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Final Report

of

# WIND ENERGY APPLICATIONS AND TRAINING SYMPOSIUM

Pleasanton, CA and Honolulu, HI

September 14 - 22, 1988

Presented by

American Wind Energy Association

Sponsored by

The Committee on Renewable Energy Commerce and Trade

United States Agency for International Development

California Energy Commission

## VALUE OF THE SYMPOSIUM

**ACCOMPLISHMENTS:**

Seventeen representatives from twelve developing nations attended the Wind Energy Applications and Training Symposium (WEATS) held September 14 through 22, 1988 in Pleasanton, CA and Honolulu, HI (See Attachment A and Attachment B).

A combination of classroom instruction and field trip experiences were utilized to acquaint the attendees with the progress of the wind industry in the United States, both technologically and economically. Through the presentations, they were introduced to experts from within the U.S. wind industry, and U.S. government and California government representatives. They were given an opportunity to ask questions and gain information with which to make judgments on the applicability of wind energy to their own countries' various energy needs.

In addition, the various receptions and informal gatherings surrounding the WEATS schedule helped facilitate the development of important personal contacts between the participants and U.S. industry representatives. Most of our U.S. industry members involved in exporting praised the symposium and found their participation worthwhile (See letters, Attachments C - G).

Some of the benefits of the symposium which materialized after its completion are:

o Mike Bergey of Bergey Windpower Co. made a visit to Morocco which resulted in an agreement with a private Moroccan company for sales, joint development and ultimately manufacture of Bergey systems in Morocco.

o NRG Systems, Inc., a manufacturer of wind measurement equipment, has shipped an order to Morocco.

o U.S. Windpower Co. received an RFP from Egypt for a 90-kW technology transfer project funded by the United Nations International Development Organization (UNIDO).

o Several companies in the industry have received an RFP from Tunisia for a windfarm demonstration project sponsored by the Trade and Development Program (TDP).

Although those attending came from varied and somewhat unrelated countries, the atmosphere was very congenial and promoted the sharing of information and ideas.

**RECOMMENDATIONS:**

Recommendations for future symposiums include the following:

1) **Shorten the length of the symposium and allow a reasonable amount of free time for the participants.** Attendance was very sparse at the sessions held in the closing days of the ten-day agenda. Several of the attenders expressed the feeling that the schedule was too full and allowed very little personal time. The result was poor attention during important topic discussions.

2) **Indicate in the invitation to the participants that their attendance at all scheduled sessions will be expected** - thus, notifying them in advance what will be expected of them.

3) **Allot more time in the agenda for each participant to talk about the development of wind energy in his or her own country and communicate this in the invitation to attend.** This was a very beneficial aspect of this year's program. Each participant seemed proud to describe what was taking place in their homeland and, in some instances, without being asked, they brought written reports to be shared. If each participant is notified in advance of the symposium that a session of this type is planned, they could be better prepared for their presentation.

4) Although the symposium content covered the range of technical and economic issues facing windfarm development as well as rural electrification, **provide a more step-by-step approach to project development.** Presenting the material in a "how-to" manner could emphasize the importance of prefeasibility study, resource assessment and other economic/technical issues which are most important to the success or failure of a wind energy project.

5) If held in conjunction with AWEA's annual Windpower Conference in the future, **include in the agenda opportunities to attend technical paper presentations given at the regular conference.** Several of the attenders, those more technically oriented, wandered into the regular sessions uninvited and found them valuable (Attachment H).

6) **The process of inviting the appropriate persons from each country should be carefully planned to allow only approved substitutions for the original guest named.** In a few instances, the person receiving the original invitation to attend the symposium was not ultimately the participant. Other people were sent in their place who may not have been the appropriate person.

7) **Prepare a media plan that will utilize every opportunity to make the event well-publicized and visibly promote the sponsoring organizations.**

## PROSPECTS FOR WIND ENERGY IN PARTICIPATING COUNTRIES

### ARGENTINA

**Prospects for wind development:**

In Argentina, the population is concentrated in the central and northern part of the country, while the wind resource is primarily in the south. Although Argentina has available supplies of oil, gas and hydropower (hydropower supplied 50% of 1987 generation), huge regions are not grid or pipeline connected. Two hydropower stations totaling 7,000 MW are under construction. Argentina is looking at wind energy development because it realizes in one or two years its capacity will have to be increased.

