

Technical Assistance

Detailed Case Study

“Hawaii is a perfect environment for solar water heating. The sun shines most of the time, we don’t have to worry about freezing, the state offers a 35% solar tax credit, and our local utility supports the purchase and installation of solar systems with generous rebates.”

—Alan Ikeda, Navy Housing Management Specialist



U.S. Department of Energy
Office of Energy Efficiency
and Renewable Energy

A Solar Success Story at Moanalua Terrace

Solar systems prove to be the environmentally and economically sound choice for heating water in U.S. Navy housing at Moanalua Terrace in Pearl Harbor, Hawaii.

Hawaii is a perfect environment for solar water heating,” according to Alan Ikeda, a Housing Management Specialist with the Pacific Naval Facility Engineering Command Housing Department in Pearl Harbor, Hawaii. “The sun shines most of the time, we don’t have to worry about freezing, the state offers a 35% solar tax credit, and our local utility supports the purchase and installation of solar systems with generous rebates.”

The Hawaiian Electric Company’s (HECO’s) \$1,500 per unit rebate for solar water heaters installed on new construction helped persuade the Navy to take advantage of Hawaii’s solar resource and install solar water heaters on family housing units. At Moanalua Terrace, the Navy had demolished 752 units of family housing, which they are rebuilding in four phases. Designers decided to use the opportunity to give the solar systems a try.

When the 100 homes in Phase I were built, money was not available for solar water heaters. However, Ikeda subsequently secured a \$130,000 grant from the U.S. Department of Energy’s (DOE’s) Federal Energy Management Program (FEMP) to retrofit the Phase I homes with solar systems. In retrofit applications, HECO rebates \$800 per unit (\$80,000 total) on approved equipment, and Pearl Harbor Family Housing will pay the difference of the estimated \$340,000 total cost, or about \$130,000.

The 136 units built during Phase II of the Moanalua Terrace project included solar systems in their specifications, so the Navy was able to take advantage of the \$1,500 per system HECO rebate for approved solar water heaters in new construction.

The Navy chose direct (open-loop) active systems that circulate potable water through

flat-plate collectors coated with a black chrome selective surface. Each system consists of a 4-foot by 8-foot (1.2-m by 2.4-m) collector made by American Energy Technologies, Ltd., and an 80-gallon (302-liter) Rheem tank containing an electric backup element.

Why solar water heating?

Federal agencies, including the military, administer more than 31% of the land area in the United States. In many of these areas, high levels of sunshine make solar technologies a cost-effective energy choice.

Solar water-heating systems offer Federal facility managers a number of advantages compared with conventional water-heating appliances. For one thing, solar water heaters are environmentally benign—they consume no fuel and produce no emissions. Solar water heaters can help Federal facilities comply with 10CFR436 of the Code of Federal Regulations (CFR) for Federal facilities, which, as one of several compliance options, requires that the life-cycle savings divided by the initial investment (the savings-to-investment ratio, or SIR) be greater than one. Solar water systems can also help facility managers comply with



Each solar water-heating system at the Navy’s Moanalua Terrace housing project offsets about 1.7 tons (1.5 metric tons) of carbon dioxide, 8.2 pounds (3.7 kilograms) of sulphur dioxide, and 11.2 pounds (5 kilograms) of nitrogen oxide every year.

Executive Order 12902, which requires increased water conservation and reduced energy consumption in Federal facilities and a significant increase in the use of renewable energy technology to help achieve this goal.

These devices also help reduce Hawaii's dependence on expensive imported oil, and save users money in the bargain. For example, the Pearl Harbor Naval Station has no other energy option for heating domestic hot water except electricity, which currently costs \$0.11 per kilowatt-hour. On a life-cycle cost basis, the solar systems are much less expensive than conventional electric water heaters or heat pumps—even without the HECO rebate!

Projects such as Moanalua also benefit solar energy technologies by helping to expand the market for solar water heaters and by fostering familiarity with the technologies among the users. At Moanalua, including the 516 homes now under construction in Phases III and IV and the 100 homes in Phase I that have been retrofitted, this translates to 752 families using solar systems to heat their water.

These projects also offer a public education opportunity. In the case of the Moanalua project, the local utility and the local solar industries association joined forces to present educational programs on the benefits of solar water-heating systems.

continued to refine their products. They now sell systems based on mature, reliable, proven technologies. In addition, the Solar Rating and Certification Corporation, a nonprofit national corporation, develops certification programs and rating standards for solar energy equipment. Most collectors carry 10-year warranties, and systems should last at least 20 years.

