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ENERGY APPROPRIATE ENERGY TECHNOLOGY PILOT PROGRAM
IN THE WESTERN PACIFIC

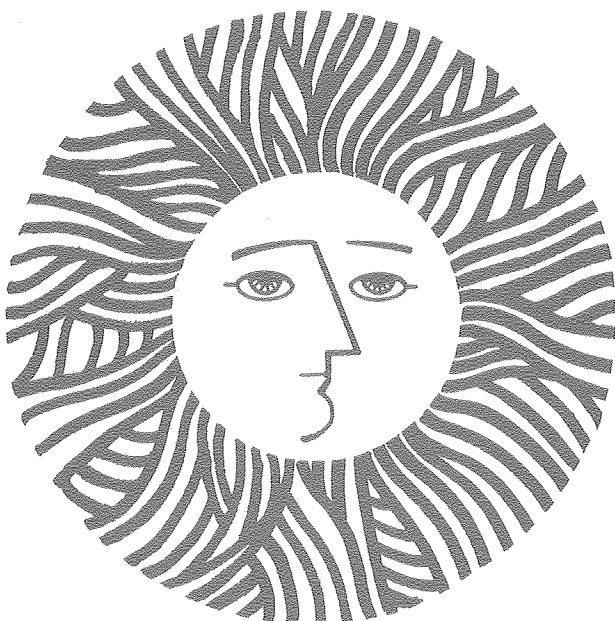
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REGIONAL AND COMMUNITY IMPACTS OF THE DEPARTMENT OF ENERGY
APPROPRIATE ENERGY TECHNOLOGY PILOT PROGRAM IN THE WESTERN PACIFIC

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ABSTRACT

The Department of Energy (DOE) distributes small grants for alternative energy projects through their Appropriate Energy Technology (AET) Grants Program. This program extends to the western Pacific, where DOE has given 15 grants for projects in American Samoa, the Commonwealth of the Mariana Islands, (CMI), Guam, and the Trust Territory of the Pacific. Average grant size is \$12.5K. Projects in Guam and the CMI include two solar systems for hot water heating, a typhoon-proof greenhouse, and a methane digester in Guam, and three educational projects for solar water heating and distilling, wind water pumping, and methane generating in the CMI. Some of the projects are successful but others are having difficulties because of particular regional engineering problems (corrosion, typhoons, construction logistics, materials, lack of technicians). Historically, federal grants are not always in harmony with western Pacific cultures, and AET grants should be distributed with a sensitivity toward long range effects.

1. INTRODUCTION

During 1977 the Department of Energy (DOE) established the Appropriate Energy Technology (AET) Grants Program. Through this program, DOE distributes grants for small energy producing systems which meet local demands, provide local employment rather than requiring large capital investments, are compatible with local environments, are easily demonstrated and replicated elsewhere, and use local renewable energy resources. Within this context, DOE has awarded grants for designing, constructing, and/or demonstrating a wide variety of energy producing and conserving systems (1,2,3).

The Lawrence Berkeley Laboratory (LBL) has been providing DOE with technical assistance. Two of our tasks are to monitor the projects, offering technical advice and assistance and to assess the direct and indirect energy impacts of the projects (1,2,3). We have made

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three trips to the western Pacific during the last two years.

1.1 Pilot and National Appropriate Energy Technology Programs

As a precursor to the national program, the DOE San Francisco Operations Office offered a pilot program with two funding cycles in Federal Region IX (Arizona, California, Hawaii, Nevada, and the western Pacific). They distributed 108 grants for a total of \$1.25 million through the first cycle in 1978 and gave out 34 additional grants for \$600K through the second cycle in 1979. The average grant size is \$12.5K. The largest grant is for \$43K and the smallest for \$50. Typical project duration is between one and two years.

In 1979 DOE transferred program management to the DOE Office of Inventions and Small Scale Technologies (OISST). Because of the pilot program success, OISST expanded the program nationwide, and all ten federal regions have now awarded grants. This spring, 1980, OISST is offering a nationwide cycle and will award approximately \$10 million by summer, 1980.

