& DEVELOPMENT OF ALTERNATIVE ENERGY SCIENCE AND ENGINEERING IN THE CARIBBEAN (NSF Grant No. INT-8302757) FINAL REPORT Submitted to NATIONAL SCIENCE FOUNDATION by Juan A. Bonnet, Jr, Principal Investigator and Chairman, UNICA Science and Technology Commission, December 22, 1983, CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

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DEVELOPMENT OF ALTERNATIVE ENERGY SCIENCE AND ENGINEERING IN THE CARIBBEAN (NSF GRANT NO. INT-8302757) FINAL REPORT TO NSF

EXECUTIVE SUMMARY

This was the third phase of a project whose primary objective is to develop the scientific and engineering capabilities of the universities and research institutes of the Caribbean and thereby to assist in the introduction of alternative energy solutions into the region. The project was conceived by the Science and Technology Commission of the Association of Caribbean Universities and Research Institutes (UNICA) and carried out under the leadership of the Center for Energy and Environment Research.

Research from the University of Puerto Rico. The financial support of the National Science Foundation greatly facilitated the accomplishment of the project's objective. This part of the project consisted of a four-day Solar Energy Utilization Workshop for the Caribbean Basin, held at the University of Florida in Gainesville. The workshop was carried out by personnel from the Solar Energy and Energy Conversion Laboratory, and the International Training Center for the Training in Alternative Energy Program. It included the basics of solar energy conversion and utilization with presentations on specific problems found in the Caribbean Basin. It also included site visits to review solar hardware development and demonstration projects in the Gainesville area. All the major lectures were videotaped. A discussion workshop was held on the last day to develop specific organizational and research plans that will allow UNICA to strengthen its institutional capabilities to facilitate the search for solutions to the pressing energy problems of the Caribbean Basin. Based on the cumulative experience of this workshop and the two previous ones on wind energy in Barbados, December 1981, and on biomass energy in Puerto Rico in April 1982, a detailed proposal to implement cooperative projects is being prepared to be submitted to international funding institutions. The overall plan proposes, among other things, the compilation of a directory of Caribbean human and institutional capabilities and the creation of a Caribbean research endowment fund. In the education and training areas, it provides for technical curriculum review, an energy auditors training program, a Caribbean universities information network and speakers bureau, and faculty enrichment through interchange programs. It also contemplates solar hardware information dissemination, technology transfer activities, improvement of solar systems maintenance, solar wind measuring equipment utilization, and video facilities. The prioritization of this

The agenda resulted from discussions and exchanges with the end users, the UNICA contact persons. This in itself is one of the major accomplishments of this project. The following report summarizes the project's main activities and accomplishments.

11, PROJECT REPORT

General: The universities and research institutes of the Caribbean region constitute an indispensable, underutilized source of knowledge, expertise, and institutional resources and facilities. This project is a major first step toward establishing a regional program of action to reinforce and expand these resources and apply them to the solution of the energy problems of the Caribbean Basin, which are draining many of the national economies. On the other hand, the large potential for solar energy available in the area is not being properly exploited. In this project, as far as we know, for the first time a representative group of the human resources in academic institutions of the Caribbean Basin, members of UNICA, has been brought together to analyze, discuss and develop joint planning for cooperative research projects in unconventional natural energy sources. This goal was successfully accomplished as shown in the workshop conclusions and recommendations.

As the third phase of the project, a solar energy utilization seminar/workshop for the Caribbean

Basin was carried out June 7-10, 1963 at the University of Florida in Gainesville. This report consists of two substantive parts and a set of complementary appendices. The conclusions and recommendations are extracted from the solar energy workshop but also include very important inputs from the previous two workshops, on wind and on biomass, which were funded under previous grants from NSF and the Exxon Educational Foundation.

2. Publications

One technical paper describing the procedures used to carry out this project was prepared. The paper entitled "Development of Alternative Energy Science and Engineering in the Caribbean" was prepared by J.R. Bonnet, Jr. and W. Koehler.

Presented at the II Interuniversity Symposium of Energy, held at the Universidad de Santiago de Chile, November 14-19, 1983. A copy of the paper is included as Appendix D. A second paper, "Status of Renewable Energy Programs in Caribbean Islands" by the same authors, is being prepared based on the conclusions of this project and other information gathered. This paper will be presented at ENERGEX '84 in Regina, Saskatchewan, Canada, May 14-19, 1984.

3. Workshop Site and Content

The Solar Energy Utilization Workshop was organized and carried out by the Solar Energy and Energy Conversion Laboratory (SEECL) of the University of Florida. The International Training Center for Training in Alternative Energy Technology (TAET) was utilized as the site. In addition, site visits were made to the Energy Research and Educational Park (EREP) and other solar utilization projects in the Gainesville area. Faculty and administrative personnel for the seminar were drawn from the TAET and SEECL programs.

The seminar stressed the fundamentals of solar energy utilization, emphasizing that the best available source should be used. Among the topics covered were characteristics of solar energy, measurement and modeling techniques for the Caribbean, heat transfer, preparation of materials, and standards and system optimization for tropical use. Applications for tropical elements were discussed and hardware prototypes were shown and visited, including solar devices for water heating, space cooling, refrigeration, cooking, conversion to mechanical energy or to electrical energy, fresh water production, and the use of solar energy in preserving crops by drying and refrigeration.

The papers "Solar Energy Conversion Research and Development at the University of Florida" and "The International Training Center in Alternative Energy Technology," both by Dr. Erich Farber, Co-principal Investigator of this project, describe the setting and many of the demonstration sites visited. A copy of the first of these two papers is...

The corrected text is:

Included as Appendix E, demonstration sites of actual solar installations in the city of Gainesville were toured. This visit included two solar-powered coin laundry facilities, apartment buildings, a hospital, and the Gainesville airport. The latter is the world's largest solar-powered building. The workshop schedule is included as Appendix A. A list of lectures is included as Appendix C and a list of the participants as Appendix B.

Summary of Recommendations:

The detailed conclusions and recommendations are included as Part II of this report. A summary of the main conclusions and recommendations follows:

1. Publication of a Caribbean directory of human and institutional resources in energy.
2. Establishment of a research endowment fund.
3. Establishment of a program of regional faculty interchange.
4. Development of curriculum on energy conversion and alternative courses.
5. Development of training programs in maintenance of energy hardware.
6. Establishment of UNICA speakers bureau.
7. Establishment of extramural science student programs.
8. Acquisition of video equipment.
9. Acquisition of solar insulation and wind measurement instrumentation.
10. Establishment of energy audit programs.
11. Establishment of a certification program for solar equipment.
12. Transferring solar equipment manufacturing technologies.
13. Energy system design, performance, and maintenance workshop.

