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PROJECTS FROM FEDERAL REGION IX DOE APPROPRIATE ENERGY TECHNOLOGY PILOT PROGRAM - PART I

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UNIVERSITY OF CALIFORNIA
ENERGY & ENVIRONMENT
DIVISION

PROJECTS FROM FEDERAL REGION IX
DOE APPROPRIATE ENERGY TECHNOLOGY PILOT PROGRAM - PART I

C. W. Case, F. B. Lucarelli, J. Morris, and H. R. Clark

August 1979

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LBL-9642

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DOE APPROPRIATE ENERGY TECHNOLOGY PILOT PROGRAM

PART I

C. W. Case, F. B. Lucarelli, J. Morris,
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(This work has been supported by the Building and Community Systems Division, Office of Conservation and Solar Applications, U.S. Department of Energy.)

INTRODUCTION

In the spring of 1977 the Building and Community Systems Division of the Energy Research and Development Administration (now the Department of Energy - DOE), responding to the 1977 ERDA Authorization Act, instructed its San Francisco Operations Office (SAN) to establish a small grants pilot program for appropriate energy technology projects within Federal Region IX (Arizona, California, Hawaii, Nevada, and the Western Pacific). Following program guidelines, SAN made these grants available to small businesses, individuals, nonprofit agencies, public agencies, and Indian tribes to design, construct, and/or demonstrate small scale energy technologies which conserve depletable fossil fuel or which use renewable energy resources.

With $500K to distribute in grants up to $50K, SAN accepted applications from September to November, 1977. They received 1100 applications requesting $21.3 million. After thorough technical, economic, and peer reviews by a variety of state and university institutions and after receiving an additional $750K from other DOE Divisions, SAN awarded 108 grants for $1.25 million in April, 1978. The grants covered a complete spectrum of small scale energy technologies including solar active and passive systems, wind machines, biomass conversion systems, energy conservation devices, recycling methods, aquacultural and agricultural systems, hydroelectric devices, geothermal systems, and integrated methods.

In the spring of 1979, DOE created the Office of Small Scale Technologies, transferring the program administration to this new office. With a budget of $8.5 million, the program is now expanding into all ten federal regions. These regions have received over 10,000 applications requesting $200 million, are just completing their review processes, and are awarding grants. Federal Region IX has offered a second program cycle during the winter of 1979 and after receiving another 1100 applications, has distributed $500K throughout the Region with 34 additional grants.

Some of the Region IX projects from the original cycle either have been completed or are nearing completion. A number of agencies, including the Lawrence Berkeley Laboratory (LBL), the California Office of Appropriate Technology (OAT), the Hawaii Department of Planning and Economic Development, and the Trust Territory Office of Planning and Statistics, are collecting data from these projects. Sources of data include quarterly reports from project managers, site visits, and direct communication with the project managers. These data will be used for a variety of reports which will help DOE and other federal and state agencies determine the constituencies of the program, analyze the direct and indirect energy savings of the projects, develop efficient and effective project reviewing and monitoring methods, and make changes in the program as the program progresses through various cycles throughout the country.

This report is the first of six reports which will synthesize the technical and economic data that have been assembled so far from the 108 projects. The purpose of the report is to assist DOE management in understanding the nature of the projects, identifying constituencies served

by the program, quantifying energy impacts of the program, and clarifying objectives for the later phases. Additionally, this document will provide Congress and the public with an easy-to-read report which will acquaint them with a few of the general and technical accomplishments of the grants program.

To serve this purpose we have developed a descriptive format which will be used both for Region IX and nationally for all DOE/AET projects. To test this format, DOE, LBL, and OAT selected 18 projects for this initial report. We are allowing a two page description for each project, including a diagram or picture. The description includes a simple entry for: project title and number; applicant name, address, and group type; project type; amount of award; and project duration with date started and date completed. One or two paragraphs describe the project in general terms, and another paragraph gives brief technical details. A final section presents project results including details on direct and indirect energy savings. Also included are information on innovative features, regional or national demonstration possibilities, and aspects of the project which can be replicated elsewhere on either a regional or a national scale.

Project Title: CONCEPT TESTING OF AN ENERGY MANAGEMENT SYSTEM

Project Number: AZ-15

Applicant: James W. Ross
7418 East Cholla Lane
Scottsdale, Arizona 85253

Applicant Category:
Individual

Project Type: Test a computer-controlled home energy management system.

Award: $9,760.00

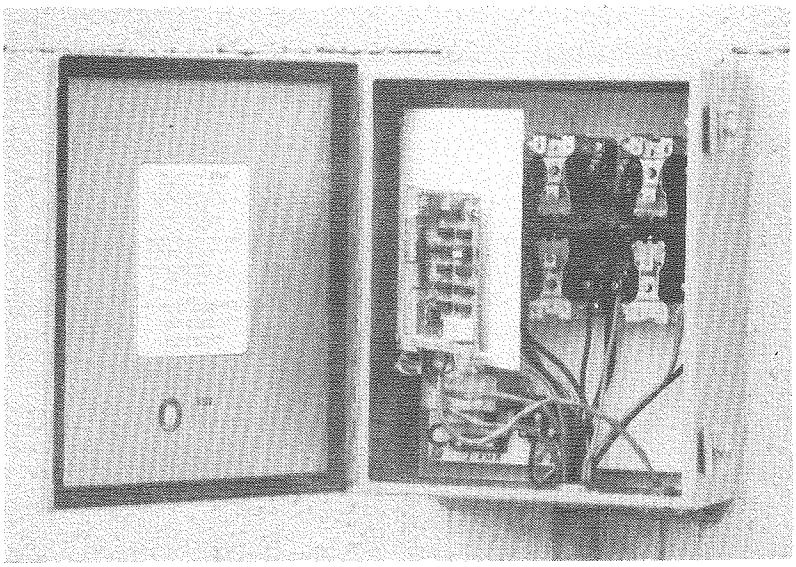
Project Term: 8 months (Project started June, 1978 - completed January, 1979)

Project Description:

- General: The Arizona Public Service Agency has filed a rate change request with the Arizona Corporate Commission intended to limit electricity use during peak hours by establishing a residential rate structure based on demand. Regardless of the outcome of this request, peak rate billing appears to be a structure which eventually will be widely used across the country. Mr. Ross has designed and built a microprocessor which controls the use of major electrical appliances by homes and small businesses during the peak demand times, thereby reducing electrical consumption during these times and offering the consumer reduced utility costs. For this project, Mr. Ross has determined user acceptance and energy efficiencies by installing systems in five homes and monitoring the results. He has designed three programs for different users, performed a series of controlled tests, collected data with magnetic recorders, analyzed data from the tests, and prepared a number of reports, manuals, and descriptive pamphlets. Electrical Contractor, Design News, Electrical Light and Power, and Popular Science have published or will be publishing articles on the energy manager.

- Technical Details: The energy manager is a microprocessor-based electrical load controller, regulating four major appliances and the central air conditioner. Another model, designed for small businesses, controls six appliances and the air conditioner. The microprocessor is preprogrammed with a read-only memory which determines the conditions necessary to shut off or turn on the appliances. A general program (the one tested) monitors the total lead current of the home using two current transformers which are coupled to the main service line and produce an input signal. The unit compares this input signal with an adjustable signal level. When the input signal exceeds this preset signal, appliances are shut off sequentially according to a priority schedule until energy use falls below the signal. The appliances remain off for 7-1/2 minutes, and if there is no longer an overload the unit turns on the appliances according to the priority schedule. A schedule in ascending priority might include

pool pump, water heater, clothes dryer, air conditioner, and range top. Either an electrician or handy homeowner can install the unit next to the circuit breaker box in about three hours.



Internal view of the energy manager.

• Test Conclusions: The unit performed effectively in all-electric homes and reduced the peak demand between 25% and 45%. The design is reliable; users reported no malfunctions of any kind. The unit should be installed only in all-electric homes so that the controlled appliances include the water heater, clothes dryer, and range top. Homes should have a demand level of about 8 or 9 kW since monetary savings for homes with lower demand do not compensate for the slight inconveniences. User acceptance was very good. There were no complaints about inconveniences, even in homes with the greatest demand reduction. By extrapolating from the data and by using the proposed rate schedule, the average yearly savings for the 5 homeowners is $178.78. Using a unit cost of $395 and an installation fee of $150, the estimated payback period is about 3 years. United Laboratories will conduct additional tests.