Many studies have been made of the Chubut region in southern Argentina. These indicate a tremendous resource potential for multimegawatt wind farms. In Neuquen province in western Argentina, there are fourteen wind and photovoltaic monitoring stations. These provinces could export energy to the rest of the country.

There is, in addition, a definite need for rural electrification. Argentina has an interest in wind/diesel/photovoltaic systems for remote village power. Many rural schools, hospitals and telecommunication systems need electricity. Cattle areas are currently using diesel systems.

**Technical and marketing issues:**

Argentina is a relatively well-developed nation compared to many of the other nations represented. There will be a need to establish local content for U.S. industry to open markets there.

Due to the poor credit condition of the country, financing will be difficult. As a result of the Bowman Amendment, USAID will be unable to fund any projects until the country manages its debt more favorably.

There are one or two turbine manufacturers in the country. For the sake of local content, IMPSA, a steel conglomerate, would like to diversify and may be an important contact.

**Critical path to development:**

The provincial electric authority for Neuquen called Ente Provincial de Energia del Neuquen (EPEN) is actively measuring and evaluating the wind resource toward the use of small capacity generators for rural areas. The president of EPEN, Eng. Luis E. Galardi, may be contacted.

## PEOPLES REPUBLIC OF CHINA

### Prospects for wind development:

The Peoples Republic of China has a very serious shortage of energy, especially in remote areas where the national grid cannot go. In those areas, wind resources are abundant. These would be areas ideally suited to wind/diesel battery storage systems. Currently they have 66,000 small size turbines providing remote power.

The PRC is now interested in cooperating with some foreign countries to construct wind farms. In Inner Mongolia, there is a plan to construct a windfarm with a capacity of 3,000-kW in cooperation with Danish manufacturers.

Also, the coastal provinces of Guangdong and Fujian are areas planned for wind energy development.

### Technical and marketing issues:

The Danes have already obtained a foothold in the country through the Danish government subsidy program that provides financing for the export of Danish machines.

PRC is primarily interested in technology transfer and will seek to establish manufacturing rights in China. As reported in Windpower Monthly, the Germans have recently signed an agreement that will lead to licensed manufacture of Messerschmidt-Bolkow-Blohm's 15m/30kW Monopteros single blade wind turbine in the PRC.

### Critical path to development:

In China, the Rural Energy Division of the State Planning Commission, headed by Mr. Wu Zhenglun, is responsible for purchasing the wind power equipment. The State Planning Commission has a future plan for wind development but they have the problem of financing it.

The previous Ministry of Water Resources and Electric Power with the State Meteorologic Bureau has done some investigation of the wind resources in China. The present Ministry of Water Resources has the information/evaluation of the work that was done.

Currently, China is pursuing a program to purchase 5 medium size machines to be placed at various sites. The performance of each system will then be evaluated with the intention of using the technology to develop their own wind energy industry.

## DOMINICAN REPUBLIC

### Prospects for wind development:

The Dominican Republic has an extreme lack of capacity and an unreliable grid - problems bigger than wind development alone can solve. The country has no indigenous sources of oil so it must be imported. The estimated contribution of renewable energy sources to the country's electrical needs is 12%. The government is interested in increasing that number.

As much as 85% of rural homes are without electricity and 60% lack access to commercial fuels. The national utility, Corporacion Dominicana Electricidad (CDE), would like the option of using dispersed renewable systems to meet the small demand for electrification at some distance from the grid.

In the central part of the Dominican Republic there are many dairy farms. Wind generated electricity could be used for household power, water pumping and refrigeration at these farms.

Good prospects also lie in the resort business where diesel is now being used and the grid is unreliable or non-existent. Here wind/photovoltaic hybrids may be desirable.