Cooperate and participate in energy demonstration projects of the Caribbean Development Bank and the Organization of American States.

Evaluation:

A comparison with previous workshops is not possible since not all the UNICA contact persons attended all three; some attended only two of the workshops. The general feeling is that the project is moving towards establishing a unique base for a more solid program to enhance the capabilities of UNICA member institutions. On the last day of the seminar/workshop, an evaluation questionnaire was distributed to each participant to elicit his views and reactions toward the seminar/workshop.

Activity. The results of the evaluation indicate that 55% of the respondents gave an overall rating of "good" and 27% of “excellent.” The tabulation included here shows the percentage of the ratings given by the participants of the three UNICA alternative energy workshops. A general review indicates that the solar workshop (#3) was superior in organization and logistics to the previous two. From the standpoint of speakers, workshop discussion and overall, the wind workshop (#1) was rated better than the others, but there is not a significant overall difference. In all cases, more than 75% of the participants agree that the workshops were successful to a greater or lesser degree in meeting UNICA goals. It is important to remark here that non-UNICA contact persons who attended the seminars were also given the opportunity to answer the questionnaire. As one of the respondents wrote: “Keep up the good work, your life (in the Caribbean) depends on it.”

EVALUATION OF UNICA WORKSHOPS
J. WIND / 1981
II. BIOMASS / 1982
III. SOLAR / 1983

(25 respondents)
(13 respondents)
(11 respondents)

Stating
Excellent, 27.1%
Good 56.6%
Fair 13.8%
Poor 0%

2. Speakers
Excellent 13.8%
Good 72.8%
Fair 13%
Poor 0%

3. Workshop Discussion
Excellent 55.2%
Good 44.8%
Fair 0%
Poor 0%

4. Overall
Excellent, 22.8%
Good 68%
Fair 8%
Poor 0%

5. UNICA Goals
Very successful 27%
Successful 46%
Somewhat successful 46%
Not successful 0%
Unaware 23%

SHOP CONCLUSIONS AND RECOMMENDATIONS

The participants in the Solar Energy Utilization Workshop met on June 10 to discuss the completion of specific UNICA organizational and research plans and the planning of cooperative projects in order to develop and extend the scientific and engineering capability of Caribbean universities and research institutes so that they may be able to contribute effectively to the wider use of alternative sources of energy in the region. In the

In the previous two alternative energy workshops, which focused on wind and biomass, participants were divided into three discussion groups: education and training needs, research and development needs, and demonstration needs. However, in this workshop, it was decided to work as one group to discuss these same three topics. The group began by reviewing the recommendations made in the previous workshops and decided to pursue these recommendations in a practical and reliable way, taking into consideration the work being done at the Caribbean Development Bank, CARICOM, and the Caribbean Meteorological Institute, among others. The following is a review of the major conclusions and recommendations:

2. Education and Training

An immediate assessment of human and institutional resources regarding Caribbean technological and scientific capabilities is needed. In many cases, foreign expertise and/or organizations are utilized due to a lack of knowledge about the capabilities available within the Caribbean region. This situation hinders further development of available Caribbean resources and often results in inappropriate or irrelevant recommendations by foreign consultants, which can generate resentment. Of course, when expertise is not available locally, new knowledge, if properly channeled through technology transfer, is generally well received.

The publication of a directory of Caribbean resources could partially solve this problem. The first issue of the human and institutional Caribbean Basin directory should be prepared, and a method should be devised to update it at least annually. This directory should also include a list of energy courses offered in the region and should be widely distributed.

UNICEF institutions believe that the greatest contribution in solar technology could come from preparing and reviewing technical curricula to teach energy-saving techniques and renewable energy alternatives. This is especially true in the case of welders, electricians, plumbers, electronic technicians, and others. Special emphasis was given.

The enhancement of techniques to maintain and conserve energy-producing equipment, such as diesel generators and gas turbines, is crucial. Many failures and poor performance of this equipment are usual occurrences in the area. UNICA should also support and work closely with CARICOM in their seminars and training courses.

The establishment of energy auditors training, certification procedures, and the development of standards, including certification for solar alternative hardware, was given high priority by the group. Energy audit technicians are almost non-existent, and UNICA institutions should establish curricula and courses to train energy auditors and assist the government in establishing an energy management certification program.

The establishment of extramural science student programs for high school students was also considered. In addition, the establishment of a UNICA speakers bureau to address professional and social groups on energy matters was recommended. The UNICA contact persons in this project could form the nucleus of such a regional energy speakers bureau. In this way, the university could also participate as a catalyst of social change in the Caribbean society.

The need for funds for regional interchange of professors was also recommended. This is especially necessary among different linguistic groups since, because of their language, culture, and political ties, technical information transfer between them is in many cases non-existent. This project has greatly helped in establishing the first link for a commonality of scientific interest, and some interchange on a direct basis has already occurred. A more formal and extensive program was recommended.

UNICA member institutions are aware of the proliferation of courses and educational materials, including the latest technical conferences, that are available on videotape. However, many of them do not have the videotape and television monitor to benefit from renting or buying this material. The group understands that the acquisition of such resources is vital.

The following equipment will be of great help in their academic and faculty continuing education.

3. Research and Development

After reviewing some of the research and development efforts ongoing at specific institutions and taking into consideration the regional role of UNICA, it was decided that the major role that could be played in the Caribbean Basin is to help enlarge and improve the solar data base available. Almost none of the UNICA institutions have a single solar insulation or wind measurement instrumentation. On the other hand, the Caribbean Meteorological Institute has ongoing programs to measure solar and wind potentials in the Eastern Caribbean, the Dominican Republic, and Puerto Rico. A program to regionalize, standardize, and provide additional adequate measuring instrumentation at UNICA institutions is regarded as the first R&D priority. Proper mechanisms to collect, analyze, collate, and distribute the information are needed.

The other area of commonality of interest was energy system design and maintenance. The interaction between components fails in many cases. More importantly, the group feels that matching to end-users and the cultural impacts of new technology to their countries is a highly sensitive area that needs further research. The new technology must closely meet the social and cultural needs. The evaluation of projects existing or under construction could be an important "grass roots" contribution of UNICA to the region.