Project Title: SOLAR AIR ACTIVE HEATER/PASSIVE COOLER COLLECTOR SYSTEM

Project Number: AZ-41

Applicant: Arizona Scientific Research
10121 Catalina Highway
Tucson, Arizona 85715

Applicant Category: Small business

Project Type: Construct and monitor a dual mode, modular, solar air collector system for space heating and cooling.

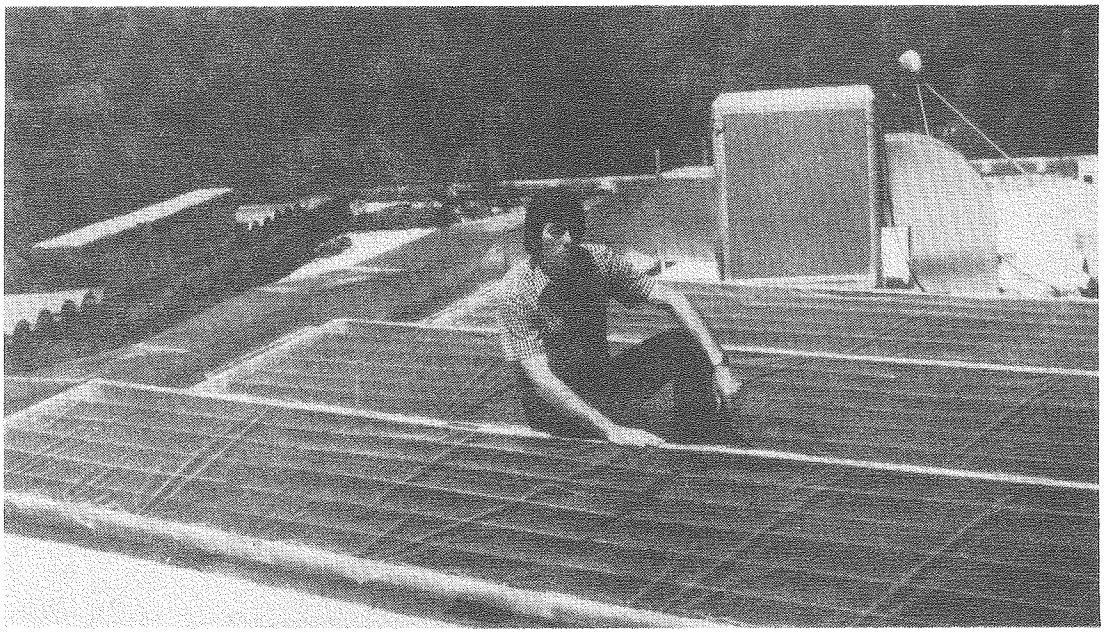
Award: $8,393.61

Project Term: 15 months (Project started June 1978)

Project Description:

• General: For this project, Arizona Scientific Research has built and is testing a modular solar air collector system for space heating and cooling. This system, designed for flat roofs common in the southwest, will heat in an active mode during the winter and cool with passive features during the summer. The mechanism for changing the mode depends on the difference in the sun's angle of inclination between the winter and summer. The accompanying picture shows the configuration of the solar panels with "V" channels placed at 45° angles to the sheet metal absorber plates. The collector is at an angle of 8° with the roof to eliminate rain water collection problems. These modular channels are painted white on the top-side and black on the interior, and the panels are covered with polyethylene which can be removed during the summer. The air flows down the "V" channels, and the modular units can be connected for either series or parallel channel air flow. During summer, the polyethylene cover is removed for free air convection to the outdoors. The sun angle is such that sunlight falls on the white channel surface which reflects most of the light. For winter heating the cover is in place; air is blown down the channels; and, because of the low angle of inclination, the black interior of the channels absorbs sunlight, converting this light into heat. Arizona Scientific Research has finished building the prototype and is now monitoring the unit for efficiency and energy savings.

• Technical Details: The prototype collector costs are $6.70/sq.ft. for 200 sq.ft. of collector, and projected costs are from $4.50 to $6.00/sq.ft. The collectors are 30' long, and the modular channels are 30' wide. Modular sections are from 24 gauge Paint Lock sheet metal. Preliminary tests are encouraging but show that there are certain heat transfer problems which must be solved either by lowering the air flow rate or creating air turbulence within the collector. The last quarterly report from Arizona Scientific Research indicates that a combination of these methods improves the heat transfer within the collector. They are also seeking a substitute for the polyethylene.



Collector system during active mode.

Project Results:

- Energy Savings: F-Chart computer calculations show that this prototype collector system will produce usable energy of 14.2 million Btu per year, giving an annual energy savings of 4.2 MWh of electricity (Lucarelli and others, in press). With a 20 year collector life, the collector will save 83.2 MWh of electricity. These figures do not include energy savings from the cooling mode which should be an additional 10%, based on preliminary tests.

- Applicability Elsewhere: This system is especially designed for the southwest, where flat roofs are common, and the sun's inclination is proper for the dual mode. Once Arizona Scientific Research solves certain efficiency problems, the modular construction, dual mode energy savings, and simple on-site construction features should make this system practical for southwest homeowners.

Project Title: HARDWARE PACKAGE AND WORKSHOP CURRICULUM FOR RESIDENTIAL SOLAR HOT WATER SYSTEMS

Project Number: AZ-52

Applicant: Dr. Stanley A. Mumma
Environmental Research
College of Agriculture
Arizona State University
Tempe, Arizona 85281

Applicant Category: State university

Project Type: Workshop for building and installing residential solar hot water systems.

Award: $11,110.00

Project Term: 12 months (Project started June 1978)

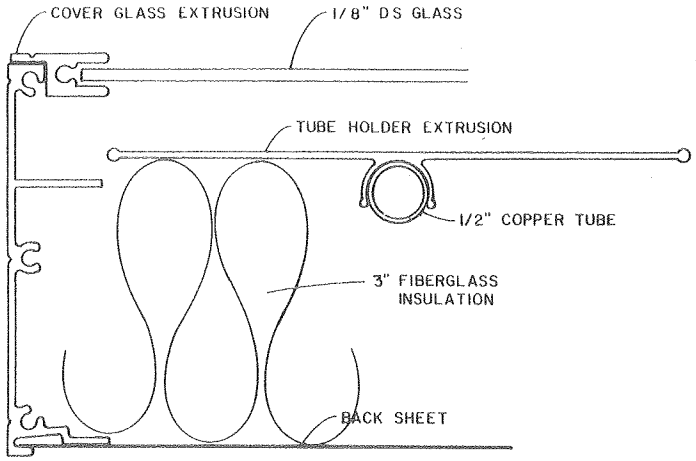
Project Description:

• General: For this project, a professor and two graduate students from the College of Agriculture of Arizona State University have developed a hardware package and workshop curriculum for instructing and assisting homeowners to build and install solar hot water systems. They have assembled a package of solar hot water heater components which homeowners can purchase from local suppliers and have organized a workshop for explaining the component assembly. The workshop cost including components is $400.

After developing the kit and curriculum and after testing and evaluating the workshops with two pilot sessions, they offered in August 1978 a two-evening, eight-hour workshop to 80 homeowners (with a waiting list of 200). The participants built two solar collectors during the first evening; and, during the second evening, they learned to install the system by studying a simulated system of collectors, controls, pump, and pipes. Last fall Arizona State, after developing and testing a new unit and a heat exchanger system for freezing climates, offered the workshop on a regular basis to 80 people per month (four sessions per month with 10 people per session). To date, approximately 700 homeowners have built and installed solar hot water systems as part of this workshop for $400 per system. This compares favorably with the average cost of about $1,500 for a similar commercial system.

• Technical Details: The collector includes 34" x 76" standard patio glass for glazing, commercially pre-bent serpentine copper tubing, an aluminum absorber plate with extruded fins, and an extruded aluminum collector box with steel backing plate. Plumbing includes retrofitting the existing hot water tank (unless the tank is too old); a low horsepower, bronze body, magnetic drive coupling, circulating pump; soft copper tubing,

with various configurations, between collector and storage tanks; and a low voltage, simple, plug-in type differential controller. An antifreeze, closed loop system with heat exchanger will be offered.