In many applications—including the Moanalua installations—modern solar water-heating systems have economic advantages over conventional water-heating systems. At Moanalua, the solar water heaters' life-cycle costs are lower than those of either a conventional electric water heater or a heat pump, and, after the payback period, the solar system continues to produce hot water for only the cost of maintenance. Solar water heaters also come in different configurations that can be matched to specific applications to maximize efficiency and cost-effectiveness. Solar water heaters' many advantages make any resistance worth overcoming.

Economics

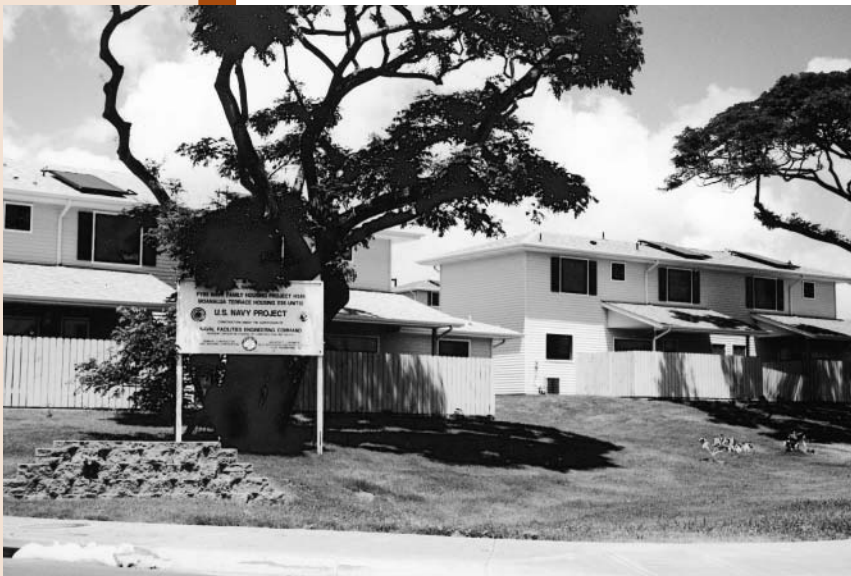
The Navy had originally planned to use high-efficiency electric water heaters in its new and renovated family housing, but decided on solar water heaters because of HECO's Residential New Construction Rebate and Residential Efficient Water Heating Rebate Programs. As the Navy's research revealed, solar water heating is a particularly attractive choice in Hawaii, because of that state's unique circumstances.

Almost 90% of Hawaii's power comes from imported oil, and Hawaii utilities are required by law to pass on fuel price increases within 30 days. If oil prices increased suddenly, the shock to Hawaiian consumers would be almost immediate. Hawaii burns about 2.1 million barrels of oil per year (more than 5,000 barrels per day) to heat domestic water, and solar water heaters can significantly reduce this environmental and economic burden. For example, the 50,000 solar water-heating systems currently operating in Hawaii avoid the burning of more than 350,000 barrels of oil each year. A typical Hawaiian family of four can avoid the burning of seven barrels of oil per year by installing a solar water-heating system.

The criteria set forth in 10CFR436 require that the SIR be greater than one. The definition of cost-effectiveness established in President Clinton's Executive Order 12902 is that systems have simple payback periods of less than 10 years.

According to the Navy's Ikeda, "An analysis of the economics of solar water heating at Moanalua shows that solar water heating is a better investment than either heat pumps or electric water heaters with or without the rebate over a 20-year period." Although the solar systems are more expensive to buy and install initially, they use far less energy to operate during a 20-year period. Even without the rebate, the Moanalua systems have a simple payback period of about 10 years and an SIR of 1.4. With the HECO rebate of \$1,500 per solar water-heating system, the simple payback is about six years and the SIR is 2.5.

Throughout a 20-year life cycle heat pumps are more cost effective than electric water heaters, but far less cost effective than solar water heaters. According to the Navy's research, even with an HECO rebate of \$725 per unit, heat



Hawaiian Electric Company/PIX07310

At Moanalua Terrace, the Navy's analysis revealed that solar water heaters were more cost effective than either high-efficiency electric water heaters or heat pumps.

Selling solar

From a facility manager's perspective, solar water heaters do present challenges compared with electric water heaters. They are more expensive to purchase, more complex to install and maintain, and—perhaps most important—residents and maintenance personnel are often unfamiliar with the technology.

In addition, some Federal managers are resistant to considering solar water heaters because of past bad experiences. The solar water-heating industry experienced failures and bad press in the 1980s, but the situation is very different today. The solar companies that survived the demise of the Federal residential tax credits in 1985

pumps have a simple payback of more than 40 years and an SIR of only 0.67.

Performance

To ensure eligibility for the HECO rebate, solar water heaters must provide 90% of the average annual water-heating load, perform consistently throughout the life of the system, and have an estimated useful life of at least 15 years. Both the Navy and the residents are satisfied with the performance of the solar systems at Moanalua.