### Technical and marketing issues:

The government-run utility, CDE, is very powerful and nationalistic. However, it knows it must get the technology into the country. The manufacturing will need to be done in the country. Therefore, technology transfer will be very important. CDE is interested in working with a well-known wind technology company whose equipment is easy to maintain.

The wind resource in the farming area is not known but is believed to be modest. Small battery-charging wind turbine packages (4 to 8 kW) are probably desirable.

However, there are government approval requirements for engine generators aimed at larger systems, and no official policy exists for renewable energy equipment.

Remote power projects will need external financing, which may be difficult due to the country's past credit problems.

**Critical path to development:**

Wind resource assessments done in the Dominican Republic have been of a poor quality to date. A feasibility study is needed to determine how to utilize wind energy for irrigation and drinking water as a first step.

The government agencies concerned with rural water supply are Instituto Domincano de Rucursos Hydralicos (INDRHI) which handles irrigation and Instituto Nacional de Aquas Potable y Alcantarillado (INAPA) which handles potable water supplies.

Companies interested in accommodating their need for technology transfer may contact the Director of Engineering at CDE.

## EGYPT

### Prospects for wind development:

Egypt has a huge power shortfall as a result of a growing population and limited indigenous resources. In addition, the nine year drought in Africa has affected the percentage of hydropower energy output. Wind energy is thought of as offering possibilities for rural electrification that would enhance the rural quality of life and slow the migration of the population to the cities.

As reported in "The Role of National Energy Planning and the Energy Mix for the Power Sector in Developing Countries" (Attachment I), Egypt has several locations with average daily and annual wind speeds high enough to be considered for the development of wind power generators. The available data indicates that the Mersa Matrouh region on the Mediterranean See has an annual average wind speed of about 20 km/hr (12.4 mph) and Hurghada region on the Red Sea Coast has an annual average wind speed of about 22 km/hr (13.6 mph). The report also states that there are many likely opportunities for alternative energies to play an important role in the not-so-distant future, if development is given the proper attention.

The European Economic Community (EEC) has funded several demonstration projects. Also, USAID is funding a demonstration project utilizing Danish equipment. The United Nations Industrial Development Organization (UNIDO) has sponsored a 90-kW technology transfer project which was written by Wincon.

There is a definite need for rural water pumping but Egypt does not currently have an aggressive program for that development, but rather, appears to be waiting for donors to recommend projects in this area.

### Technical and marketing issues:

Rural electrification is the best area for wind energy development since the national grid does not extend into the windy areas.

Financing the project may present a problem. USAID has been reluctant to help fund projects due to the heavy subsidy of conventional energy in Egypt.

**Critical path to development:**

The New and Renewable Energy Development Authority (NREA) is the agency primarily responsible for making decisions on whether to buy wind energy equipment. Mr. Eng. Hafez Sharaf Eldin, Chairman of NREA, is the key decision-maker (Telex No: 22985 EEARE).

A national program for wind energy manufacturing in Egypt is in progress. The development of wind power applications in Egypt in the last four years have centered on pilot plant scale or prototype systems.

## GREECE

**Prospects for wind development:**

Greece, a country of many islands, has an interconnected grid from the mainland to some islands. The Public Power Corporation (PPC), a state-owned monopoly, has a Department of Alternative Energy Sources.

Many islands are not connected to the grid and rely on autonomous diesel systems to provide power. In these locations the wind is very good, particularly in the summer when demand is high due to tourism. The island of Mikonos, for example, has wind speeds from 10-11 meters/second (10.9-12.0 yards/second). For the islands, therefore, wind energy is competitive with other energy sources installed.

Several small wind projects have been started. For example, the Keynorth Project on the island of Kythnos is a small windfarm of five 20-kW turbines, 200-kW of photovoltaic cells and diesel. They are working on a management system to optimize the use of the wind and solar and minimize the diesel. Other projects are proposed (Attachment J).

All of Greece's projects have been 40 to 60% sponsored by European Economic Community (EEC) grants.