Collector assembly.

Project Results:

- Energy Savings: The project goal is to have 10% of the 500,000 homeowners in metropolitan Phoenix attend the workshops during the next five years, resulting in 50,000 new solar units. (There are 700 new units to date.) This will be an annual electrical energy savings of about 300 million KWh, worth approximately $15 million in 1979 dollars. There has been an impact on local suppliers as participants purchase components directly from these suppliers.

- Applicability Elsewhere: As the university has designed this package for temperate climates, the program can easily expand throughout the southwest and, with certain modifications, throughout the rest of the country. The Tennessee Valley Authority, the American Institute of Architects, Research Centers Consortium, and the Arizona Solar Energy Research Commission are interested in the program.

Project Title: PROJECT SAW: SOLAR - ADOBE - WIND

Project Number: AZ-81

Applicant: Window Rock School District #8
Box 559
Fort Defiance, Arizona 86504

Applicant Category:
Public agency/
Indian tribe

Project Type: Workshop for solar active, solar passive, and wind technologies for the Navajo Nation.

Award: $46,800.00

Project Term: 36 months (Project started June 1978)

Project Description:

• General: For this project, the Window Rock School District #8 is providing an educational program and demonstration in solar active and passive systems and wind technologies for high school students and adults of the Navajo Nation. This project responds to several problems of the Navajo Nation: the shortage of low cost, traditional housing; the expense and inaccessibility of utilities; a 60% unemployment rate; and a high dropout and unemployment rate for high school age students. The school district is using the grant to provide an alternative energy educational program, Project SAW: Solar - Adobe - Wind, in which students are building an experimental solar home with greenhouse areas, a solar water heater system, a wind energy system, a passive solar system with a rammed-earth Trombe wall, and traditional Navajo styling (eight sided hogan). Current enrollment in the classes includes 30 students during the day and 40 adults in the evening. Winter weather delayed construction, as expected, but with spring, work will continue on manufacturing the rammed-brick walls and Trombe wall, laying out the building design, and ordering the solar and wind components. To publicize the project, the school is editing a video tape of the work. Construction work will continue during the summer as part of the summer school program, and a fall 1979 Native American Solar Energy Conference will include this model home.

• Technical Details: The octagonal house or "Hogan" will include two greenhouses, a solar hot water heater, a sleeping loft, an eastern entry, block walls of rammed earth (Cinva), a central fireplace, skylights, a wind electric system, and a Clivus Multrum composting toilet. As part of the three-year project, this year the students are making the earth bricks, building layout, and masonry; next year, the greenhouse, plumbing, and wiring; and the last year, the wind and active solar systems and final house construction.

Adobe manufacturer.

Project Results:

- Energy Savings: This is a demonstration and educational project incorporating and promoting alternative energy technologies in homes and businesses throughout the Navajo Nation. Therefore, the energy savings will be indirect.

- Demonstration and Applicability Elsewhere:

  - A model hogan will be available to visitors.

  - The school district now has an educational program which can be duplicated throughout the Navajo Nation and elsewhere.

  - The hogan demonstrates alternative and simple house construction methods.

  - The district's film, video tape, and media facilities will promote the project.

  - Long term benefits include employment, conservation, and inexpensive housing.

Project Title: SOLAR/ADOBE PROJECT

Project Number: AZ-85

Applicant: Equinox - Solar Consulting
Mike Frerking and Nigel Dickens
Star Route 1 East
Chino Valley, Arizona 86323

Applicant Category:
Small business

Project Type: Workshop on adobe block construction, solar systems, and water conservation.

Award: $24,403.00

Project Term: 15 months (Project started June 1978)

Project Description:

• General: During the summer of 1977, the Solar/Adobe Project of Chino Valley offered to the public two skill oriented, labor intensive workshops on adobe block and building construction, solar energy applications, and water conservation. These workshops were designed for lower income communities, owner/builders, and those interested in conservation, but the admission charge restricted attendance. In order to encourage the lower income groups, DOE funding has enabled Solar/Adobe Project to present, at no admission charge, a series of 12 two-day workshops over a 12 month period at 12 different locations. They have completed five of the workshops. The Project has reached an additional audience through evening film and slide programs and a do-it-yourself adobe construction booklet.

Saturday A.M.: Indigenous arid region architecture, adobe construction techniques, adobe and uniform building codes, the owner/builder.

Saturday PM: Adobe block making, block making with forms, slab forming, block stability.

Sunday A.M.: Contemporary solar heating/cooling adobe applications, passive solar heating and cooling concepts, adobe wall construction, and the uniform building code.

Sunday P.M.: Passive solar heating demonstrations and displays, wall construction techniques, block and soil testing.

(Each day has 2 to 3 hours of classroom instruction and 4 to 5 hours of field work.)

Solar Adobe workshop class.

Project Results:

- Energy Savings: This is an educational project, and therefore all energy savings are indirect since the project itself does not save energy but educates people in energy saving technologies. This project develops skills that will enable the owner/builder to create an energy efficient, solar heated/cooled home with minimal environmental impact. The Project also provides opportunities for small scale, environmentally sound, community industries such as adobe block making and block laying.

- Applicability Elsewhere: There is a fine multiplier effect for energy savings through appropriate energy technology workshops. This program is a well organized educational effort for regional technologies and is the type of program which can be offered throughout the country.

Project Title: TWO-STAGE EVAPORATIVE COOLER

Project Number: CA-18

Applicant: J. B. Williams
P.O. Box 664
Northridge, California 91328

Applicant Category:
Individual

Project Type: Develop and test a two-stage, residential, evaporative cooler.

Award: $7,812.00

Project Term: 14 months (Project started June 1978)

Project Description:

- General: Single-stage evaporative coolers were once widely used in the southwest where flow wet-bulb temperature or low summer humidity conditions prevail. Because evaporative cooling is ineffective during times of high humidity, homeowners have switched to refrigerated air systems, which consume additional energy for the compressor motors and evaporative fans. For this project, Mr. Williams is developing and testing a two-stage, residential, evaporative cooler. The unit is similar to a conventional evaporative cooler; but Mr. Williams has added a pre-cooler coil and a wet pad system for second stage cooling, enabling the unit to operate in more humid climates and at greater efficiency. After completing an extensive literature search and design phase, Mr. Williams has built the unit and is starting preliminary tests.

Project Results:

- Energy Savings: To estimate the project's energy savings, Lucarelli and others (in press) have compared this system to a conventional air conditioning system in California. The California Energy Commission estimates that the average central unit in California uses about 2.4 MWh/year or 83.6 million Btu/year. Because the evaporative cooler uses only water pressure and fans with no compressor, this unit will use about 40% of the energy of a conventional central unit, resulting in annual energy savings per unit of 5.02 million Btu or natural gas of 1.5 MWh of electricity. With a ten year life, savings will be 15.0 MWh of electricity.

The cost of the cooler will be about $1,500, including installation, compared to $3,000 for a 3-ton refrigerative cooling system.

Project Title: LOMPICO LOGS

Project Number: CA-184

Applicant: Richard Linebarger
P.O. Box 1207
Felton, California 95018

Applicant Category: Individual

Project Type: Construct, test, and demonstrate a prototype tool for converting slash, brush, and forest waste material into usable fuel.