1.2 Program in the Western Pacific

Within Federal Region IX are the four U.S. political entities in Micronesia and Polynesia, referred to collectively in this paper as the western Pacific. American Samoa, the Polynesian entity, includes the seven islands of the Samoan group east of the 171st meridian of the west longitude. The main island, Tutuila, has 48 square miles and a population of 30,600 according to the 1977 census (4).

Micronesia includes about two thousand islands within 3 million square miles of Pacific Ocean between the equator and 22° N. latitude and from 130° to 172° E. latitude. Total land area is about 900 square miles. A few of the islands are fair sized, including Guam with 207 square miles, Ponape with 127 square miles, and Saipan with 47 square miles. Others are like Majuro, a portion of a coral atoll 30 miles long and rarely more than a couple of hundred yards wide. About one hundred of the islands are occupied, mostly with sparse

settlements. Major population concentrations are in the District or political centers, which average around 10,000 people. A 1975 census shows Guam with a population of 102,057, and a 1973 census shows the remaining population of Micronesia to be 112,649 (4).

Micronesia is split into three jurisdictions, each with a different political affiliation with the U.S. Guam, an unincorporated territory of the U.S., is the largest of the Micronesian islands, located at the southern extremity of the Mariana archipelago. The Commonwealth of the Northern Marianas Islands (CNMI) is a commonwealth of the U.S. and includes the remaining 16 islands of the north-south trending Marianas chain. The Trust Territory of the Pacific, a United Nations trust administered by the U.S., includes six Districts within the archipelagoes of the Eastern and Western Carolines and the Marshall Islands. Four Districts: Yap, Truk, Ponape, and Kosrae, are the Federated States. Two Districts: Palau and the Marshall Islands, desiring greater independence, are the Independent States. In 1981 all six Districts will be deciding on their degree of independence from the U.S.

This paper describes the technologies, engineering problems, and social and energy impacts of the nine projects from Guam and the CNMI. A longer version of this paper, in progress, describes these projects as well as the remaining seven projects in American Samoa and the Trust Territory of the Pacific.

1.3 Western Pacific Setting for AET Projects

AET projects in the western Pacific are having different regional impacts than the projects in the U.S. People are also encountering difficulties completing simple projects because of problems related to these remote tropical settings. Each jurisdiction or District has its own characteristics affecting small scale energy development. The following general statements do not necessarily apply to all of the islands in all cases. This is particularly true of Guam and American Samoa.

An important issue for the islands is the economic and political relationship to the U.S. World War II destroyed most of the islands' economically, physically, and culturally, and the U.S. has dominated postwar development. In turn the military importance of the islands has controlled U.S. policy toward development. Some of the postwar development has been impressive, particularly regarding facilities and structures such as transportation and hospitals, but these facilities are usually modeled after U.S. institutions and often are not in harmony with local cultures (5,6). In 1981 many of the islands will be deciding how they should affiliate with the U.S. Some are anxious for greater independence, and for this

the islands must diversify their economies, which are almost totally dependent on government employment and federal spending. The islands use imported fuel oil with subsidized rates, further increasing economic dependence. Island leaders are seeing the correlation between energy independence and economic and political independence. Accordingly, there is increasing interest in small decentralized energy systems using local resources and labor. Political leaders on the islands are giving AET projects strong support.

World War II and U.S. policy toward the islands have had a major effect on western Pacific culture. War damage is still very evident including rusted planes and landing craft on the beaches, tanks and guns in the jungles, and shell marks on the cliffs. On islands such as Saipan, virtually everything was destroyed, including vegetation. Postwar development has included using modern technologies and institutions, and these have had far reaching effects. For example, on outlying islands, there is a critical need for small power systems for communication (typhoon warnings) and refrigeration (medical supplies). However, these systems can completely change day-to-day living patterns and must be introduced with sensitivity toward long range cultural effects. In addition, the federal grant system has not always worked well in the western Pacific. A successful grant project implies using a management structure, written communication and instructions, and project time schedules. Many of these things are foreign to western Pacific cultures. An additional social problem affecting energy development is the very high unemployment rate (5,6).