From the standpoint of technology transfer, the group recommended that UNICA assume an advisory role in transferring knowledge about manufacturing technologies processes. The solar water heater is a good example where already local manufacturers of flat plate collectors have established themselves in Barbados, Trinidad, Puerto Rico, the Dominican Republic, and other countries. The certification process of such products to meet local needs could also be catalyzed by UNICA. Solar cookers, solar stills, solar distillation units, solar steam, solar air

Conditioners, wind turbine generators, etc., are examples of technologies that, with proper training, can be manufactured locally in many cases. Manuals and training through UNICA member institutions to private concerns could help such possibilities. It was recommended that UNICA establish a research endowment fund to be distributed on the basis of strict competition of scientific proposals and peer review. The established foundation for higher education operating in Colombia could be used as a model. The UNICA newsletter should be expanded to include information related to RED projects and courses at member institutions. UNICA contact persons could become a scientific correspondence bureau for the newsletter.

Section 4 - Demonstration

After a long discussion, it was decided by the UNICA contact persons that it was not realistic to recommend specific energy demonstration projects. This decision was based mainly on the fact that there seems to be an adequate number of energy demonstration projects in the Caribbean sponsored by the UN, the World Bank, IADB, OAS, USAID, CIDA, CARICOM, etc., and even if they are of interest to the universities of the region, they currently have a lower priority when compared with other more urgent needs. UNICA's intention is to cooperate as much as possible with established programs of CARICOM, CDB, and OAS.

Section 5 - Conclusion
It was concluded that UNICA should undertake the preparation of a proposal to implement the recommendations referred to above. The program delineated in this report is realistic and has been developed by the users after more than two years of discussion and three workshop meetings. It is anticipated that it could be carried out in about three years with a budget of about $300,000. The proposal should include three annual review meetings involving the UNICA contact persons. Besides carrying out the review, it is recommended that three specific topics be used for presentations/discussions at the meetings. The three recommended topics, in order, are:

The following text is corrected:

The areas of preference are: (1) technology transfers, (2) energy systems designs, performance, and maintenance, (3) science and technology.

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Bonnet, Juan A., Jr. and Koehler, W., 1983. "Development of Alternative Energy Science and Engineering in the Caribbean," presented at the 11th Interuniversity Symposium of Energy, University of Santiago, Chile, November 18 to 19, 1983.

Farber, Erich &., 1974. “Solar Energy Conversion R&D at the University of Florida,” Buildings Systems Design, February/March.

Figure 7/83
June 8/83
June 9/83,
June 10/83

Appendix A: 'Solar Energy Utilization Workshop

June 7-10, 1983 Schedule

Lecturers: Farber, Pagano, Soderstrom, Bush, Bonnet

Topics: Welcome and Introduction, Solar Energy: An Overview, Characteristics of Solar Radiation, Solar Measurements and Modeling for the Caribbean, Heat Transfer Properties of Materials, Collectors, Standard and Systems Optimization for Tropical Use, Applications of Solar Energy, Applications in Tropical Climates, Agricultural Applications, Photovoltaics, End Use Matching Workshop (Group Discussion), Closing Luncheon

TAET = Training Alternative Energy Technology Center
EREP = Energy Research and Education Park

Solar Energy Utilization Workshop
June 7-10, 1983
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APPENDIX C

SEMINAR LECTURERS RESUMES

ERICH A. FARBER

Dr. Farber holds the rank of distinguished service professor at the University of Florida. He is an internationally recognized pioneer in the field of solar energy and has dedicated more than a quarter of a century to the SEECL at the University of Florida. This is one of the largest solar energy laboratories with national and international recognition. Under his leadership, the TAET program was initiated at the University of Florida. He has traveled worldwide as an invited consultant to many countries. In addition, he served as a consultant to USAID and VITA. The idea for the TAET for the third world participants, in fact, came from the idea of efficiency in disseminating information by bringing the participants to the University of Florida.

QUAN A. BONNET, JR.

Dr. Bonnet is Director of the Center for Energy and Environment Research of the University of Puerto Rico. Previously, he was Assistant Executive Director for Planning and Engineering of the Puerto Rico Electric Power Authority. Dr. Bonnet received his B.S. in Chemical Engineering from the University of Michigan in 1960 and his Ph.D in Nuclear Engineering in 1971 from the same university. He is a registered Professional Engineer, Certified Energy Auditor, and Chemist. He is currently the President of the Board of Examiners of Engineers, Architects, and Surveyors of Puerto Rico. He is Associate Professor at the Gayanin Technological University College and a member of the System-wide University Board. He was Technical Director of the XVII Convention of the Pan American Union of Engineering Associations (UPADI-82) held in San Juan in August 1982. He is the Chairman of the Science and Technology Commission of the Caribbean Association of Universities and Research Institutes (UNICA). He is also a member of several energy and environmental advisories.

A member of the Puerto Rican Academy of Arts and Sciences and the New York Academy of Science, he was honored with the 1981 Mobil Award for outstanding scientific accomplishments in Puerto Rico. He served on advisory committees in Puerto Rico and the U.S. He has published numerous articles in scientific journals, and many of his technical papers have been included in conference proceedings or abstracts.

KENNETH G. SODERSTROM

Dr. Soderstrom has been a faculty member of the Mechanical Engineering Department of the University of Puerto Rico (UPR) for over 20 years. Most recently, he was the Associate Director of the Center for Energy and Environment Research (CEER) of UPR. As Associate Director of CEER, he was responsible for the Mayaguez laboratory operations, which included three of the five scientific divisions of the Center, namely, Solar, OTEC, and Marine Ecology. For over a decade, Dr. Soderstrom has been dedicating his research efforts to developing technology transfer in alternative energy through programs of CEER. He has traveled extensively throughout the Caribbean area in relation to international programs of CEER. His most recent research and publications have concentrated on the application of solar energy to tropical environments. He is presently on sabbatical leave from UPR and is a Visiting Professor in the Mechanical Engineering Department of the University of Florida, and participates actively in both TACT and SEECL programs.

ROBERTO PAGANO

Dr. Pagano is the Technical Director of the TAET Program, a position he has held for the last four years. He has traveled extensively throughout Africa and Europe and is multilingual in English, Italian, and French. In addition to his involvement with teaching and technical direction of the TAET program, between sessions he makes follow-up visits as a consultant to countries of the participants' origin for additional training and advice in the adaptation of appropriate energy technology. Dr. Pagano also brings to this program his experience in energy.

