PROJECT ASSISTANCE COMPLETION REPORT (PACR) PD-ABE-695
RENEWABLE ENERGIES 78997
PROJECT NO. 664-0325

I. INTRODUCTION

This Project Assistance Completion Report covering the period of August 31, 1979 through September 30, 1984 describes the completed activities initiated by the NASA Lewis Research Center under the Tunisia Renewable Energies Project Grant Agreement between the U.S. Agency for International Development (USAID) and the Government of Tunisia.

II. PROJECT DATA

A. Title and Number: Renewable Energies - Project No. 664-0325

B. GRANT AGREEMENT DATE: August 31, 1979
Amended August 30, 1980

PACD: December 31, 1984
TDD: June 30, 1985
EOP Evaluation: Done by RMA Inc. (March 1986)

C. FUNDING: A.I.D. $1,548,000

Expenditures: $1,548,000

GOT Contribution: TD 516,000

D. IMPLEMENTATION/ORGANIZATION: Ministry of National Economy (MNE) through the Societe Tunisienne de l'Electricite et du Gaz (STEG).

III. EXECUTIVE SUMMARY

This project involved the experimentation of renewable energies (photo voltaic power and small wind energy conversion systems) in rural areas. It permitted the analysis and field testing of solar and wind energy technologies (i.e. PV solar power generation, PV and wind water pumping, solar greenhouses with thermal storage and solar water heating) and the evaluation of their technical, social and economic feasibility for meeting future Tunisian energy needs, thus improving the quality of life in rural areas and contributing to the economic development of Tunisia.

The objective of the project was to design, procure, assemble, test and install PV and small electric wind generators such that the GOT could demonstrate the ability of solar and wind technologies to perform work and supply the minimum services necessary in remote villages with agricultural settings and evaluate this energy alternative in conjunction with the district energy applications program.

IV. PROJECT GOAL AND PURPOSE

The goal of the Project is to demonstrate the economic, social and technical value of alternative energy resources and technologies in assisting development and in improving the quality of life in Tunisia. The scope of the Project is limited to selected areas of the economy and should be viewed as a first step in implementation of alternative energy sources for Tunisia's social and economic development programs. This Project is designed to demonstrate the ability of alternative energy resources of sun and wind and alternative energy technologies to meet the energy needs of a village and its surrounding agricultural activities.

The specific purpose of the Project is to provide information to Tunisian decision-makers that will assist them in relating economic and social development to energy availability.

Also, the Project should increase the understanding of Tunisian decision-makers of the limits and value of selected renewable energy technologies in order to give them the capacity to decide when and where they should be introduced into rural economic development programs. Renewable energy forms should also be evaluated for their applicability to the regional economic development program.

V. PROJECT IMPLEMENTATION

The Tunisia Renewable Energy Project had two principal implementing parties, the Ministry of National Economy (MNE) and the Societe Tunisienne de l'Electricite et du Gaz (STEG): The (MNE) was responsible for coordinating all energy activities. MNE has designated the (STEG) to provide technical services and project management and coordination functions for the GOT. USAID, through a Participating Agency Service Agreement with the National Aeronautics and Space Administration (NASA) provided technical services and project management. It was the responsibility of NASA to provide the solar and wind expertise required to ensure that correct design principles and adequate engineering practices were followed in implementing the selected project demonstrations. STEG was

responsible for implementing host country activities with Technical Assistance provided by NASA and/or contractors to NASA.
Working with other government agencies and private contractors and in coordination with STEG, NASA has developed specifications, designs and installation of the following solar and wind technology applications.

A. Agricultural Applications (Hammam Biadha)

1) A solar heated greenhouse with thermal storage (three sites).

2) A 1.3 KW photovoltaic-powered water pumping system for use with drip irrigation systems for greenhouses farming and orchards (two sites).

3) A 1.3 KW photovoltaic system for a remote farmhouse domestic power needs (one site).

B. Village Applications

A 27 KW photovoltaic system to service the residential, commercial and public sectors of Hammam Biadha.

A solar hot water system and a solar refrigerator for the village health center.

These were installed by Solar Power Corporation and STEG in 1983 and have been operating satisfactorily since that time.

C. Wind Energy Application (El Haouaria)

Two grid-intertied wind turbines were installed at an isolated and unattended site (El Haouaria) within 300 meters of the mediterranean sea.