Initially, residents complained that they didn't have enough hot water because the utility only allowed the backup element to come on for one hour per day. However, since the timers were adjusted to allow the backup elements to operate for a maximum of 2 hours per day, there have been no complaints.

Leaving a legacy

Protecting the environment is everyone's job, and renewable energy technologies make that possible with reliable, cost-effective equipment. Some businesses and government agencies are beginning to base development decisions on life-cycle cost analyses, which include the cost of operating and maintaining installations throughout their anticipated service life. This is good news for renewable energy technologies, because although they are typically expensive to purchase, they require minimal maintenance, no fuel, and produce no emissions, which makes them a good long-term investment.

At Moanalua, solar water heaters are the most economical water-heating option, even without the utility rebate. If we include the estimated costs of avoided emissions in the mix, a good investment looks even better. Based on the U.S. Environmental Protection Agency's Emission Factors for calculating emissions offsets, each solar system at Moanalua offsets about 1.7 tons (1.5 metric tons) of carbon dioxide, 8.2 pounds (3.7 kilograms) of sulphur dioxide, and 11.2 pounds (5 kilograms) of nitrogen oxides every year. According to the National Park Service's assignment of costs to those emissions offsets, this amounts to an additional annual dollar savings of \$72.77 per unit. Multiplied by the 136 units in Phase II of the Moanalua project, the savings is almost \$10,000 per year.

By using solar water heaters to provide hot water for family housing, the Navy demonstrates environmental awareness and good financial management. Other Federal agencies can realize the same benefits by following the Navy's good example at Moanalua Terrace. ♦

20-Year Life-Cycle Cost Analysis

Including HECO rebate:

	Basecase (electric)	Solar System (90% solar fraction)	Savings (per unit)
INITIAL INVESTMENT			
Incremental Cost/Unit	\$400	\$2,310	-\$1,910
FUTURE COSTS			
Recurring Costs*	\$659	\$741	-\$82
Energy Costs**	\$5,352	\$539	+\$4,813
TOTAL PRESENT VALUE	\$6,411	\$3,590	\$2,821

*Includes maintenance and capital replacement costs discounted over 20 years using the National Institute of Standards and Technology's (NIST's) 1998 discount rate of 4.1%.

**Based on the U.S. Department of Energy's (DOE's) projected energy prices for electricity in DOE Region 4.

Savings-to-investment ratio (SIR) = 2.5

Simple payback = 6 years

Discounted payback = 7 years

Note that this analysis includes a \$1,500 per unit rebate from the Hawaiian Electric Company and does not include the costs associated with emissions produced by the utility company to generate electricity. Analysis performed using NIST's Building Life-Cycle Cost (BLCC) software tool.

MOANALUA PHASE II ANNUAL AVOIDED EMISSIONS COST ESTIMATES*

	Avoided Emissions**	Cost of Avoided Emissions***
CO₂	1.7 tons (1543 kilograms)	\$23.80
SO₂	8.2 pounds (3.7 kilograms)	\$6.97
NO_x	11.2 pounds (5.1 kilograms)	\$42.00
Annual Value of Avoided Emissions		\$72.77

*Per unit, compared with an electric water heater.

**Based on the U.S. Environmental Protection Agency's Regional Emission Factors.

***Based on the National Park Service (NPS) assignment of costs to emissions, revised 9/97.

NPS Assignment of Emission Costs

CO₂	\$14/ton (\$0.015/kilogram)
SO₂	\$0.85/pound (\$1.88/kilogram)
NO_x	\$3.75/pound (\$8.33/kilogram)

Note that this analysis does not include the cost of emissions produced by generating the electricity to run the pumps on the solar systems.

Moanalua Project Details



Project Description: Solar water-heating systems installed on 136 units of new Navy housing

Location: Oahu, Hawaii

Design: R&R Solar Supply, Honolulu, Hawaii

Installation: Dorvin D. Leis Company, Inc.

Collector: AE-32 from American Energy Technologies, Ltd.

Pump: PACO 006B

Controls: Heliotrope DTT94

Tank: Rheem 81VTCR80-1 80-gallon (302-liter) top connect

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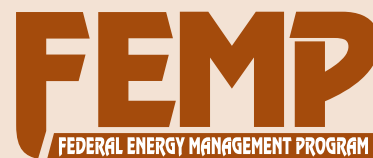
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Building Life-Cycle Cost (BLCC) software tool is available at
[http://www.eren.doe.gov/femp/techassist/softwaretool/
softwaretools.html](http://www.eren.doe.gov/femp/techassist/softwaretool/softwaretools.html)

This case study is available on the FEMP Web site
(<http://www.eren.doe.gov/femp>) and from the
FEMP Help Desk (1-800-363-3732).



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