Projects at Mikonos and Andros (vertical axis machines) utilize Greek designs by Greek manufacturers. Hellenic Aerospace has developed their own design. With good government support for wind, the academic sector in the country has been very active. In addition, 155-kW Danish turbines are also being used.

A recent article in Windpower Monthly indicated that Greece plans an installed wind power capacity of 20 MW by 1992. With less than one MW currently the target is very optomistic.

Greece's overall policy on renewables is being studied by the newly established Centre for Renewable Energy Sources (CRES). The CRES studies will take two and a half years to complete and will be financed by the European Commission.

According to the Energy Minister, Anastasios Peponis, PPC's current program on renewables will also be taken into consideration by CRES and form only a part of the national plan.

**Technical and marketing issues:**

Wind/diesel hybrid systems for the islands would be a fuel saver in place of expensive, poorly maintained diesel systems. Hybrid systems may be able to be marketed if local content can be established.

The size of turbine system they are seeking is medium-sized for grid connected applications. Additional interconnect cables will also be needed. The policy for wind energy organization in the interconnected system has not yet been established.

The government to promote renewable energy, has recently passed laws that have allowed for private power production. Private consumers are allowed to install three times their needs in wind energy and sell the excess to the PPC. Local authorities have no limit on capacity and the amount of excess to be sold to PPC.

Competing with EEC financiers and suppliers is extremely difficult for U.S. industry.

**Critical path to development:**

CRES is expected to play a key role in wind energy through the preparation of a country assessment and policy report. The Chairman of CRES is Prof. D. Lalas. Prof. Spyros Kyritsis is the the director.

## GUATEMALA

### Prospects for wind development:

Guatemala has considerable hydropower resources as well as geothermal potential that is being developed. However, the difference between the wet and dry season leaves a need to develop an alternative to hydropower. Special areas may hold good potential for wind energy utilization to offset the shortfall in hydropower. Reliable wind resource data is not yet available. With a reasonable wind resource, however, it is believed that windpower could be competitive with other alternatives.

Production of electricity in Guatemala is controlled by the Instituto Nacional de Electrification (INDE), a government agency. INDE also controls urban distribution of electricity by Empresa Electrica de Guatemala, S.A. (EEGSA).

EEGSA is very interested in investigating the feasibility of wind farms in Guatemala. Wind is favored because it is indigenous and has a shorter project lead time, and because peak wind season complements the dry season for hydroelectric capacity.

Over 60% of Guatemala's 7.9 million people live in rural areas and only 7% of them have electric power. The new democratic government has placed an emphasis on the needs of the rural poor. Rural electrification is a central part of the government's plan to improve the health, welfare, productivity and political homogeneity of the predominantly native Indian rural population.

INDE is also responsible for rural electrification but grid extension is difficult, slow and expensive. Small scale renewable systems have the potential to stimulate local manufacturing and benefit economic development and job creation.

### Technical and marketing issues:

Any turbines used in Guatemala would have to be rated for severe seismic loads due to the possibility of earthquakes. The country is mountainous and the complex terrain causes wind channeling. Palin Canyon, a pass 45 km south of Guatemala City, is believe to have good wind resources like Altamont Pass in California.

The Inter-American Development Bank (IDB) has provided INDE with attractive financing for electricity generation projects in the past. Assuming prefeasibility studies show wind to be economically viable, IDB has indicated an interest in funding a full feasibility study and perhaps implementation. IDB can allow up to 70% financing but this will be linked to the Guatemalan Ministry of Finance ranking a wind energy project as a priority.

Wind turbines to be part of an integrated multi-technology dispersed rural electrification program would likely range from 100-W to 100-kW and be designed to charge batteries, drive a pump and process motors or turn a mechanical shaft. Small systems are likely to be economically attractive at sites with average wind speeds of 4 meters per second. It is believed large areas of the country will meet that criteria.

The northwestern area, Antiplano, has been targeted by INDE for a stepped up electrification program. Development in this area is also a priority for USAID and other donor organization, thus offering possible financing sources.