"Resources and environmental system analysis in which he was involved at MITRE Corporation, prior to his appointment as Technical Director of the TAET Program. MARTINO. BUSH Dr. Bush is one of the regular faculty members of the TAET program. He has been with the program for over two years and teaches in many areas of alternative technologies, such as energy needs and uses, including the use of different fuels, decision analysis, solar energy collection, and storage. His basic background is in fuel technology and chemical engineering. He has lived in the U.K., Canada, and for three years in Trinidad as a lecturer at the University of the West Indies. KHE VAN CHAU Dr. Chau is an Assistant Professor in Agricultural Engineering, University of Florida, specializing in grain drying and storage, and solar energy. His Ph.D. dissertation (from the University of California) was on solar collectors. Dr. Chau is a native of Viet Nam and worked in that country for several years in agricultural engineering and became the Director-General for Planning and Technical Affairs, Ministry of Agriculture before returning to the U.S. in 1975. He has extensive experience in tropical, developing countries. He is familiar with, and has visited the Philippines, Thailand, Taiwan, and India. Dr. Chau has been the lecturer in charge of solar crop drying for the "Training on Alternative Energy Technologies" during the past 2 years. He has also served as an instructor in many short courses and workshops on solar crop drying for Florida county agents. He is the author or co-author of numerous technical papers on solar collector design and analysis, and solar drying under hot and humid conditions.

SIMPOSIO INTERUNIVERSITARIO DE ENERGIA Santiago de Chile, November 1983

DEVELOPMENT OF ALTERNATIVE ENERGY SCIENCE AND ENGINEERING IN THE CARIBBEAN

Juan A. Bonnet, Jr.* Center for Energy and Environment Research University of Puerto Rico

Wallace C. Koehler, Dr. Center for Energy and Environment Research University"

Abstract of Puerto Rico. This paper describes two pilot projects designed to improve the capabilities of Caribbean universities and research institutes in helping solve the energy problems of the region. Most of the region is almost completely dependent on imported petroleum to satisfy its energy needs. This dependency has exacerbated economic problems, with the escalation of petroleum prices in the past ten years. A potential solution to reduce both the high degree of dependence and economic costs is to develop other energy systems. The region is blessed with solar, wind, ocean, biomass, and geothermal resources that could be exploited to reduce and displace oil consumption. One approach is to develop the scientific and engineering capabilities of regional universities. Under the auspices of the Association of Caribbean Universities and Research Institutions (UNICA), with U.S. National Science Foundation support, a project to foster cooperative research efforts to assist in the introduction of alternative energy solutions has been developed. The UNICA project utilized the research workshop format. A network of scientists and engineers working in energy was established to promote cooperation, interchange of technical information and development of joint projects. Three workshops were convened on the most promising energy alternatives: wind energy in Barbados in December 1981; tropical biomass in Puerto Rico in April 1982; and solar energy utilization in Florida in June 1983. In each of the workshops, a list of needs and priorities in education and training, research and development, and demonstration projects was worked out and are discussed in this paper. Basic energy data on Caribbean Basin countries was collected in order to perform system analysis of energy alternatives. The project has already

stimulated technological interchanges in the region. The project is chaired by the Science and Technology Commission of the Association of Caribbean Universities and Research Institutes (UNICA). The project described in this paper is...

This paper was carried out with support from the U.S. National Science Foundation under Grant No. INT-6300757 and previous NSF grants. The authors acknowledge this support with deep appreciation.

A. Introduction

The 51 inhabited islands of the Caribbean archipelago have a total area of about 230,300 square kilometers and a population of approximately 20 million. It is a complex region, strategically located, with a diverse ethnic, cultural, and political base. The Caribbean is a mosaic of not only independent states but also entities having varying relationships with the United States and European powers.

The Caribbean community has a rich potential in inexhaustible alternative energy sources. In addition to geothermal energy, which is abundant in locations such as St. Lucia, many feasible inexhaustible solar-related alternative energy sources exist. This is largely due to the fact that the Caribbean, lying between latitude 10°N and 25°N, has a resulting year-round solar insolation of approximately 2000 BTU per square foot per day. A few of the more common solar-related resources are trade winds, ocean waves, moderate ocean currents, extensive ocean thermal masses, year-round biomass production, agriculture, and mariculture. Table 1 summarizes geographic, demographic, and other data for the Caribbean region.

Only one of these island-states, Trinidad, produces fossil fuels. Trinidad has 1/45th of the land area and 1/20th of the population. The size of its foreign exchange reserves places it among the first six of all the nations in the British Commonwealth. The other 50 island communities depend on imported fossil fuels for 99% of their energy requirements. It is estimated that 37,950,000 barrels of oil per year are imported by these communities.

Since the 1950s, the Caribbean has made strenuous efforts to diversify its economy by providing more jobs through industrialization and by expanding tourism. Like many developing countries throughout the world, these early efforts were almost totally reliant on fossil fuels.

Based on the use of imported fossil fuels, by the end of the 1980s, most of the archipelago could potentially become a disaster area unless the dependence on these fuels is reduced and the use of alternative energy sources is greatly increased. There are four major obstacles to progress:

(a) Lack of manpower
(b) Inadequate research in the use of existing technologies and the adaptation or modification of various technologies to fit the social and physical environment
(c) Lack of a grassroots cooperative energy program involving the universities and research institutes of the regions
(d) Lack of investment capital

A system of cooperation is of great importance in a region whose history has been one of fragmentation and dependence on external markets and authority. The long history of dependence on external rulers has left many of the Caribbean peoples with a bitter legacy of resentment, even hatred. The ideological conflicts that characterize the contemporary Caribbean are evidence of this, just as the boat people from Cuba and Haiti and the illegal immigration into Puerto Rico from the Dominican Republic are indicators of growing poverty and discontent.

Aid from industrialized countries is important, but it cannot alone provide a solution. Caribbean development, in the end, depends on the capability of the Caribbean people to analyze their problems and, with assistance from others, find solutions for them.

Cooperative relationships between individual United States and Caribbean universities, though valuable in themselves, do not fully meet the need for transforming donor-recipient relationships into a larger partnership of scholars and scientists.

Because of the urgency of the energy situation in the Caribbean, it is crucial to the orderly economic and cultural development of the region that a degree of energy self-sufficiency be developed at an early date. If this does not occur, disastrous consequences will result as the price of imported fuel rises.

The cost escalates beyond the reach of all but the most well-endowed (or most heavily subsidized) communities, thus forcing them into either a position of complete dependence on those who have more, or into a position of extreme poverty, beyond which economic and political survival may become impossible. The universities and research institutes of the Caribbean region constitute an important under-utilized resource of knowledge, expertise, and institutional facilities.

This resource is under-utilized largely because (a) the region is not looked upon as a whole; (b) there is little communication among the scientists of the region; and (c) because the Caribbean community does not perceive its universities as being intimately involved in the development process. Yet, a great deal of valuable work is being done in its universities and research institutes.