The wind turbines are a Bergey Windpower Excel-S 10 kwp unit and a Jacob Wind electric 23/12.5 kwp unit. Both units were installed in June 1984 by a crew from the U.S. Solar Energy Research Institute and STEG and have been operating satisfactorily since that time with the exception of some minor repairs and spare parts due to damages caused by lightning strikes.

VI. PROJECT RESULTS/EVALUATION

The project began in 1980 and the solar electricity system at Hammam Biadha came on line in February 1983. The two small wind energy conversion systems (SWECS) were installed, tested and connected to the STEG electricity distribution grid in September, 1984.

Hammam Biadha is a village of 30 families (about 150 people) located 150 km southwest of Tunis. A large primary school (for 500 students) is located in the village, as are stores, a mosque, and a public well. Most of the residents are engaged in small holder agriculture. At a cost of $1.4 million (USAID grant) matched by TD 160,000 (GOT), a 20 kilowatt photovoltaic electrical system was installed to supply residential, commercial, and institutional users. Since 70 amps is the maximum output of the system, each family is allocated a maximum of 5 amps (at 220 volts). The machines in the school's carpentry shop must be run in series, since concurrent use of several power tools would overload the circuits. The system's design capacity was based on a 300 kw/year per family design standard with a 10% growth factor (to account for increases in demand and in the number of consumers projected over a five year period). A battery storage system was installed, which can supply the maximum 10 day power needs for users (up to 360 kwh), as a backup component needed during overcast periods in winter months. Overcast conditions are not expected to ever exceed 10 days.

During the 5 year pilot project period, data on performance, consumption, demand, cost, etc. were collected, as a basis for future decision-making, on whether a regular power grid extension would have been preferable. Residential uses of the power consist mainly of lighting, televisions, and refrigerators (summer only). This consumption pattern is interesting (and somewhat surprising) if one considers the ballpark national income and expenditure figures below:

The capital and installation costs of the photovoltaic system were heavily subsidized by USAID. The families residing in the village since 1980 are only paying TD 3/month up to a total of TD 60 (amortized over 20 months) for installation of a STEG electric meter. Each of these households has been connected free to the photovoltaic power source, and each household only pays the nationwide use rate for its actual metered consumption. The actual cost of producing photovoltaic current is much higher than the conventionally fueled electricity because of the high capital investment and the limited supply distribution pattern of a maximum of one km due to electricity distribution losses. Diesel produced electricity remains the preferred system because of less capital investment in spite of more frequent maintenance, repairs and higher operating costs.

A diesel electric system for the village would have produced a real user cost about 1/3 of the solar cost. STEG welcomed new connections to the village's photovoltaic system, since the battery's life will be prolonged if it is discharged more frequently and more fully and per unit costs came down.

Part of this high capital cost is the "buy American" requirement which is part of the AID grant, according to STEG. Transport from the U.S. to Tunisia added 100% to the cost of the U.S. equipment, and the U.S. consultants' fees were high. STEG claimed that purchase of European solar equipment would have involved substantial transport cost savings, and that for future system installation, local technicians, assisted by the European suppliers' staff technicians, would also be technically adequate and more cost-effective. Local skills, however, were substantially improved by the USAID training experience.

The greenhouses also seemed to have economic feasibility problems which will hamper replication. They are plastic tents with expensive foundations, which were given free to farmers on a pilot basis.

Technically, there have been some problems with the converters needed to change the DC produced into AC for consumption. Responsibility for maintenance of the wind mills has not been assumed effectively by users or by STEG. The only grain mill in the village is run by a diesel motor, since such a machine would exceed the capacity of the photovoltaic system. Farmers prefer diesel irrigation pumps, which operate faster than the solar-run drip irrigation systems. The drip system requires a cistern which can store drip-fed water to speed up the irrigation process. There was little evidence that the village's aggregate productivity or the local farm economy were improved by the project. Data were not sufficiently available to permit an adequate cost benefit economic analysis.

Except for these cost-effectiveness and technical questions raised, the Hammam Biadha village PV solar energy system is operating well and appears to be easily keeping up with the present loads.

The two small wind electric generators installed at El Haouaria represent an excellent additional wind energy resource connected to the nationwide STEG distribution grid for energy conservation purposes.

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