Critical path to development:

While the laws allow private or cooperative power generation and distribution, INDE has control over anyone selling power to EEGSA or energy users. INDE is not expected to offer purchase rates that would encourage private wind farm developers. Any wind farm development is likely to be undertaken by INDE itself.

Because of a lack of in-house expertise, INDE and EEGSA will need technical assistance for feasibility studies, project planning, construction and operation of wind farm facilities.

A research program to characterize the wind resource will have to be implemented. Such a program would come under the purview of Carlos Mansilla, Director General for New and Renewable Energy Sources, Ministry of Energy and Mines (MIEM).

A cost-sharing relationship between a U.S. manufacturer to erect a demonstration wind turbine has been offered with EEGSA covering construction, labor, and management expenses.

A communication from Raul Aguilar of EEGSA received since the symposium indicates that a program to assess their wind resource is planned (See Attachment K).

## JORDAN

### Prospects for wind development:

An interest in wind energy in Jordan began in 1979 and the country has high hopes for wind energy. Studies since that time have indicated that the best use of wind energy is for water pumping and electricity generation by small systems to supply rural areas. Studies have determined that wind is the most economic method of rural water pumping, thus paving the way for agricultural development in desert areas. Jordan now has two indigenous generations of mechanical wind pumping systems and is designing and producing electrical pumping systems of about 10-kW capacity.

The Jordan Electricity Authority (JEA) controls the production, transmission, distribution and sale of power within the country. The Royal Scientific Society (RSS) and JEA have been collecting wind data at three sites, Ras Muneef, Angara and Rehara, with technical assistance for erection of the monitoring units and initial analysis of the data provided by CowiConsult, a Danish firm.

In addition, a single 10-kW turbine was installed next to a wind farm comprised of twenty five 4-kW wind turbines at each of the three locations to compare performance. Studies by engineers from the Univ. of Jordan indicate the cost of electricity generated by the turbines was less than half that produced by JEA's gas turbines. The single units were the cheapest to run. The study also found the possibility of wind power for water pumping to be promising.

Also, Jordan is in the process of studying results from a 300-kW grid-connected wind farm and is expecting results in the near future. A recent discovery of large natural gas reserves to be used for bulk power is likely to have a negative impact on the development of commercial wind generation.

### Technical and marketing issues:

There are no plans to allow private wind farms or to encourage private wind energy generation.

The Jordanians do not impose import duties nor do they plan to subsidize wind energy systems. There is hope, however, that foreign firms will assemble grid-scale turbines in the country or cooperate with local firms for construction of components such as towers, controllers, and turbine blades. JEA requires a local agent for all international tenders.

**Critical path to development:**

The agencies responsible for making decisions to buy wind energy equipment are the Ministry of Energy and Mineral Resources (MEMR) and Royal Scientific Society (RSS). Dr. Hisham Khatib is the Minister of MEMR. The president of RSS is Dr. Jawad Anani.

Jordan does have a high interest in stand-alone applications and national grid connected systems and, as mentioned, has done model projects for both applications. Large scale implementation will depend on economic factors and availability of investors.

## MOROCCO

### Prospects for wind development:

Morocco is a poor country with an economy based on agriculture. It does not produce oil and is therefore interested in alternative energy sources. In the early 1980's the government created the Center for the Development of Renewable Energy (CDER) based in Marrakesh.

Of the various renewable technologies emphasized at CDER, wind energy is the most traditional. Wind energy proved efficient during World War II when there where 10,000 windmills in Morocco. It is the most advanced country in Africa as far as wind energy pumping. The government is very supportive of wind development.

CDER has undertaken the task of collecting wind data into an atlas. Some interest in wind farms has begun although there is no activity or large machines in the country presently.

Now that the dispute in the Western Sahara region of southern Morocco is settled, Morocco is seeking to develop that area with rural water pumping and electrification systems.

### Technical and marketing issues:

The greatest potential remains in the area of water pumping. Educational opportunities will benefit the country's further utilization of wind power.

Morocco has considerable potential donor aid available. Most of the aid however, unlike USAID funding, is tied-bilateral aid requiring a commitment to purchase from a supplier from the same country as that of the donor. Thus, U.S. companies are at a disadvantage to compete.