Award: $10,000.00

Project Term: 12 months (Project started June 1978)

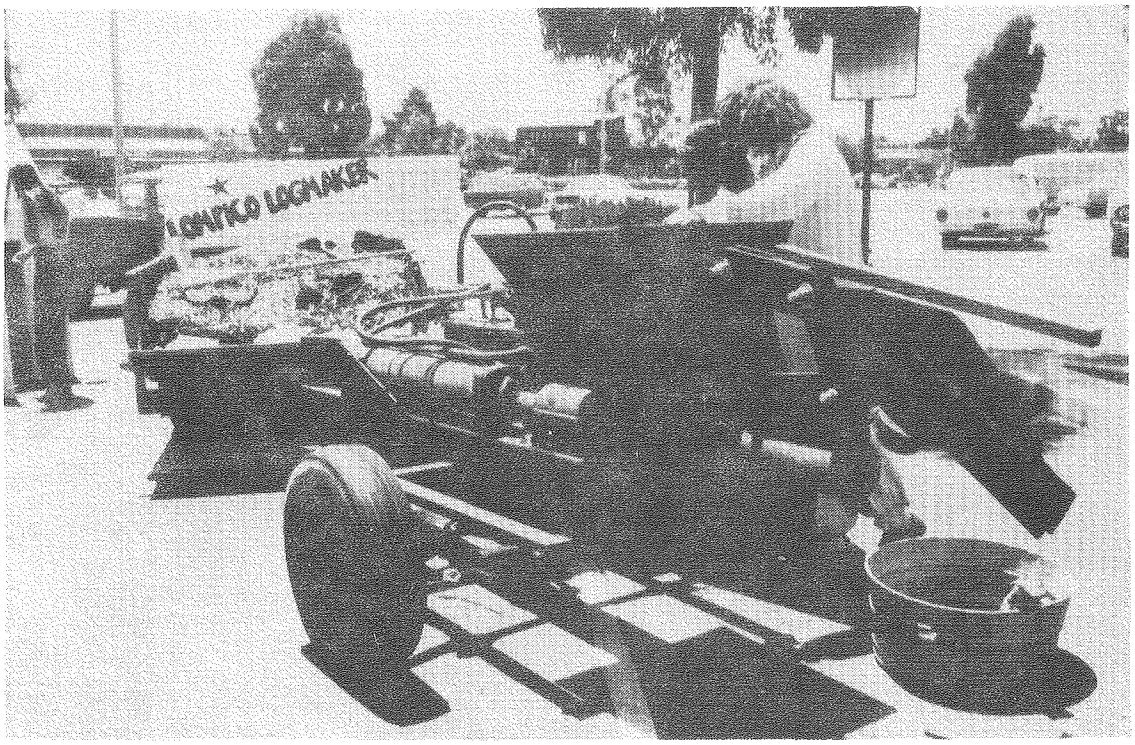
Project Description:

- General: For this project, Mr. Linebarger is building and testing a tool which chips and compacts slash, brush, and other forest waste material into burnable logs. The prototype tool, which the applicant has just completed, consists of a log chipper and a cylinder/hydraulic ram system with a small compressor mounted on a trailer. Waste material is fed into the hopper of the chipper, ground into chips, sprayed with a binder/combustion solution, and compressed by the hydraulic ram. When the proper amount of material has been compressed, the operator opens a rear gate on the cylinder and ejects the log, which must season like regular firewood. Now Mr. Linebarger is experimenting with various non-petroleum based binders, testing the logs, planning a second generation device with additional safety and automatic features, and demonstrating the tool (Sun Day).

Project Results:

- Energy Savings: The pre-project energy consumption was 1,189.2 million Btu/year based upon 6,000 gallons/day of water. The post-project energy consumption will be 632.5 million Btu/year - a savings of 556.6 million Btu/year of natural gas. With a twenty year lifetime, total energy savings will be 11,130 million Btu of natural gas (Lucarelli and others, in press).

- Applicability Elsewhere: Because of the success of the Environmental Container Reuse Program and the energy efficient methods of this project, two more similar operations are being undertaken in northern California, another is planned, and a fourth is being built in Oregon.



Demonstrating tool at Santa Cruz Sun Day Fair.

Project Title: SOLAR PROCESS HEATING FOR A BOTTLE STERILIZING PLANT

Project Number: CA-649

Applicant: Ecology Center, Inc.
2179 Allston Way
Berkeley, California 94704

Applicant Category:
Community group

Project Type: Demonstrate waste heat recovery and solar hot water heating for an industrial bottle washing plant.

Award: $8,480.00

Project Term: 12 months (Project started June 1978)

Project Description:

- General: The Ecology Center operates the Environmental Container Reuse Program for collecting, washing, packaging, and returning approximately one million wine bottles to wineries for reuse each year. This operation saves about 2/3 of the energy required for new glass containers, but an engineering analysis showed that about half of the energy used in this washing process could be saved by reclaiming some of the waste heat in the discharge water and supplementing the gasfired boiler with solar heat. For this project the Ecology Center is installing a heat exchanger system and an array of solar collectors. The heat exchanger system will retain heat from the waste water, and the solar system will provide additional preheating of the water after the heat exchanger and before normal heating from the steam boiler. These systems will be connected to the two bottle sterilizers. This simple solar system is a compromise between cost of energy saving equipment and energy savings, and the Ecology Center can add additional collectors and a storage system at a later date.

- Technical Details: The heat exchanger is installed on the roof and has two Radiator brand, 24 sq.ft. each, shell and tube exchangers for two passes. (Two exchangers are lighter and easier to install than a single unit.) The solar system has 10 Sol-Power Collectors which are 30.6 sq.ft. each and include copper absorber, aluminum box, U.V. stabilized Lexan glazing, 1/2" isocyanate foam and foil insulation on back (R-16). The frames are redwood and the plumbing includes 1" copper connecting pipes with 1" silicon hose. The heat exchanger system is operating, and the solar system is installed and will be operating after a solenoid valve controller problem has been corrected.

Project Results:

- Energy Savings: The pre-project energy consumption was 1,189.2 million Btu/year based upon 6,000 gallons/day of water. The post-project energy consumption will be 632.5 million Btu/year - a savings of 556.6 million Btu/year of natural gas. With a twenty year lifetime, total energy savings will be 11,130 million Btu of natural gas (Lucarelli and others, in press).

- Applicability Elsewhere: Because of the success of the Environmental Container Reuse Program and the energy efficient methods of this project, two more similar operations are being undertaken in northern California, another is planned, and a fourth is being built in Oregon.

Project Title: SOLAR/WOODSTOVE DOMESTIC WATER HEATING SYSTEMS

Project Number: CA-668

Applicant: Mill Creek Energy/Sunworks
1420 Felta Road
Healdsburg, California 95448

Applicant Category:
Small business

Project Type: Test a variety of domestic water heating systems which use combinations of wood and solar energy.

Award: $7,750.00

Project Term: 14 months (Project started June 1978)

Project Description:

• General: This joint project of Joe Carter, former associate editor of the Wind Power Digest, and Richard Conrat, owner of Sunworks, has two parts. The first part involves installing and monitoring eight different combinations of woodstoves and solar systems for providing residential hot water. In northern California, as in other heavily forested areas, wood is widely used for space heating, but no one has studied retrofitting existing stove systems in combination with solar systems for domestic hot water heating. During the fall, 1978, Mill Creek Energy/Sunworks retrofitted eight different solar and wood systems in the homes of volunteers. The volunteers paid for the equipment but received free installation in exchange for monitoring the systems for a year. Using an extensive array of monitoring equipment, including some equipment donated by Sonoma State College, they monitored the systems during the wood-heating winter season. The grantees are reviewing the data along with data from the second part of the project for a series of reports.

The second part involves establishing a woodstove test facility for studying in a controlled environment the performance of different configurations of heat exchangers for a variety of woodstoves. Eleven woodstove manufacturers have donated stoves, and through a series of controlled tests with thermosiphons and forced flow modes, the grantees are studying problems such as: What are optimum conditions for maximum heat energy absorption by the exchanger? Does an increased exchanger surface-to-volume ratio increase efficiency? Does the firebox heat exchanger have any adverse effects on internal combustion? They will make the data and results available to DOE through reports.

- Technical Details: The eight configurations are varieties of: solar thermosiphon/woodstove thermosiphon; solar thermosiphon/woodstove forced circulation; solar forced circulation/woodstove thermosiphon; and solar forced circulaton/woodstove forced circulation. The systems use a variety of flat plate collectors, and different commercial and custom built heat exchangers are being tested.

Project Title: SOLAR HEATED GREENHOUSE

Project Number: CA-706

Applicant: Central Valley Community Development Corporation
3530 North Dinuba Boulevard
Visalia, California 93277

Applicant Category: Community group

Project Type: Build and demonstrate small commercial greenhouses for family farmers.