Consequently, it is essential that Caribbean universities and research institutes should be utilized to their fullest to achieve greater self-sufficiency in basic necessities such as energy and food. The Association of Caribbean Universities and Research Institutions (UNICA) has sought to provide a forum of cooperation necessary to develop solutions to the problems of energy in the Caribbean.

To do so, UNICA has launched a program to foster cooperative research effort aimed at assisting in the introduction of alternative energy solutions. This project provided for and depended upon the active cooperation of universities and research institutes from the Spanish, English, French, and Dutch speaking Caribbean. The levels of research work varied, and required the more advanced centers to provide technical assistance to those which are less advanced.

In this way, the effort to find viable programs for the use of alternative sources of energy was shared by all the institutions involved. The project attempts to make full use of a network of Caribbean institutions, providing a mechanism for training at appropriate centers within the region, and involving

Many participants are involved in research programs and in the preparation of a comprehensive regional program for using alternative sources of energy. Through this method, the quality of science and engineering research was improved, and the potential for stimulation for technology transfer and for further cooperative efforts were realized. The project focused on the need for the countries of the Caribbean archipelago to achieve greater self-sufficiency in energy; on the role that Caribbean universities and research institutes can play in meeting this need; and on the fact that the region has a rich potential in inexhaustible alternative sources. It represents the first indispensable step in using the existing network of research centers, schools of natural sciences and engineering, and other related university departments in a coordinated program to help meet the region's energy needs. Furthermore, it points the way to an exciting concept of the region as a laboratory for the development of alternative sources of energy, in which lessons can be learned and demonstrations carried out that will be of benefit to other countries that have similar needs.

The objective of the project was to develop and extend the scientific and engineering capability of Caribbean universities and research institutes so that they will be able to contribute effectively to the wider use of alternative sources of energy in the region.

Mechanism for Achievement:
a. The Association of Caribbean Universities and Research Institutes (UNICA)

In the late 1960s, perceptive Caribbean educators saw the future development of the Caribbean community as a matter of regional concern. To meet their common needs they created UNICA, a voluntary association of Caribbean universities and research institutes dedicated to positive, carefully directed efforts for Caribbean development. Founded in 1968 by 16 universities located in ten Caribbean countries, the organization now has 45 member institutions representing a constitution.

The text has a constituency of more than 300,000 students and 30,000 faculty. Expected Significance: The success of the project has had a profound effect on the creation of a program to develop economic independence and energy self-sufficiency within the Caribbean. This should lead to greater social and economic progress. The Caribbean may thus serve as a model of the benefits which can accrue through the development of the local scientific and engineering capabilities of regional universities as they work together to solve problems of immediate national and regional significance.

3. Project Description
a. Overview: The project, limited in time and specificity of its purposes, represents the first important step toward a major coordinated program of research and technology adaptation to be undertaken by the universities and research institutes of the region.

The work was carried out in three phases. The first phase involved planning activities, identification of UNICA institution contact persons, and background literature searches. The second phase involved holding three workshops dealing with various aspects of the alternative energy problem: on wind, biomass, and solar utilization. The third phase involves the completion of research plans and proposals resulting from the workshops, the preparation of education and manpower training plans, and the compilation of reports on the alternative energy database and organization which has been generated. Funding for this project came from grants from the U.S. National Science Foundation and the Exxon Education Foundation.

b. Procedure

1. Phase One: Phase One of the project consisted of all planning activities. The steps completed in Phase One included:

(2) Appoint members of the UNICA Commission on Science and Technology and receive their agreements to serve. This was completed before June 1980 and the following persons agreed to serve:

* Dr. Erich Farber, Director of the Solar Energy Institute, University of Florida, Gainesville.
* Professor Gerald

Lalor, Pro-Vice-Chancellor of the University of the West Indies, Kingston, Jamaica, and Head of the Department of Chemistry. * Dr. Juan A. Bonnet, Jr., Director of the Center for Energy and Environment Research at the University of Puerto Rico. * Eng. Francisco Gutiérrez, Director of the Institute of Petroleum, Central University of Venezuela. * Dr. Howard P. Harrenstien, Civil Engineering Department, University of Miami.

(2) Convene a meeting of the UNICA Commission on Science and Technology and discuss the need for a cooperative program of alternative energy science and engineering research and education for the Caribbean. Prepare an outline draft of a plausible workshop plan.

(3) Contact all UNICA member universities and ask their chancellors or presidents to appoint university faculty liaison representatives to work on the alternative energy program. In order to implement the project, this Commission requested from the universities and research institutes which are members of UNICA to appoint official contact persons knowledgeable in energy matters. They could provide information on the energy state of affairs of their respective islands, participate in workshops, and serve as a focus to initiate educational and research activities in their institutions. A questionnaire was circulated to all UNICA contact persons and two follow-up notices were sent to assure maximum response. This experience reflected the reality of lack of information about energy and renewable energy matters in the Caribbean. After a search in general and specialized libraries and other information centers in the Caribbean, it was found that the best data were available at the Caribbean Development Bank in Barbados, the Island Resources Foundation in the Virgin Islands, and the Center for Energy and Environment Research in Puerto Rico.

(4) Convene various meetings of the UNICA Commission on Science and Technology in conjunction with the November 24-25, 1980, Center for Energy and Environment Research - organized.

"Symposium on Alternative Domestic Energy Systems for Puerto Rico, and the December 15-17, 1980 Clean Energy Research Institute-organized Third Miami Conference on Alternative Energy. At these meetings, prepare a questionnaire on alternative energy to be completed by the UNICA faculty representatives. (5) Receive and compile the results of the questionnaires at CER. This activity was completed and resulted in the paper “Energy Alternatives for the Caribbean". The paper represents the most up-to-date general description of renewable alternative energy projects and potential in the Caribbean and constitutes a major contribution of this project. Phase One activities were conducted primarily in San Juan, Puerto Rico and Miami, Florida, using the facilities of CER and the Clean Energy Research Institute (CERI) respectively.

2. Phase Two

Phase Two consisted of the organization and conduct of three alternative energy workshops. Attendance at all workshops was by invitation only, and consisted of the UNICA contact persons, the UNICA Science and Technology Commission members, and invited industrial and investment representatives, key liaison faculty from supporting universities, involved faculty from the region who are known to be active in alternative energy research, and selected governmental personnel. Assignments were issued in advance, and the workshops were held in the vicinity of the most suitable places for demonstrations of viability and feasibility of the concept. The three workshops were concerned with:

(1) Wind as an Energy Alternative for the Caribbean
(2) Biomass as an Energy Alternative for the Caribbean
(3) Solar utilization.