Some amount of local content will make the difference for setting up projects.

**Critical path to development:**

The Ministry of Energy and Mines of Morocco is responsible for decisions regarding the purchase of wind energy equipment. Mr. A. Fakinhani, Director General of CDER, is the key decision-maker.

The current status of wind development involves planning for technology transfer in cooperation with USAID and other international institutions.

The resource knowledge of Morocco has been obtained through seventeen meteorological stations that have been maintained by CDER.

All contacts for development must go through CDER which will then recommend to the utility in the country. CDER is similar to the Solar Energy Research Institute (SERI) but on a smaller scale.

## NIGERIA

### Prospects of wind development:

The development of electrical power in Nigeria began with diesel plants, first in Lagos, the capital, and then in 18 municipal townships. In 1950 the Electricity Corporation of Nigeria was created to coordinate all of them. Between 1950 and 1980 there was tremendous growth in the power capacity in the country, from 43 MW to 5,000 MW.

The government created a directorate for wind development. The electricity department under that directorate is charged with providing electricity to rural areas. Urban electrification comes under the national body, NATA.

The government is planning a major rural electrification program in response to tremendous needs within the large, diverse rural population. Experience with rural electrification using diesel has been disappointing. The cost is very high due to adverse foreign exchange. Since diesel plants are no longer economical, Nigeria is looking to renewable forms of energy, such as hydropower, wind, and biomass.

### Technical and marketing issues:

With rural electrification as a priority, no consideration has been given to wind farm size projects.

There is a concern that there may not be sufficient wind resource in the rural areas needing development. However, if sufficient wind resource is found, there will be a very good opportunity for rural electrification.

### Critical path to development:

Nigeria has a limited knowledge of their wind resource. The government representative, Mr. John Lodam, is in the process of writing recommendations. It is unlikely that there will be any activity for about a year.

## PAKISTAN

### Prospects for wind development:

Pakistan is an energy poor country with two-thirds of its oil requirements coming from outside the country. As a result of the 1973 energy crisis, it began a program to explore renewable energy resources. The country's greatest need is for grid-connected power generation, since it experiences wide-spread power shortages of as much as 25%.

With 70% of the population in rural, agriculture-based areas, the initial emphasis was placed on biogas energy units for heating, cooking and lighting as a replacement for expensive imported kerosene. Seventeen solar stations have been installed on the basis of grants from foreign countries and international agencies such as UNDP, EEC, JAYCOR, etc.

There are two wind farms currently in Pakistan. In addition, several wind water pumpers have been installed.

### Technical and marketing issues:

Pakistan does not have enough knowledge of their wind resource. Several monitoring stations have been set up but analysis of that data is needed.

It appears they have low wind resources in the coastal areas where they want to construct the wind farms. Consequently, they are seeking technology that can be productive in low wind velocity areas.

### Critical path to development:

Pakistan has existing data that needs to be analyzed. In addition, they need to be educated on how do a good resource assessment.

A possible funding source would be USAID. The local mission in Pakistan is very active and the country receives a considerable share of USAID support. Recently a notice for setting up an in-country distributor of renewable energy equipment was released under the USAID Agricultural Commodities and Equipment Loan Project.

## SRI LANKA

### Prospects for wind development:

Sri Lanka, a small country with 60 million people, has a current electric generating capacity of 1,000 MW. Of that, 70-80% is hydropower (about 3.3 cents/kWh US) and the balance is diesel (about 8 cents/kWh US). There are no indigenous fossil fuel resources. Demand is increasing by about 8% annually. The total hydropower potential is estimated at about 2,000 MW but most of the economically favorable sites have been developed, making future hydropower development expensive.

Thermal (diesel) power can be increased but Sri Lanka's powerful environmental lobby is very influential and critical of conventional energy development.

The government has installed several photovoltaic demonstration facilities that have successfully demonstrated the technology. In addition, the Dutch and the Asian Development Bank (ADB) are involved in funding biomass (rice hulls) projects.