Award: $7,574.00

Project Term: 15 months (Project started June 1978)

Project Description:

• General: For this project, the Central Valley Community Development Corporation, a nonprofit community group, has constructed and is operating a low-cost, attached, commercial greenhouse and will build a similar free-standing greenhouse this summer. These greenhouses demonstrate to local family-farmers how simple solar passive methods can greatly reduce the high heating costs associated with ordinary commercial greenhouses, thereby making greenhouses a simple and efficient tool for extending the farming season through the winter. For the first part of the project, the group and eight youths from a local manpower agency built an 84' long greenhouse attached to the south facing wall of their newly acquired community center. They completed construction in early January but, because of the late planting, have limited this year's crops to tomato seedlings. For the second part of this project, the group will repair and modify an existing free-standing greenhouse as a demonstration for the many local farmers who do not have buildings with walls capable of supporting attached greenhouses.

• Technical Details: All construction uses easily available secondhand or inexpensive new materials. They did construction in eight phases:

1) Install greenhouse support beams from the center (15 5" x 5" beams six feet apart attached with steel plates and bolts - mostly scrap material);

2) Pour concrete piles to support the greenhouse south wall;

3) Build truss plates from scrap metal to support the 60° south wall;

4) Construct a north roof and ceiling using standard secondhand materials (1/2" 4' x 8' exterior plywood);

5) Construct east and west walls with standard dimensions to reduce costs (studs 24" on center, 4' x 8' plywood);

6) Construct south wall with four mil polyethelene double layered glazing (polyethylene rather than glass or plastic to reduce expenses);

7) Build compost pit around perimeter of greenhouse base (to regulate heat loss and supply compost for summer planting);

8) Install water heat storage drums (55 gallons) against north wall.

Compost pit insulation.

Project Results:

- Energy Savings and Demonstrations: The key to this project is construction of small commercial greenhouses with passive solar features using mostly secondhand and some inexpensive new materials. The group has taught these construction methods to 16 youths and are demonstrating to the farmers that commercial greenhouses can be cheaply built and operated, thereby extending the growing season. Energy savings are mostly secondary savings resulting from demonstrating and implementing these ideas.

Project Title: REMOTE LOCATION WIND ELECTRIC SYSTEM

Project Number: CA-716

Applicant: James R. Sencenbaugh
Sencenbaugh Wind Electric
2235 Old Middlefield
Mountain View, California 94040

Applicant Category:
Small business

Project Type: Design, build, and test a low power, high reliability, wind electric system for remote locations.

Award: $37,280.00

Project Term: 24 months (Project started June 1978)

Project Description:

- General: Installations at remote locations such as telecommunication repeaters, fire lookout stations, meteorological and seismic stations, and summer cabins often require power of less than 1 kW/day. Wind machines can provide this power, but high capital cost and the costs of servicing and maintaining these wind systems can be more expensive than the alternating systems such as diesel or gasoline powered generation. Therefore, a low maintenance, low cost, highly reliable wind machine, designed for continuous operation at remote sites and requiring only occasional servicing, will have considerable primary and secondary energy saving impact. For this project, Sencenbaugh Wind Electric, a company with extensive experience in designing and building wind electric conversion systems, is designing and field testing a 400W (rated windspeed 18 mph), 12VDC or 24VDC battery charging, wind-driven generating system engineered for remote locations. During the first year of the project, Sencenbaugh Wind Electric completed the design of the machine and the construction and initial testing of the three prototype machines. During the second year, they will test the machines at three remote sites in California, Colorado, and Washington, gather field data periodically, do an engineering evaluation of the equipment removed from the field, and do final modifications for optimizing the design.

- Technical Details: Sencenbaugh Wind Electric has designed a working, pre-production prototype wind machine which is essentially a three bladed horizontal axis machine of direct drive configuration (no gearing) and uses an integral body and generator housing of cast aluminum. The machine is able to operate in environmental conditions which include: temperature from -70 to 140°F, ice build-up to 2.5" on rotor and body, salt water spray, lightning strikes, and a survival wind speed of 130 mph with gusts up to 160 mph. The machine has a one year minimum time between servicings.

- Performance Specifications:

Operation

Maximum continuous output at 14.4 VDC	400 watts
Peak output	600 watts
Maximum excitation power	56 watts
Cut-in wind velocity	8 mph
Maximum output wind velocity	18 mph
Maximum design wind speed	130 mph
Propeller diameter	7.5 ft
Propeller rpm range: cut-in	280 rpm
maximum output	1000 rpm

Construction

Propellers	Sitka Spruce
Castings	356T6 aluminum
Steel	1018 or equivalent
Stainless Steel	300 series
Finish	Solar Gray, polyurethane
Shipping weight (generator,blades,tail)	80 lbs
Heaviest lift	65 lbs
Container size (wind generator and con. panel)	40" x 74" x 16"

Project Results:

- This project will provide DOE and the public with a system design, test data, and prototypes for a high reliability, small wind machine for use where environmental conditions are a controlling factor or servicing is a problem. Applications include commercial use at repeater or monitoring sites, power for communications at remote or environmentally hostile locations, and domestic use at summer cabins.

Project Title: SMALL FARM AND HOMESTEAD ANAEROBIC DIGESTERS

Project Number: HI-11

Applicant: Michael Weitzenhoff
University of Hawaii
Honolulu, Hawaii 96850

Applicant Category:
Individual

Project Type: Develop and demonstrate small farm and homestead anaerobic digesters.

Award: $13,000.00

Project Term: 12 months (Project started September 1978)

Project Description:

- General: For this project Mr. Weitzenhoff is developing and demonstrating two prototype, continuous flow, anaerobic digesters for a small farm and a homestead. The small farm digester has a capacity of 12,000 gallons for an input of 600 gallons of slurry per day with a 20 day detention time. This digester is large enough to process the wastes produced by 260 pigs or 40 dairy cows. To minimize costs, the digester will use locally available, secondhand materials and will be fabricated of nylon-reinforced butyl sheeting formed into a bag.

The homestead digester will process the sewage wastes and organic refuse from a family of four. Mr. Weitzenhoff selected a digester capacity of 330 gallons of slurry based upon a 15 gallon of slurry per day input and a 20 day detention time. The digester consists of six 55 gallon drums welded together like sewer pipe. Biogas production from the digester will be increased by including a photosynthetic loop in the system. Mr. Weitzenhoff will use the digester sludge to raise algae in a pond and will feed this algae into the digester to balance the feedstock carbon/nitrogen ratio and to increase methane production.

- Technical Details and Energy Savings: The small farm digester should produce 426 million Btu of gas annually based upon an assumed gas production of 6 cubic feet (60% methane) per pound of total solids of pig manure, an optimal operating temperature of 95°F, a 20 day detention time and an 80% plant use factor. Mr. Weitzenhoff intends to convert the biogas into electricity. The waste heat from the electric generator will be used to maintain the digester temperature at 95°F. Assuming a generator efficiency of 25%, 33.5 MWh of electricity will be produced annually from the small farm digester. With a ten year life, the digester-generator combination will produce 335 MWh of electricity.

The homestead digester will produce 7.6 million Btu of biogas annually. This estimate assumes an 80% plant use factor, a 95°F operating temperature, a 20 day detention time, and gas production rates ranging from 6 cubic feet of biogas (60% methane) per pound of algae to 9.2 cubic feet of biogas per pound of refuse and sewage. The 95°F operating temperature will be maintained by enclosing the digester in a geodesic dome, which will act as a solar collector.

Annual energy production from the two digesters will be 433.6 million Btu of gas. If converted into electricity at a 25% conversion efficiency, the gas will produce 33.5 MWh of electricity. Assuming a ten year lifetime for the digester, total energy savings should approach 4,336 million Btu of natural gas or 335 MWh of electricity.

In addition, the small farm digester will produce 35 dry tons of stabilized sludge each year, which will have a high fertilizer value. The sludge should contain 2.4 tons of nitrogen as organic nitrogen and ammonia nitrogen, 2.1 tons of phosphorous (P_2O_5) and 0.5 tons of potassium (K_2O) (Lucarelli and others, in press).