The subjects were carefully chosen to emphasize those technologies which show the most promise of being cost-effective in the short term. The choice also drew on the Puerto Rico experience in developing an understanding of the most viable energy alternatives. A paper was prepared titled “Alternative Energy in the Caribbean." Each workshop was

The project plan was tailored according to the project needs and the capabilities of the host institution, but it included certain essential aspects or areas of emphasis. In general, these areas were:

(1) The state of the art in the particular technology,
(2) Estimates of the magnitude of achievable resources,
(3) Identification of barriers to commercialization,
(4) Socioeconomic considerations,
(5) Plan for meeting science and engineering education requirements,
(6) Identification of needs in basic research,
(7) Time-frame for meaningful demonstrations,
(8) Time-frame for maximum contribution to energy self-sufficiency,
(9) Identification of sources of investment capital.

Wind energy was given first priority, as it is generally considered to be the most likely candidate as a short-term cost-effective alternative energy source. Wind energy can be converted directly to mechanical energy and then to electricity without involving the Carnot cycle and the unavoidable thermodynamic losses associated with such energy conversion.

Moreover, the Caribbean is an area where the trade winds are predictable and of sufficient power level. It is logical to concentrate on this source as one which could provide an early payoff. The chances of early success should motivate and stimulate the growth of science and engineering capabilities in local universities, as the needs for manpower training and local engineering capability should be quickly realized.

Due to existing expertise and the presence of the Caribbean Meteorological Institute and the

Caribbean Development Bank, the wind workshop was held in Bridgetown, Barbados in December 1981.

Biomass was the second form of alternative energy considered since agriculture has traditionally been the principal source of income in the Caribbean. The year-round solar insulation, coupled with frequent rains on windward shores, provides one of the finest environments on earth for prolific biomass production. As imported fossil fuel prices rise, it is

It's critical that this biomass potential be converted to clean-burning substitute fuels, such as methanol and ethanol. There is reason to believe that ethanol production from sugar cane is already cost-effective, particularly if attention is given to the productive use of wastes which are generated by the process. The second workshop was held in San Juan, Puerto Rico at CER in April 1982. The third and final workshop, focusing on solar energy utilization, was held at the University of Florida, in Gainesville, in June 1983. This workshop's orientation was toward the completion of specific organizational and research plans, and the planning of cooperative projects. Gainesville is considered the Solar Capital of the World.

Phase three constitutes the reporting and implementation phase. The plan is to compile a narrative of the accomplishments of the project, and to report on the plans that individual institutions have made to enhance their science and engineering capabilities in support of alternative energy commercialization in their regions. This is underway at present. It is anticipated that these plans will include mechanisms for demonstration and for training and education of the local manpower, involving university faculty and students as resource personnel.

It is also anticipated that this phase will solidify the interactive and cooperative nature of UNICK, with the result that growing trust and scientific and technological interchange among sister institutions will emerge. This phase will also be used to finalize plans for continuance of similar types of activities into the future, being careful to build upon the experiences of the past and upon the capabilities which were acquired in the conduct of the initial project. Goals in basic research are to be identified, and recommendations made to granting agencies, industry, and financial institutions for the timely support of this research are to be identified, and recommendations made to granting agencies, industry, and financial institutions.

Financial institutions have timely supported this research.

1. Project Application Potential

A list of renewable energy technologies deemed technologically suitable for the Caribbean, in rank order of estimated commercial readiness, is as follows:

1. Solar hot water
2. Cogeneration
3. Hydroelectric
4. Electricity from solid waste
5. Small wind machines
6. Large wind machines
7. Electricity from bagasse
8. Solar ponds

9. Photovoltaics
10. Ocean thermal energy conversion
11. Geothermal energy conversion
12. Others

The value of contribution in barrels of oil saved per year for each alternative energy technology at the end of full commercialization by the year 2000 has been calculated. This is presented in Table 2, where it can be observed that the combined contribution from the sources listed totals 154,230,000 barrels of oil saved per year. Consequently, the region could theoretically provide all necessary primary fuels for its electrical generation needs.

As shown in Table 3, many technologies are undergoing research, development, and/or demonstration in the Caribbean region. They range from offshore oil exploration to geothermal to biomass. The table also demonstrates the wide range of donors or executing agencies, which include international and regional organizations, foundations, and countries. The table also substantiates our conclusion that wind, biomass, and solar are appropriate alternative energy sources for the Caribbean.

Workshop Summary

1. Wind as an Energy Alternative for the Caribbean Workshop

The first UNICA workshop was carried out in Bridgetown, Barbados on December 6-9, 1981. Some 50 persons participated. The first part of the workshop consisted of background papers on wind energy. Especially significant was the participation of Dr. T.S. Anderson, President of the USA Wind Energy Association, an organization which has a keen interest in the Caribbean. Following the general presentations, the participants were divided into three workshop groups addressing the following subjects:

(1) Education and Training Needs (2) Research and Development Needs (3) Demonstration Needs. Each of the workshop session groups produced a report. It is interesting to note that the recommendations are similar and that they focus on information needs and the lack of human resources. A generalization and prioritization follows: (1) A resource assessment of human and institutional capabilities, wind resources, and demonstration projects in the region is needed. (2) After the first recommendation is implemented, detailed action plans and proposals to implement the other workshop recommendations are needed. (3) Sources of funding to continue this project and to implement the most important recommendations should be sought.

The group believes that if the above recommendations are implemented, the scientific and engineering capabilities of the universities and research institutes in the region will be greatly enhanced and strengthened in wind as an appropriate energy source for the Caribbean region.

2. Biomass as an Energy Alternative for the Caribbean

The second workshop for UNICA contact persons was held in San Juan, Puerto Rico on April 28-29, 1982. It is significant that the same UNICA contact persons who attended the wind workshop were also able to attend this workshop. The liaison initiated among UNICA contact persons facilitated the establishment of direct contact between some of the UNICA member institutions. This workshop was carried out immediately following the Seminar on Fuels and Feedstocks for Tropical Biomass II held in San Juan, Puerto Rico on April 26-27, 1982. Many of the UNICA contact persons were also able to attend this seminar, which provided them with more thorough knowledge of biomass as an energy resource. The biomass workshops indicated that the group feels that: (1) Research, development and demonstration projects in biomass as an energy source must be established in the Caribbean region. Funding to carry out such projects is critically needed. (2) Provision of training.