The western Pacific presents a number of special engineering problems. One is typhoons which annually devastate many of the islands. Energy systems must be designed to withstand winds of greater than 150 mph, which present problems particularly for wind machines and solar collectors. Supplies are difficult to find locally, and if they are ordered from elsewhere, they seldom arrive according to schedule. Technical help and current information are hard to find. Local people should repair their systems with local materials so the systems must be designed accordingly. Wind machines have not had a good history in the western Pacific as parts are difficult to find, machinery corrodes, and repairs are complicated. Rapid corrosion in the tropical salt air is a problem, as is termite damage to wooden structures. Communication difficulties between remote islands hamper demonstrating projects and solving of common problems. There is no AET network of the type which has been so important in encouraging projects elsewhere, as in the Hawaiian Islands.

A final group of problems concerns the philosophy of energy production: decentralized

versus centralized systems, capital intensive versus labor intensive systems, and renewable versus nonrenewable supplies. For example, some of the poorest islands, with high unemployment, low energy demands, and no energy infrastructure, are interested in importing large complicated central systems.

2. SPECIFIC PROJECTS

Guam is primarily an urban island, and the U.S. influences are more noticeable here than on the other western Pacific islands. Projects and problems are more typical of Hawaii than of the Trust Territory Districts. DOE has given six AET grants in Guam: two for building active solar water heating systems; one for constructing a small typhoon-proof greenhouse for local farmers; one for building a biomass conversion facility for a large commercial farm; one for studying solar designs for a public market; and the last for constructing wind powered, electrically lit buoys for remote harbors.

For the first of the two solar hot water projects, DOE gave Dr. Frank Jacquette of the University of Guam \$12K for constructing simple solar hot water systems and demonstrating these systems through public workshops and with installations in public buildings (2). Dr. Jacquette has designed a series of simple on-site constructed, hot water systems, training volunteers to construct these systems during weekend workshops. The volunteers have installed these systems on three public buildings; a penitentiary, a firehouse, and a youth center. Construction techniques include a few innovations to make these collectors somewhat easier to build than usual. Techniques include using off-the-shelf materials such as tempered patio door glass for glazing and galvanized steel pipes for tubing. In addition, he has devised a special tool for attaching the galvanized pipes to the galvanized steel absorber plates. Collectors use both sinusoidal and parallel piping configurations, and water circulating systems are either thermosiphon or use circulating water pumps with storage tanks and heat exchangers.

For the first workshop 20 inmates of the Guam Penitentiary built a ten collector system with storage tank and heat exchanger for hot water for the penitentiary. Although the initial response from the inmates was encouraging, they did not have the incentive to keep the system working because ambient water temperature is 80°F. Now the system is not operating. At the second workshop Boy Scouts and other volunteers installed a system on a firehouse during a weekend fair. Local response and turnout was not too good because of inadequate publicity. At the third workshop, the most successful, a group of young people installed a thermosiphon system on the Guam Youth Affairs Center. The system is

operating well after a year.

The impact of this project has not been as great as it could have been for a number of reasons. First, some of these public buildings do not have a great need for water hotter than the ambient temperature of 80°F. Second, Guamanians are unfamiliar with alternative technologies, and successful workshops require extensive publicity. Third, people running the workshops should organize follow-up maintenance and demonstration programs. Fourth, the solar industry has had difficulty attracting interest on Guam as most alternative energy interest is in ocean thermal energy conversion.

For the second project, DOE gave Dr. Jacquette another grant for \$7.5K for developing a high temperature solar collector using discarded fluorescent light tubes. Dr. Jacquette is trying to design a simple solar system which will withstand typhoons, use noncorrosive and recycled materials, and heat water above 150°F for either absorption air conditioning or industrial applications. The collector uses copper tubes inside evacuated, fluorescent light tubes. One end of a four or eight foot section is removed, and the section is acid washed. A flat black copper tubing configuration is inserted; a new glass end is annealed to the tube; and air from the tube is evacuated.

