D-4

(2) Calculated Net Investment — $ 138,810

[as calculated by BLCC computer program] — Enter on Form D-4

(3) Savings to investment ratio — 3.56

[as calculated by BLCC computer program]

(4) Date grant funds are desired — ______

Enter on Form D-2

(5) Time required to achieve "full annual energy cost savings rate" — less than 2 yrs

(6) Date the "full annual energy cost savings rate" is projected to occur — ______

(7) Supplement for savings to investment ratio — 1.10

(8) Calculated savings to investment ratio — 4.66

Enter on Form D-4

[add supplement from (7) to BLCC calculated savings to investment ratio from (3)]

(9) Brief description of process used to determine the "full annual cost savings rate" for the proposed project and how the timing of achieving that rate was determined:

The energy measures associated with this application are relatively straightforward and should not require more than 2 years to fully implement from receipt of funding.

Proposal for the Federal Energy Efficiency Fund

ENERGY EFFICIENCY PROPOSALS
FORM D-4 ENERGY

LIFE-CYCLE COST INFORMATION

Calculated Net Savings: $ 355,038 (See Form D-4A)

Calculated Investment: $ 138,810 (See Form D-4A)

Calculated Savings to Investment Ratio: 4.66 (See Form D-4A)

Detailed description and calculations:

See SAVEnergy Audit Report for details. BLCC computer files are available on the enclosed 3.5 inch disk. A hard copy is also enclosed in the SAVEnergy Audit report.

Proposal for the Federal Energy Efficiency Fund

ENERGY EFFICIENCY PROPOSALS
FORM D-5 ENERGY

ENERGY INFORMATION

(1)	Projected life-cycle energy use before project:	21,392 million Btu
(2)	Projected life-cycle energy use after project:	18,342 million Btu
(3)	Total energy saved, (1)-(2):	3,050 million Btu
(4)	Efficiency improvement, [(3) / (1)]*100:	14.3 %

Detailed calculations:

Energy consumption for FY94 was 2,724,330 kWh (9,295.4 million Btu) and natural gas consumption for FY94 was 120,970 therms (12,097.0 million Btu). Total energy consumption during FY94 was 21,392.5 million Btu.

Net energy savings are projected to be 353,968 kWh (1,207.7 million Btu) and 18,421 therms (1,842.1 million Btu) for a total net energy savings of 3,049.8 million Btu. See SAVEnergy Audit report for additional details.

Proposal for the Federal Energy Efficiency Fund

ENERGY EFFICIENCY PROPOSAL
FORM D-6 ENERGY

AGENCY FUNDING INFORMAITON

(1)	Amount of agency dollar equivalent funds provided: (provide detailed description below)	$6,000
(2)	Amount of agency funds to be provided:	$0
(3)	Total agency funds provided, (1) + (2):	$6,000
(4)	Federal Energy Efficiency Funds requested:	$132,810
(5)	Total Federal funds required, (3) + (4):	$138,810
(6)	Agency contribution, [(3) / (5)] * 100:	4.3%

Detailed description:

Agency equivalent funds are in the form of agency personnel time for request-for-proposal development, proposal evaluation, contract management and coordination.

Proposal for the Federal Energy Efficiency Fund

ENERGY EFFICIENCY PROPOSALS
FORM D-7 ENERGY

NON-FEDERAL FINANCING INFORMATION

(1)	Amount of non-Federal dollar equivalent funds provided: (provide detailed decription below)	$ 0
(2)	Amount of non-Federal fund provided: (provide detailed description below)	$ 37,770
(3)	Total non-Federal funds provided, (1) + (2):	$ 37,770
(4)	Amount of agency dollar equivalent funds provided:	$ 6,000
(5)	Amount of agency funds provided:	$ 0
(6)	Total agency funds provided, (4) + (5):	$ 6,000
(7)	Federal Energy Efficiency Funds requested:	$ 132,810
(8)	Total Federal funds provided, (6) + (7):	$ 138,810
(9)	Total of all funds provided, (3) + (8):	$ 176,580
(10)	Non-Federal financing, [(3) / (9)] * 100:	21.4 %

Detailed description:

The non-Federal funds provided are from Seattle City Light, the local electric utility, and are in the form of a utility rebate based on the amount of the first year electricity conserved.

Appendix G

Glossary of Terms and Abbreviations

Table G.1. Glossary of Terms and Abbreviations

°F	degree Fahrenheit
AIRR	adjusted internal Rate of return
BLCC	Building Life-Cycle Cost software program version 4.11
Btu	British thermal unit
ccf	100 cubic feet
CFC	chlorofluorocarbon
CFL	compact fluorescent lamp
cfm	cubic feet per minute
CFR	Code of Federal Regulations
DOE	Department of Energy
DSM	demand-side management
ECM	energy conservation measure
EER	energy-efficiency ratio
ELC1	electronic ballast - 1 lamp
ELC2	electronic ballast - 2 lamp
ELC4	electronic ballast - 4 lamp
ESPC	Energy Savings Performance Contracting
FEEF	Federal Energy Efficiency Fund
FEMP	Federal Energy Management Program
FY	fiscal year
gal	gallon
gpf	gallon per flush
gpm	gallon per minute
h	hour
hp	horsepower
HPS	high-pressure sodium
ht rec.	heat recovery
kW	kilowatt
kW-mo	kilowatt-month
kWh	kilowatt-hour
LCC	life-cycle cost
LED	light emitting diode
LTSM	Lighting Technology Screening Matrix
mil.	million
MILCON	military construction
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPV	net-present value
ODP	open drip-proof
O&M	operations and maintenance
P.V.	present value
R&D	research and development
REF	specular reflector
rpm	revolutions per minute
s	summer
SIR	savings-to-investment ratio
TEFC	totally enclosed fan-cooled
therm	100,000 Btu
W	Watt
w	winter
WCM	water conservation measure
W/fix	Watts per fixture
yr	year

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