The following text requires education on Caribbean tropical biomass. UNICA should increase its dissemination of information and technology transfer activities in the region. The role of the UNICA Foundation in securing funds to implement the recommendations of workshops is very important. The Caribbean agricultural programs, especially in sugar cane and other food crops, are undergoing significant economic stress. The possibility of a reorientation towards biomass for energy and food combined is an alternative that must be pursued immediately. This is the main reason for recommendation number one. The group feels the only reason this energy alternative is not being developed faster is due to lack of funding.

The third workshop was held June 6-10, 1963 in Gainesville, Florida. During this workshop, the basics of solar energy conversion and utilization were covered and expanded to specific problems found in the Caribbean Basin. Presentations on solar radiation measurements and modeling in the Caribbean, heat transfer, materials, collectors, applications of solar thermal, dryers, distillation, photovoltaics, and system analyses were delivered. All presentations were videotaped and visits to field installations were carried out.

The solar workshop carefully reviewed the recommendations made during the previous workshops. The group recommended that priority be given to research, development, and demonstration projects in solar, biomass, wind, and other appropriate energy systems. There should be an expansion in education and training in appropriate energy technology and uses through the UNICA network. There is a need to increase university and research institute interest. Data are often insufficient in the Caribbean to permit the desired level of planning. The development of a data collection and analysis capability drawing on existing regional expertise is required. There should be an expansion in internal UNICA communications through newsletters, workshops, etc. Analyze experience and develop an expanded appropriate energy network. Finally, there should be development and maintenance of the practice of utilizing renewable energy sources.

Collaboration research and exchange of data among UNICA members. 7. Seek external funding to finance increased energy technology development and transfer in the region. D. Conclusion The Caribbean region is richly endowed with renewable alternative energy sources which could, in time, provide energy self-sufficiency to the region. Three of the main sources--wind, biomass and solar --have been studied and analyzed. It is shown that these three provide the most promising beginning to resource utilization and petroleum substitution. Caribbean universities and research institutes could and should help in the development and utilization of these energy sources. The three UNICA sponsored workshops provide a mechanism to transfer technological and scientific knowledge within the Caribbean, one which will develop indigenous capabilities. Clearly, these efforts must be expanded and institutionalized to further alternative energy development in the region. This paper points out some of the impediments to cooperation as well as delineating a system of cooperation. One is insufficient data. Another is the inchoate network among universities and research institutes in the Caribbean. This paper describes an effort for a more realistic plan for education, training, research and development and for deeper data collection and evaluation. This is a pioneering effort occurring at a historical moment when there is a renewed interest in the "rediscovery" of the Caribbean region. This paper should be useful to all funding and development agencies which are becoming aware of the region and willing to do something helpful based on solid ground. This effort is a very healthy seed. Let us hope that somebody will water and nurture it for the benefit of the Caribbean community path.

ARRAY OF RESEARCH & DEVELOPMENT OF FLORIDA SOLAR ENERGY CONVERSION AT THE UNIVERSITY DR. ERICH A. FARBER, Professor & Sciences Director, Solar Energy & Energy Conversion expresses concern that meeting...

"Eve's German is there and has been using it at several and best cites the time needed and so on to oval well. It is distributed and exhibited for racial purposes and the no balloon effects upon it are evident when converts are needed. Our present usage of energy can be compared to our eons. It went off and operates on genuine some income of getting resources in the field of energy. The most abundant income is with ray. This incoming energy was lost in very intricate processes over millions of years converted to other forms of energy needed. This conversion from one scenario to the other forms should be done in a few cases along the most vital route. This procedure will ensure the less waste yet efficient way of doing things in life and take it all at once. One of the kinds will equip the equipment once earned into a necessarily made invention. The simplest filters use a span of materials: rock, ice, sand, etc. These can be made to follow as an art.

A sun under identical conditions can be used to create heat. This heat is then transferred from the solution through the wall of the water tank to the water to be used. Slowly in the system, the primary circuit operates at atmospheric conditions and the water tank needs only to be collected. It can be constructed simply, it may be patterned after the most efficient design, like a conventional swimming pool.

A system with a water storage tank must be above the top of the absorber to produce a section with a pump. These standard units may be suited to an increasingly developed dual convection system which eliminates the problem. It consists of two tanks inside the other, the outer being connected to the collector, filled with an aqueous solution.

A set of plates is attached to copper tubes soldered to it in a fin-tube configuration and is found satisfactory for a type of American system. An apartment is needed for hot water. The system then transfers the heat from the solution through the wall of the inner tank to the water to be used. Slowly in the system, the primary circuit operates at atmospheric conditions and the water tank needs only to hold the collector. The collector can be constructed simply; it may be patterned after the most efficient design, like a conventional swimming pool."

Consider the following text:

"Ponder a Sun Wall, hence Soest as Be at Soars. The Soret is in the Seat. The State's Sun Rin seat is a favorite. Get at the state and see the House Heating. It is regulated through very frequently, more cones are enabled to heat as a 'luminary plate'. The plate is painted black on the portion exposed to the sun. About half of each plate shows each shade by the plate covered box. The air will enter it and pick up the heat. In essence, the top air circulation can free cherry trees from frost.

All of the above-mentioned collectors are really one. The Sun and See tie tell rose lute plates 10 degrees. This tries to attain higher collection efficiency during the winter when the days are colder. This could be done with the built-in flat part of the Solar Baking solar oven, Fig 10, an ordinary glass-covered box facing the Sun. Cooking and baking temperatures in such a device can be obtained with very little (every 13 minutes) reorientation. Leave it in the sun and get the dish cooked up to the desired temperature for the required time in the home of the oven.

Solar Distillation is cold but can be appreciated in many parts of the world. The latent trend of water Solar energy can be achieved with very simple equipment. It can convert Sun rays into freshwater. The iron plate with short legs is painted black and holds the brackish water. The sun shines from above and the water evaporates in the form of droplets. This fresh water can then be collected for future use.

As clean water can be seen in Fig 12, the pure water is covered by a layer at about 48 degrees which forms most of the condensing surface. It is much better than the pan and can produce water dropwise without much difficulty.

Solar Refrigeration and AC use a lot of energy for air conditioning. It is reported that much of the food shortage in the world could be prevented if food that is abundant during certain parts of the year could be preserved from spoilage and thus preserved for use during the rest of the year. This requires refrigeration and for remote areas without electricity, solar refrigeration may be a well-suited solution."

NOTE: This is an interpretation of the text as some parts were not clear.