Dr. Jacquette is still working on his project, but the good and bad features are already apparent. The construction work is beautiful - the work of an artist - and preliminary tests show that this collector will resist corrosion, heat water to above 150°F, and withstand winds up to 75 mph. Construction is difficult though, requiring special skills and equipment. Only a few people in the western Pacific, including Guam, have the talent to build such a system.

The next project involves an unusual greenhouse design for eliminating typhoon damage to crops. Crops are damaged both directly by the winds and indirectly by wind driven ocean salt spray. Protective systems are either nonexistent or do not work because of inadequate construction and materials, lack of greenhouse and greenhouse gardening knowledge, and improper design. DOE has given Mr. Eugene LeRoy \$3K for constructing a typhoon-proof greenhouse. Mr. LeRoy will erect, upon an existing sunken concrete foundation, 15' by 30', a heavy wooden framework for supporting roofing and bug-proof screening. During typhoons, standard plywood storm shutters will be attached to the frame with a thru-bolt mechanism. Other features include detachable rain gutters and raised modular planting beds for French intensive gardening. With greatly increased greenhouse vegetable production, one greenhouse will suffice on a subsistence basis for a number of families.

For the fourth project DOE is funding a \$7K biomass conversion project for a commercial farm. Pedro's farm is the largest vegetable farm on Guam; growing or raising on 500 acres a variety of vegetables, fruits, animals, and fish. The farm is in the interior of the southern mountains. Access is difficult, and the farm is four miles from the nearest power lines. Portable gasoline generating units power irrigation pumps and some farm equipment. These units use approximately 200 gallons of gasoline/month, which must be brought in from town. An additional expense is providing fertilizer for the acidic clay soil. Other farmers in the area have the same problems: no power and not enough organic matter in the soil. To address these problems, four years ago, workers on the farm constructed a combination pigsty/compost/methane digester. In spring, 1976, just when they were finishing the facility, Super typhoon Pamela badly damaged the farm and the digester. Pedro's farm is using the DOE grant to restore the digester.

Bad weather and impossible roads have made visits to the project difficult, and details are missing about number of pigs, washdown methods, generator output, gas quality, and composting material. The composting facility is a forced air-bin unit with a pump spraying the digester's nutrient rich sludge on the compost. The digester is an iron cover type. Now the methane gas is used for cooking the pig feed but eventually will be used for the generating units.

DOE awarded the New Guam Research Institute a \$5K grant for a passive solar study of the public market in Agana. Because of Guam's tropical temperatures and high humidity, air conditioning accounts for much of Guam's energy end use. Reliable end use data are not available. Traditional construction with passive features is rarely used because of new imported building materials and the U.S. influence on building design. An analysis of passive approaches for cooling the non-air conditioned and very uncomfortable public market makes sense, particularly when comparing this building to the nearby comfortable festival facility with traditional architecture including overhangs, plantings, and natural air circulation. The New Guam Research Institute may have been formed hastily for this grant and is no longer interested in the project. DOE will try to salvage something from the project, but the Institute will probably return the grant money.

For the final Guam project, DOE awarded \$3K to Mr. Charles Ludwig for building a prototype-electrically lit, wind powered buoy (3). He was to place additional buoys in certain remote harbors so that local fishermen could leave earlier in the morning and return later at night, thereby extending their fishing day. Unfortunately, an automobile accident

severely injured Mr. Ludwig, and he will not continue the project.

As a group, the Guam projects seem to be working fairly well. The projects are not startlingly innovative, but they seem to be encouraging small scale alternative energy development. Local interest varies, and some of these projects, particularly the greenhouse and the digester, will probably be duplicated elsewhere on the island. Replication elsewhere in the Pacific, stemming directly from these projects, is not likely.

2.2 Projects in the Commonwealth of the Northern Marianas Islands

The CMI differs considerably from Guam. The setting is remote, resembling an outlying Pacific island, but the economy is stronger than for the other Trust Territory islands. The Commonwealth affiliation signifies a strong economic tie with the U.S. DOE is funding three projects on Saipan, the political and economic headquarters for the CMI. The projects involve different groups of people under the direction of Mr. George Chan, administrator/engineer for the CMI Environmental Protection Agency.