Project Title: SOLAR HEATING FOR A RURAL FIREHOUSE

Project Number: NV-12

Applicant: John Brown, Chief
Diamond Valley Firehouse
Eureka, Nevada 89316

Applicant Category:
Local agency

Project Type: Solar space heating system in a rural firehouse.

Award: $13,390.00

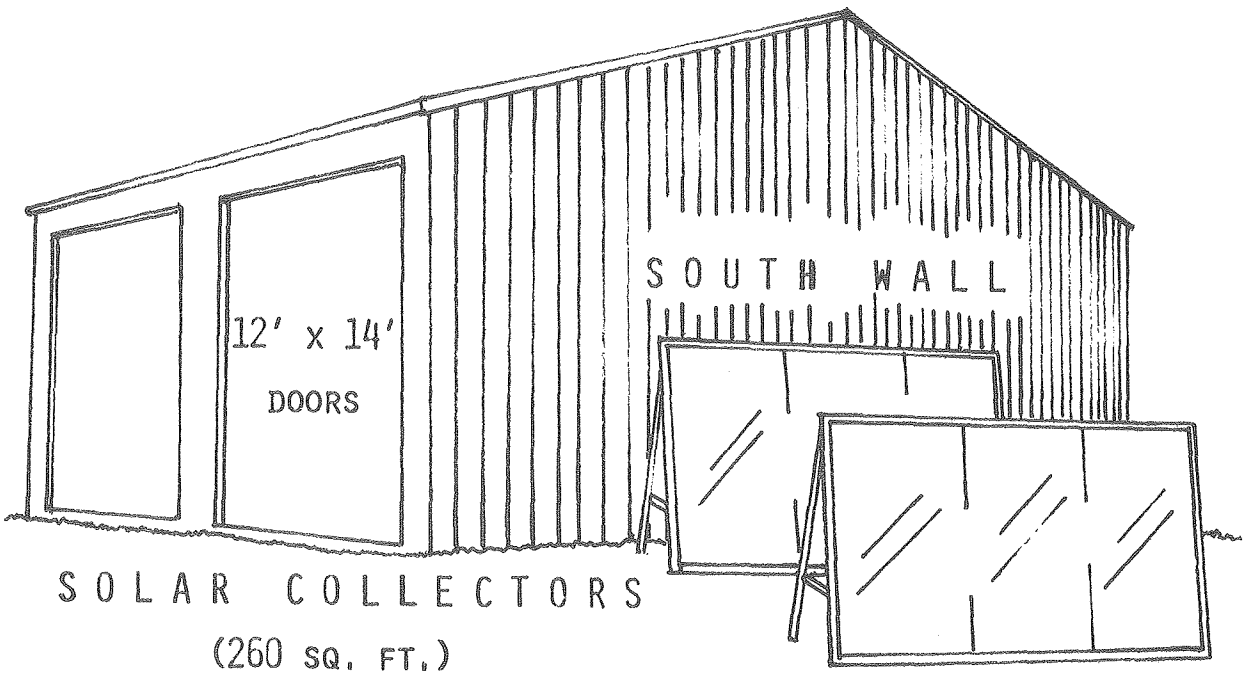
Project Term: 12 months (Project started September 1978)

Project Description:

• General: For this project, the Diamond Valley Volunteer Fire Department is installing an unusual solar space heating system for their firehouse to satisfy a number of local energy requirements. The department serves the small town of Eureka (population of 600) and 72 surrounding farms and ranches. During the winter the firehouse temperature must be at least above freezing to prevent water from freezing in the trucks, but ideally the temperature should be about 50°F so that the trucks will start quickly. The volunteers must be able to install and maintain the system, and the system should be a source of emergency water for the trucks. The fire department has designed a simple system which fulfills these criteria and also demonstrates energy savings by solar heating a public building.

They are installing an on-the-ground hydronic array of collectors with a thermosiphon system delivering the water to 12" uninsulated storage pipes under the firehouse eaves. Warm air will circulate to the trucks below, and in emergencies a gravity feed system will deliver water to the trucks. The ceiling storage and delivery system, while somewhat inefficient for ordinary space heating purposes, will heat the firehouse to about 50°F and is easily installed and maintained. While the fire department is completing this project, the city is planning solar space heating installations in other public buildings.

• Technical Details: The system includes fourteen Sun Works collector panels with 18.6 sq.ft. net area per collector. Collector details include: copper sheet and tubes, enthone selective black surface, extruded aluminum sides, single 3/16" no-iron glass glazing, drain down model. The collectors are ground mounted and include a thermosiphon system. Twelve-inch diameter water storage pipes have been donated to the department. They are adding additional insulation to the firehouse.



The Diamond Valley Firehouse.

Project Results:

- Energy Savings: F-Chart calculations show primary energy savings of 34.4 MWh of electricity. With a twenty year life for the project, total energy savings will be 688 MWh of electricity. Secondary energy savings will result from solar space heating of other Eureka public buildings and public demonstration of these installations.

Project Title: PYRAMID LAKE SOLAR ASSISTED FISH HATCHERY

Project Number: NV-21

Applicant: Pyramid Lake Indian Tribal Enterprise
Star Route
Sutcliffe, Nevada 89510

Applicant Category: Indian tribe

Project Type: Industrial solar heating and cooling of water for a fish hatchery.

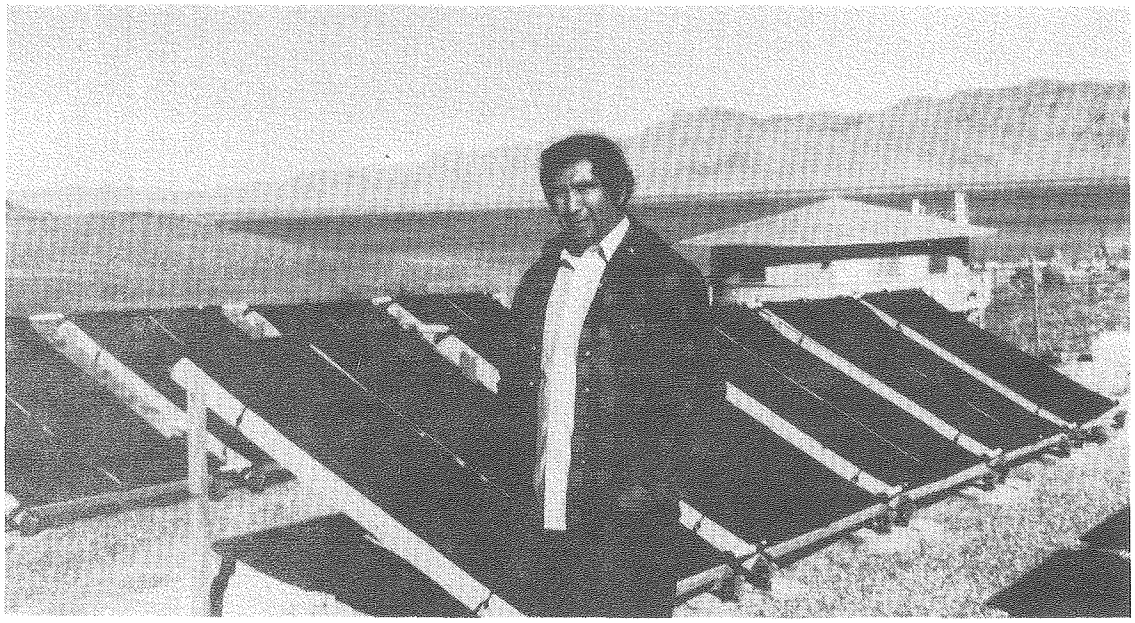
Award: $46,874.00

Project Term: 24 months (Project started June 1978)

Project Description:

- General: The Pyramid Lake Paiute Tribe is restoring their fish hatchery operation which was destroyed by upstream diversion of the Truckee River during the early 1900's. Presently the Tribe is operating a Lahontan Cutthroat Trout hatchery and is building a second hatchery, ten times larger, to be completed later in 1979. For fish husbandry, water temperature regimes are the most important operating parameter; for Cutthroat Trout the hatchery should maintain the temperature at 54°F, requiring heating during the winter and cooling during the summer. By building a solar water heating and cooling system, the tribe will increase the output of the facility, reduce the electricity consumption, and create employment for tribal members. During the first nine months of the project, the tribal members have installed a solar hot water system with the help of a Sacramento consulting firm. The system is operating, and during the remaining project term the Tribe will install an evaporative/radiative cooling system and will collect data and monitor the project for energy savings and fish output.