"Both an example of our early work along these lines was aimed to gather high temperatures by concentrating solar energy and then circulating the hot oil around the generator of an ammonia absorption from the refrigeration system. This picture is somewhat out of sequence since all the applications thus far dealt with solar energy concentration, but it was put here since it was actually our first attempt. We believe, however, that the concentration without devices holds much more promise since non-concentrating devices can also utilize the diffuse portion of solar energy. The diagram illustrated in the picture, shows collectors drawing out the ammonia from the system. This ammonia is compressed and then expanded, providing the cooling effect by evaporation. After having done its work, the ammonia vapor is reabsorbed in the ammonia absorber of the system into the water. Figures 15 and 18 show a similar system that eliminates the primary fluid and reduces the heat losses by providing solar heat to get into the system and do its work. This small 4x4 foot unit can produce 40 lbs. of ice on a good day. It should be pointed out that all the applications mentioned so far did not require concentration of solar energy, and therefore could utilize the diffuse portion of solar energy and work even on cloudy days. The supply and demand are in phase: When the sun shines hottest, the need for refrigeration increases. Solar Energy Concentration For some uses, however, higher temperatures are needed. If this is the case, then concentration is called for. Some stationary designs are good and the better ones tend to follow the sun. Figure 17 shows a simple high-temperature absorber. It consists of a number of parabolic troughs, each with a pipe running along the focal line of the parabola. The system or parabolic trough is inclined at an angle equal to the local latitude. Depending on the diameter of the pipe, the solar energy reflected by the parabolic surfaces falls on the focal pipe which is painted with a good absorbing paint (flat black). This absorbs the energy and transmits it to the fluid inside the pipe. This device can easily produce high temperatures."

"Rice, not water, is stewed on high heat. Some energy is lower during the early morning and the late afternoon. The above method might hurt due to shaking, but the same principle and stationary setup have considerable advantages, both economically and because the units do not need much attention. If better efficiency is desired at a Solar Power Plant, then cylindrical parabolas can be utilized which are allowed to follow the sun. They produce steam to operate small steam engines, which in turn drives a small generator and lights up bulbs. This demonstrates the equivalent of 800 watts of electrical heat. A large parabolic absorber is shown in Fig. 1P, having dimensions of 6 feet with a glass-covered focal tube. The glass cover reduces losses from the heated tube. Depending on the need, different absorber types can be used. Copper has been found to be ideal for absorbing high-temperature panels. The absorbers are mounted on a rotating panel to face the sun. Electrically driven motors make the rotation units follow the sun. Miniaturized models were designed for portability as they are lightweight without sacrificing functionality. The construction of such a large device must be sturdy since wind loads in windy areas may make it difficult to keep the device stable and prevent it from overturning. This unit has been used to produce steam for the operation of fractional horsepower steam engines and to provide 80F oil to operate a solar refrigerator. Other methods of concentrating solar energy are being explored, among them the use of Fresnel lenses (including giant lenses), but they are not widely used because of their cost in large sizes and their weight. However, Fresnel lenses specially made from plastic sheets with grooves cut or embossed can be produced in large sizes and lighter weight. The lens shown in Fig. 2O is of this type and can produce a temperature of 2000F. A very effective way of concentrating solar energy involves using pieces of reflecting material (for better results they can even be slightly curved), such as mirrors or reflecting metal surfaces, and arranging them in such a way."

Many attempts to deflect the solar radiation on one spot from the surface type have been made with thousands of these mirrors laid in some of the large solar furnaces in the Solar Cooking. This is shown in Fig. 2, where three of them are concentrated. Such mirrors can also be set up in different patterns like the one shown in Fig. 3.2, where circular pattern heating the fluid penetrates at the central section. If higher concentration, thus higher temperatures, and smaller focal regions are desired, then either small mirrors are needed or continuously curved surfaces can be employed. In this manner, lenses of optical quality can be made. But these are very expensive and there is a practical limit to the use of them. Two such mirrors of fair quality are shown in Fig. 2.3, the one on the left being strong enough to hold its shape by being properly formed.

The one on the right is supported by ribs made from wood. This type of construction, where the reflecting metal sheets are held loosely to allow for expansion and contraction, thus reducing distortion, is common. This type of construction is cylindrical. When a good quality mirror is required, such concentrators are used. The concentrator can be adjusted to modulate the degree of concentration. This design will shorten the distance from the focal point to the heated area. For higher concentrations than the ones previously cited, more precision is needed for high-temperature applications. For this purpose, the mirror has to be more perfect. Fig. 4 shows such a mirror. A good example of this is the Solar Furnace.

In a solar furnace, with a concentration ratio of similar scale, temperatures of up to several thousands of degrees can be reached. Solar furnaces can be used whenever concentrated heat is needed. Materials can be placed in containers surrounded by the furnace so any desired atmosphere can be maintained. In this way, the solar energy can be concentrated onto very small spots for very high temperatures. It is not necessary for the container to be of high-temperature resistant material.

(Remason, 197-)

The following text is an attempt to correct the original text. Some sentences or phrases were impossible to fully decipher due to the extent of errors:

"Presently, the energy that activates this system has not yet been generated to a high degree. The furnace has been designed to produce external high energy which will extract water from its surroundings, which may be of great importance. It's believed that the solar furnace will be an important tool on the moon, and it may be possible to produce the necessary energy to send fuel from the earth to the moon.

This work will increase the creation of energy and as a result, the amount of water and quantity of steam delivered to the moon will increase with the use of the absorber and boiler. This process can be repeated throughout the night using other sources of energy.

There are two basic types of hot air engines that operate in a closed cycle. They function based on the exchange of heat between hot and cold surfaces. When the unit is in contact with the hot surfaces, it absorbs heat and thus increases the pressure inside. The piston will be pushed down when the pressure in the engine is high and returns to its original position when the pressure is low.

This process can be improved by either pressurizing the engine or filling it with gases such as hydrogen or air. However, these engines become more complex with such additions and adjustments.

Figure 6 shows a quarter of a cross-section of a hot air engine. The space is under heat in a vertical position. The piston cylinder is heated and the heat is caused by the engine components.

Another engine is shown in operation with a radiation coil around the hot end of the piston cylinder. The actions illustrated are mechanically operated and the engine movement must be automated.

Enough hot air can power small engines. Adjusting the mirrors periodically will ensure efficient operation.

No further land is needed in cases where animals are used to pump water out of ditches. The furnace, when angled correctly, functions much better than when positioned flat. This solar furnace, which has been positioned to face the sun, is effective at heating an area.

It provides a concentrated spot of heat that can power the engine. This eliminates the need for wood, coal, or liquid fuels. With solar energy, it is possible to generate heat only when needed."

This text appears to be scrambled and nonsensical, potentially due to a faulty translation or text scanning. Without knowing what the original text should be, it's impossible to offer a coherent correction. If you have a clear version of the text, I would be more than happy to assist you in correcting any grammatical or structural errors.