For the first project DOE gave \$600 to the Department of Education for instructing high school students in building during their vocational courses two types of inexpensive solar collectors for domestic hot water heating. The first collector uses all salvaged materials including neon light tubes, discarded automobile windows, and waste polyurethane packing material. The cost of the collectors is negligible; construction is simple; and the collectors should be adequate for heating the water to 120°F. The second collector uses material available from the local hardware store, including galvanized iron framework and plating, copper tubing, and glass glazing. A simple monitoring program done by the students will measure the collectors' efficiency. The usual problem of acquiring materials according to schedule is delaying construction. No lumber is available and a shipment will not arrive until spring, 1980.

For the second CMI project DOE gave the Division of Agriculture \$1.5K for constructing and demonstrating a simple, but unusual, small farm methane digester. These digesters, which are operating successfully elsewhere in the Pacific and Asia, are constructed of reinforced concrete and use a water column to pressurize the gas from anaerobic digestion of pig wastes. Effluent from the digester helps grow algae in shallow basins. The algae are used either as livestock feed or as vegetable garden fertilizer. The Young Adult Conservation Corps is donating construction time; the Division of Agriculture is supervising and monitoring the work; and the Division of Environmental Quality will monitor and analyze

gas and algae production.

For the third project DOE gave the Community and Cultural Affairs Division \$1.2K for constructing and demonstrating a wind water pump and solar distilling unit. This project will demonstrate solutions to two local water supply problems. First, many of the local wells are contaminated, either from the limestone subsoil or from seawater intrusions. Second, many of the villages and farms do not have piped water supplies, and water is hand drawn from the wells. A combined wind pumping/solar still should demonstrate that an intermittent wind resource can pump water from a well into a storage tank, and a simple solar still can make the water potable.

The system is being built on a public toilet and shower block. A SPARCO residential wind-driven water pumping machine has been ordered. This machine will pump water from a well to a 1400 gallon storage tank on the roof of the restroom block. A simple shallow water solar still, also on the roof, will distill about 7 gallons/day. The roof will also have a storage tank for the distilled water, which will be used for drinking. The still will use concrete, wood, and a simple glass configuration. This system is an attempt to solve some local problems, but of course the solution depends on importing a relatively expensive (for them) wind machine. Glass also may be difficult to obtain. The two bladed wind machine will have to be disassembled for typhoons, and the solar still may also be susceptible to both typhoon damage and vandalism. Perhaps local farmers will be able to replicate this system with available materials and not have to import commercial machines. The people working on this project are resourceful, with plenty of expertise and experience with systems in developing countries. The CMI projects should be successful because of the people involved, the educational potential, the use of mostly local materials, and proven systems and ideas. DOE should receive a good return from the combined three project investment of \$3.3K.

3. CONCLUSIONS

In general, federal grants have encountered problems in the western Pacific, particularly in the Trust Territory islands, and yet renewable energy technologies, which seem to be quite important to these islands, need outside encouragement. Often success of a project varies inversely with the size of the grant, within limits, of course. The very small grants such as those in the CMI encourage volunteer participation. The people have a stake and an interest in the work. A small grant often means that local materials will be used; the project is a small one done within a comfortable time frame; and the project is labor rather than capital inten-

sive. Most important, if the project is successful, it can be easily replicated.

The following are a few general observations. Peace Corps help on the outlying islands of the Trust Territory is important. The Peace Corps has started an alternative energy educational program for their workers, and this program should help promote new small scale energy projects. Also, more projects will probably be done through cooperatives, a business structure more in the tradition with Micronesian culture. After DOE has given a grant, it is important that someone visit this project regularly. Too often the government has given grants with no follow-up, and if someone does follow up, it is never the same person twice. The group doing the work is as important as the project - good people do good work. DOE should encourage proven technologies here, not innovative ones. Nothing discourages replication more than energy devices that are not working. For economic and political reasons mentioned earlier, western Pacific leaders have an active interest in the success of these AET projects and are encouraging new projects. Finally, all energy devices have social consequences, and DOE should distribute their grants with a sensitivity to long term indirect effects.

4. ACKNOWLEDGMENT

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