- Technical Details: The collector system consists of 1200 sq.ft. of unglazed FAFCO solar collectors mounted on south-facing racks constructed on-site. The configuration includes 3 rows of collectors, 10 collectors to a row, with PVC piping trenched from collectors to storage tanks. The collectors are situated next to an existing urethane, 95,000-gallon water storage tank on the hill above the hatchery and have direct plumbing with the storage tank (200 gpm flow with 3 hp pump - manual temperature controls pending installation of automatic differential temperature control system - Omega digital thermometer (Model 2176A) with thermocouples at 10 stations). During the second year they will install the evaporative/radiative, nighttime, misting cooling system. Engineering features include a low maintenance system because of the remote location of the hatchery, heavy rack construction due to wind exposure, and an on-site all purpose maintenance building.



Storage tank and solar collectors overlooking the fish hatchery.

Project Results:

- Energy Savings: By raising water temperatures from 49°F to 54°F and by operating collectors at maximum efficiency, the system will displace 653 million Btu of fuel oil annually. With a ten year lifetime, energy savings from the project will approach 6530 million Btu of fuel oil. The cooling system will save additional energy (Lucarelli and others, in press).

- Innovation and Demonstration: This unusual industrial application of a solar system is an excellent match between a solar system and end use, has already created additional jobs for the tribe, and demonstrates solar water heating and cooling to the tribe. A number of tribe members are installing home solar hot water units.

- Applicability Elsewhere: Industrial applications and the efficient matching of solar systems to end use are widely applicable elsewhere. This is a well conceived, designed, and constructed project; and, because of its demonstration potential, should encourage unique industrial and practical home solar applications.

Project Title: AGUA CALIENTE

Project Number: NV-64

Applicant: Fergus Wallis
Agua Caliente Trailer Park
P.O. Box 173
Caliente, Nevada 89008

Applicant Category: Small business

Project Type: Small scale application of a geothermal system for domestic hot water and space heating in a trailer park.

Award: $30,000.00

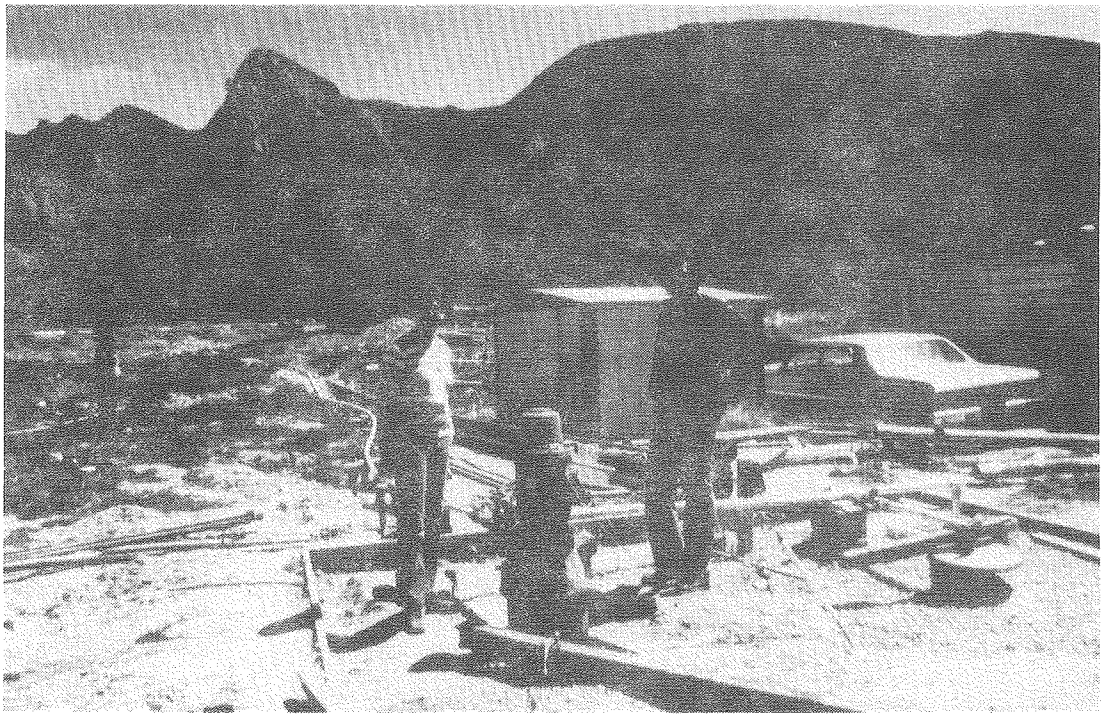
Project Term: 9 months (Project started June 1978 - completed March 1979)

Project Description:

- General: For this project Fergus Wallis, part-owner and operator of the Agua Caliente Trailer Park, has had a contractor drill three shallow wells into a geothermal reservoir about 50' underground beneath the trailer park. The contractor has done preliminary tests for the flow and quality of the water, installed a pumping system on two of the wells and a reinjection system on the third, and connected the system to all 53 trailer spaces for domestic hot water and space heating. The park houses primarily low income, retired people to whom this new source of energy represents considerable savings. (Electricity is the only other domestic energy source).

The town of Caliente is small (600 people) and has not been able to attract new small industry; non-availability of electricity has been a factor. This new geothermal source works successfully for small business application. During the summer of 1979, the city will measure the reservoir for capacity and continual flow and will study the prospects for using this resource for additional industrial and domestic purposes.

- Technical Details: There are three wells: 33' deep, 145°F, 15 gpm with a jet pump; 80'deep, 160°F, 100 gpm with a 5 hp Johnson Turbo pump; 58', 140°F, reinjection well (104°F reinjection temperature). There are two types of heat exchangers: flat coil and A configuration. Additional details include: forced air circulation with existing heating fans, uninsulated PVC piping, wells within a few hundred feet of the park, and the water is also used for laundry.



Geothermal well and pump.

Project Results:

- Energy Savings: The hot water meets the total hot water and space heating requirements of each trailer connected to the system. By using F-Chart calculations and assuming an average trailer size of 550 sq.ft., R-12 insulation in the wells, R-22 insulation in the ceiling, and 15% glazing (double panel), the annual energy savings from this geothermal system should be about 780 MWh of electricity. The ten year lifetime savings will be about 40,200 million Btu or 7,800 MWh (Lucarelli and others, in press).

- Applicability Elsewhere: A small industry, a medical center, and a small school are near the reservoir and are considering either drilling wells or establishing a small district heating system. This small scale geothermal system can be replicated throughout Nevada and in parts of Utah, Arizona, and California. DOE is funding a similar project in the second phase of the Region IX AET Program.

Project Title: SATAWAN HEALTH DISPENSARY SOLAR HOT WATER SYSTEM

Project Number: TT-1

Applicant: Lazarus E. Salli, Director
Office of Planning and Statistics
Trust Territory of the Pacific Islands
Saipan, Mariana Islands 96950

Applicant Category: Public agency

For: Satawan Island
Lower Mortlocks, Truk District
Eastern Caroline Islands
Trust Territory of the Pacific Islands

Project Type: Installing and demonstrating a solar hot water and wind pumping system for a small western Pacific island health dispensary.

Award: $7,000.00

Project Term: 16 months (Project started September 1978)

Project Description:

• General: Satawan Island, with a population of 600, is typical of many small western Pacific islands, lacking basic medical facilities and rudimentary education for personal hygiene. To meet this need, the Department of Health, Education, and Welfare (HEW) has designed and is building a small health dispensary, which will serve both Satawan and the other neighboring Mortlock Islands. HEW originally designed the facility to include a standard electrical system but changed the plans because Satawan has no electricity and importing fuel oil for a generating system presents too many problems. For this project, the people of Satawan, with help from the Trust Territory Office of Planning and Statistics, are installing a solar hot water and wind pumping system for the dispensary.

