PDWAX 979

Final Report of the

WIND ENERGY APPLICATIONS AND TRAINING SYMPOSIUM

San Francisco, CA
Amarillo, TX
Washington, DC

September 19-28, 1990

Presented by

American Wind Energy Association

Sponsored by

The Committee on Renewable Energy Commerce and Trade

The U.S. Trade and Development Program

The U.S. Agency for International Development

BACKGROUND

In 1988 and 1989, the American Wind Energy Association held Wind Energy Application and Training Symposia (WEATS) in conjunction with the association's annual Windpower conference. Similarly, energy policy-makers from developing nations were invited to the United States to learn about the achievements and applications of the U.S. wind energy industry through presentations and field trips.

Suggestions for improvement from participants and industry members as a result of both symposia were incorporated into the planning for the 1990 event. The most notable change was the inclusion of a field visit to view wind-generated water-pumping applications at the USDA Agricultural Research Center in Amarillo, TX.

ACCOMPLISHMENTS

Sixteen representatives from 11 developing nations participated in the 1990 WEATS program held in San Francisco, CA, Amarillo, TX and Washington, DC from September 19 through 28, 1990. The symposium agenda and participant list are attached (Attachment A and B).

Consistent with previous symposia, the format included classroom-style training and field trip experiences to acquaint the participants with the history and progress of wind energy development in the U.S., technologically and economically. The speakers were drawn from the U.S. wind industry, federal and state government agencies, and private investment industry.

The field trip experiences for viewing large and small system applications continues to be the highlight of the training program. Seeing actual applications of the technology offers a realistic picture of wind energy's ability to meet various energy needs. It clarifies and changes perceptions which may not be accurate.

Brief presentations about wind energy development in all the countries represented were made by the participants. Several reports were prepared and presented along with slides for further explanation. The one-on-one symposium wrap-up session on the last day continues to be a good method of discovering what can be the next step in working with each country to development their wind energy potential. It encourages personal relationships between industry members and the country representatives which can be built upon in further contacts. The information about each country was gained from both these activities and from questionnaires that each participant was asked to complete.

This year's WEATS program contained several new components. As previously mentioned, the field visit and demonstration of mechanical and electric wind-generated water-pumping applications was added. In many developing nations, the need for water for drinking and irrigation make this particular application most attractive. Along with the windfarm demonstration visit, it gives

a fuller view of potential wind energy applications. Some participants found windfarms most interesting, some water-pumping. In general, everyone found the WEATS program to be beneficial in some way.

On the last day, two panel discussions were added to the program this year. The panel on U.S. financial assistance programs included speakers from the Dept. of Energy, the Agency for International Development, the Trade and Development Program and the Export-Import Bank. The second panel titled "Creating a Successful Project" included speakers from the Dept. of Commerce, the World Bank, the private investment community, and the wind industry.

The intention was to bring together various experts involved in fund and managing worldwide energy projects to help answer questions and explain the processes that lead to success. Many questions were fielded by the panel members and it appears that the information was helpful to the participants.

EVALUATION

The format for the WEATS program developed over three years has proven to be effective. Field visits to both large and small applications were effective and should remain in the schedule, if possible logistically.

From the comments offered on the participants' questionnaires, it is clear that more time needs to be allotted for the program itself. The topics of design, performance, and economic evaluation need to be covered in greater depth.

Four of the 11 countries had been represented at previous WEATS programs. Concentrating on a smaller number of repeat countries with high potential for wind energy development for the next year nurtures relationships that hopefully translate into tangible sales results. Potential guests for next year's symposium will be drawn from nominations of past participants.

RECOMMENDATIONS

1) **Lengthen the program to four full days of topic presentations** interspersed with the field visit experiences. An agenda that is too full lessens the impact the material presented.

2) When making invitations, **concentrate on the same countries that have been represented before.** This encourages a continued relationship that can translate into more tangible sales results in time.

3) **Give greater attention in the agenda to the topics of design, performance, and economic evaluation of the technology.**

PROSPECTS FOR WIND ENERGY DEVELOPMENT IN PARTICIPATING COUNTRIES

CAPE VERDE

Participant: Jose Pedro B. Duarte Fonseca
Instituto Nac. de Investig. Technologica
CP 185 Praia, Santiago
Rep. of Cape Verde, WEST AFRICA

Cape Verde, a small island nation off the coast of West Africa, has strategic significance for shipping and air travel between Africa and other continents. Cape Verde just signed an agreement with U.S. Agency for International Development to act as an intermediate stop between U.S. and Africa. Cape Verde also receives donor aid from many other countries. DANIDA, the Danish aid agency, has provided financing for wind development in coordination with RISO, the national wind energy laboratory of Denmark. Currently they have one Bonus wind turbine in a wind/diesel application and four Vestas 55 kW machines in addition to a 10 kW Aeroman. DANIDA plans to invest in 30 units in 1991.