Sri Lanka is beginning a two-year wind measurement program. The program is being conducted with funding from the Dutch government on the condition that Dutch equipment be used. The equipment was due to be installed by the end of 1988 in five sites considered to be promising: one in the south, one in the southeast and three in the hilly central region.

After the first year of the program, various organizations such as USAID will be approached for funding of a feasibility study. An initial contact with the USAID Office of Energy has already been made.

### Technical and marketing issues:

Sri Lanka's state utility , the Ceylon Electricity Board (CEB) , resists having wind facilities interconnected with its grid. The CEB has no plans to install wind equipment and any projects, therefore, would be experimental or initiated by private persons for their personal requirements. It is anticipated that virtually all of the island will be connected with the utility grid, making stand-alone installations very few.

**Critical path to development:**

The Ministry of Power and Energy is the agency responsible for purchasing wind energy equipment. Prof. K.K.Y.W. Perera, the Secretary, is the key decision-maker.

It would be useful to have technical level representatives from the Ministry of Energy attend informational sessions in which wind speeds, generator output, and a variety of other technical questions might be addressed.

Sri Lanka is planning a wind resource study in 1990-91. U.S. assistance in analyzing the wind data they collect under the measurement program may be beneficial.

## TUNISIA

### Prospects for wind development:

Tunisia is an oil-exporting country which also imports heavy oil and natural gas for production of electricity. In 1986, the import of these fuels prepresented 7% of its total imports. The Tunisian government, therefore, is very receptive to programs and technologies that can help reduce the consumption of fossil fuels.

The Societe' Tunisienne de L'Electricite' et du Gaz (STEG) is responsible for generation and distribution of power in Tunisia. Created in 1985, the agency responsible for conservation and new energy sources in Tunisia is L'Agence de Maitrise de L'Energie (AME), part of the Ministere de L'Energie et des Mines. AME has recently taken an interest in developing wind and other renewable energies (see Atttachment L).

Tunisia has considerable wind resources. The best resources seem to be concentrated on coastlines with a northwest exposure and elevated sites in the hills of the interior region. Very high wind resources were found at two elevated sites along the north coast, at Cap Serrat and Cap Bon. The complex terrain of the Atlas Mountains in northern Tunisia provides sheltering and concentration of wind resources. It is highly probable that conditions may be similar to Altamont Pass and Tehachapi in California, providing a significant source of inexpensive wind-generated electricity. In the southern region, the proximity to the Sahara Desert and Meditteranean Sea may give rise to large temperature/pressure gradients across the hills in the southeast and, thus, produce wind channeling in passes or other corridors.

Wind resource data is available from a number of sources but little of this data is of a form and quality that is useful in siting a large wind energy facility. Modern U.S.-produced wind resource monitoring equipment has been installed at several sites. It appears that the seasonal resource correlation to demand should be good and the diurnal wind resource correlates to typical utility consumption patterns.

In addition, it has installed photovoltaic and geothermal projects. The geothermal is working quite well.

The prospects for rural electrification are very good. In 1987, the World Bank funded a $300,000 pilot rural electrification project utilizing wind energy. The tender, however, was never sent to U.S. companies.

**Technical and marketing issues:**

Windfarms in Tunisia are most likely to be owned and operated by STEG. The major obstacle for windfarm development seems to be the need for outside financing.

It is questionable whether there is a sufficient need for new commercial capacity until after 1996 since Tunisia is committed to construction of three new fossil fuel plants in the future.

The willingness of U.S. companies to enter into technology transfer agreements will be important for market development in Tunisia. The local production of wind pumps, for example, has already been achieved.

**Critical path to development:**

Tunisia needs more and better resource monitoring/assessment studies. Currently, it has released a tender to U.S. industry for TDP funding of a feasibility study for a wind farm project. It is likely that after completion of the feasibility study, a pilot facility of 1 to 5 MW will follow.

Within STEG, renewable energy development comes under the purview of Mr. Khereddine Guellouz, Le Directeur, charge de la Direction Recherches et Developpement.