The only source of fresh water on the island is rain water collected from roofs with catchment systems, and the dispensary will have three water tanks for catchment. Two tanks, each with a 5000 gallon capacity, collect run-off from the roof and are on the ground. A third tank has a capacity of 2000 gallons and is mounted on a 30' stand to provide water pressure by gravity. A wind pumping system, engineered to meet the island's particular problems of corrosion, typhoons, plastic degradation, and lack of supplies and maintenance expertise, will pump the water from the two ground-level tanks to the third gravity tank. Water from this third tank will flow through two commercial solar thermosiphon units. Each system includes an insulated stainless steel (anti-corrosion) 50 gallon storage tank and

three solar collectors with 120 square feet total absorption area. To reduce corrosion, the storage tank stand and collectors are galvanized steel. All materials and equipment are factory made and come as packaged units, reducing the problem of ordering equipment from a number of U.S. companies and preventing delays and the mismatching of equipment.

Project Results:

- Energy Savings: Ambient water temperature is about 80°F, and the solar system will heat this water to about 140°F (collector outlet temperature) for washing laundry, cleaning equipment, and bathing. Based on a supply of 150 gallons/day, annual direct energy savings are about 11.2 MWh of electricity. Twenty year lifetime savings are 220 MWh of electricity. Indirect energy savings should be considerably more. Very few of the western Pacific islands use these simple solar collecting techniques, and this solar system will be widely demonstrated to people from a large surrounding area who use the dispensary.

- Applicability Elsewhere: Simple solar and wind systems should be encouraged throughout the western Pacific. Certain engineering problems make successful operation of these technologies a challenge, but simple adaptations such as this, using local manpower and materials, will certainly encourage replication on other small Pacific islands.

Project Title: WESTERN PACIFIC SOLAR HOT WATER HEATER CONSTRUCTION AND DEMONSTRATION

Project Number: TT-6

Applicant: Dr. Frank Jacquette
University of Guam
Agana, Guam 96910

Applicant Category: Individual

Project Type: Construct and demonstrate simple solar hot water systems for the western Pacific.

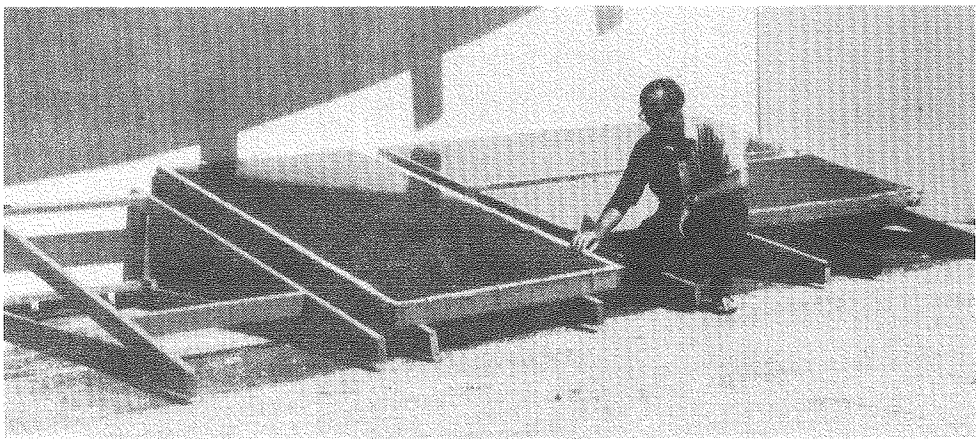
Award: $12,000.00

Project Term: 9 months (Project started September 1978 - completed June 1979)

Project Description:

- General: Because ambient water temperature in the Guam water lines is about 80°F, residents most often use electrical hot water heaters to increase the temperature to 120°F, the usual temperature for household and non-industrial use. Energy for this small temperature differential can easily come from solar systems, but there are very few residential solar systems on Guam. For this project, Dr. Jacquette has devised a simple solar system using off-the-shelf components. He has demonstrated to various groups how simply these systems can be built and has installed systems on three public buildings. In his first effort, Dr. Jacquette, with help from the Boy Scouts and other volunteers at a weekend fair, installed a simple solar system on the Dededo firehouse. For another building, he and twenty inmates from the Guam Penitentiary built a 10 collector heat exchanger system for the penitentiary. Finally, a group of young people built a system for the Guam Youth Affairs Center. All of these systems are simple, using easily obtainable materials, and are engineered for local problems such as typhoons, corrosion, maintenance, and rapid plastic degradation. Over 200 people have participated in the construction of the units. To inform others of his techniques, Dr. Jacquette has written three different books describing his systems. He has distributed these books throughout Guam.

- Technical Details: Off-the-shelf materials include tempered patio door glass for glazing, galvanized steel for pipes and absorbers, and simple fasteners for the pipes. Pipes are in both parallel and sinusoidal configurations, and both thermosiphon systems and heat exchangers with pumps are used for circulating water. Book titles include "Sun Power Now - Steel Box Sinusoidal Hot Water Collector Plans", "Sun Power Now - Flat Plate Collector Steel Box Thermosiphon", and "Sun Power Now - Wood Box Flat Plate Collector."



Building solar collectors during a weekend fair.

Project Results:

- Energy Savings: There are primary energy savings from the systems which have already been installed or will be installed as the demonstrations continue. We have not quantified these savings yet; in some cases, such as the Guam Penitentiary, hot water above ambient temperatures has not been available. Indirect savings will result from the books and from showing and encouraging others to build these systems.

- Innovation and Demonstration: The project has a practical approach for using local materials, overcoming difficult engineering problems, and providing simple maintenance systems. The demonstration potential is considerable and may be the most important part of the project as many of the western Pacific people are unfamiliar with solar techniques.

- Applicability Elsewhere: Dr. Jacquette has designed these systems for Guam and the western Pacific. He has demonstrated them widely on Guam and through his books his techniques will probably spread to other Pacific islands and districts. Simple solar methods are a very important part of the western Pacific energy situation.

Project Title: FISHMEAL FROM SOLAR HEATED DRIERS

Project Number: TT-11

Applicant: Buruta Jicko
Romanum, Truk
Eastern Caroline Islands
Trust Territory of the Pacific 96942

Applicant Category: Small business

Project Type: Solar drying of fish by-products for a small industrial application in the western Pacific.

Award: $14,150.00

Project Term: 18 months (Project started November 1978)

Project Description:

- General: Romanum, Truk, typical of many small islands throughout the western Pacific with a sparse population (about 300 people), depends entirely on expensive imported fuel oil for its limited energy requirements. For this project, they are designing and building a small solar drying and grinding system for processing fish by-products into chicken feed. This project will establish a small cooperative industry on the island, introduce solar systems to the island inhabitants, test different methods for solar drying, eliminate expensive fuel consuming trips to Truk for chicken feed, and with the help of the Truk District Government promote industrial applications throughout the Pacific. A number of engineering problems make this project unusual: parts and plans are extremely difficult to obtain; all construction is susceptible to corrosion and typhoons; plastics degrade within a few months; nearby engineering help is not available; and maintenance of any system is a limiting factor. With the help of the Peace Corps and Marcelino Actouka, the Energy Planner for the Trust Territory and the only native engineer in Micronesia, different types of solar dryers are being designed and constructed according to the above constraints. The Cooperative will have a four step drying and grinding process (two steps for drying and two steps for grinding) for the fish by-products, producing fishmeal for the chickens. They are currently investigating different grinding methods and should have the entire system operating by mid-summer.

- Technical Details: The grinder will be hand or wind powered. All materials except the grinding wheel will be native to Truk (no glass or plastics if possible). Different dryers will be tested.

Project Results:

- Energy Savings: Total primary energy savings are difficult to quantify because this industry would not exist if dependent on traditional fuels for energy. People throughout the western Pacific, despite the communication problems, are slowly establishing an alternative technology network. Results of this project will be widely disseminated with the help of the district and Trust Territory governments.

- Innovation and Demonstration: This is a highly innovative light industrial application of solar energy using simple, easily maintained processes which can be duplicated throughout the Pacific. The Truk District Government has offered considerable help because success of this project is extremely important to the Trust Territory. The Peace Corps will also disseminate results through their network. This small grant is very important to the western Pacific alternative energy development.

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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