Wind resource data is available and appears to be very good. Currently 2% of the nation's 9 MW capacity is generated by wind. Solar represents 0.5% and the remaining comes from conventional sources. Only 80% of the population is grid-connected. Water-pumping and desalinization plants are high priority applications for wind technology.

Cape Verde is environmentally conscious and aims to meet as much of its demand as possible from renewable energy sources. In addition, its close ties to West Africa make it a good stepping stone to the huge African market.

Mr. Fonseca, in the U.S. for graduate study, will be returning after a year. Until he returns, contact should be made with Eng. Pedro Alcantara Silva, Director of the Centro de Energias Renovaveis (CER), Instituto Nacional de Investigacao Tecnologica.

Other key people responsible for the development of wind energy in Cape Verde are:

Dr. Adnan Rocha, Minister of Industry and Energy (MJE)
Dr. Jose Brito, Minster of Planning and Cooperation (MPC)
Dr. Joao P. Silva, Minister of Rural Development (MDRP)

Contact should be made with each of the ministries listed above to begin an information exchange and development of potential projects. U.S. Agency for International Development is an important link in the process of developing future wind projects.

CHILE

Participant: Ernesto Tironi
General Manager
Corporacion de Fomento de la Produccion (CORFO)
Moneda 921, Oficina 814
Santiago, CHILE

Mr. Tironi represents CORFO, a holding company of electric utilities, charged with research and development. In Chile 20% of the electricity is generated by public utilities, 80% is by private companies.

Chile is a long narrow country that runs for 3000 miles along the western border of South America between the Andes mountains and the Pacific. Eighty percent of the population lives in the central region. The population, and therefore the utility grid, is more dispersed in the north and south.

Not much wind energy development has occurred to date but there are definite prospects (see Attachment C). Chile's 16 Billion kilowatt hours of annual consumption is met primarily by hydropower in the central region; by coal, heavy oil and diesel in the northern region; and by diesel and natural gas in the southern region. Total capacity in all regions is 3,800 MW.

A comprehensive wind measurement program is needed but some initial^^+^U(5^^
been collected and evaluated by various Chilean universities. The findings have led to the selection of several areas and applications for wind energy development.

The highest potential for large wind system development is found in the northern region near Chuquicamata. This high plateau is the site of an energy-intensive copper mining operation. The mining companies located at the end of the grid are high energy consumers with the money and infrastructure to support a wind project. The University of Chile has measured annual wind averages of 8.5 m/s for 10 hrs/day in this region. Current generation by coal, heavy oil and diesel costs approximately 5.9 cents/kWh. The nearby city of Arica (7.5 cents/kWh) could utilize wind-generated electricity.

A second potential location is Easter Island which lies quite a distance from the mainland of Chile. It has a small population but the high cost of diesel-generated electricity (10 cents/kWh) and the winds averaging 6 m/s for 6 hrs/day make it a good location for wind integrated in a diesel mini-grid as a fuel saver.

Small scale wind systems have potential to electrify the over 200,000 rural villages that are not connected to the grid. The wind resource has not been widely studied and therefore specific sites are not identified. In many of these villages, water-pumping for irrigation would benefit their expanding fruit exports.

Along the 3000 mile coast of Chile there are numerous fisheries that require power for refrigeration. The southern region around Punta Arenas appears to have good wind to meet this need.

Important in establishing the political will for the use of wind energy in Chile will be a wind measurement program. Seed money from the U.S. to support a such an assessment program is needed. Mr. Tironi expressed an interest in developing joint ventures and licensing agreements with U.S. companies. He indicated that sufficient capital could be raise in-country to fund a project that determined to be economically feasible.

Chile is a key prospect country and may be worth utilizing Trade and Development Program funding to do a definitional mission as a preliminary step to funding a feasibility study.

An additional contact is Pedro Goic, Director, Centre de Informacion de Recursos Naturales, Manuel Montt 1164, 223 6641 Santiago.

COSTA RICA

Participants: Jorge Valverde
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Instituto Costarricense De Electricidad (ICE)
Saban Piso 6, Apartado 10032-1000
San Jose, COSTA RICA

Enrique Morales
Engineer, Special Studies
Instituto Costarricense De Electricidad (ICE)
Sabana Piso 6, Apartado 10032-1000
San Jose, COSTA RICA

Costa Rica has an installed capacity of 866 MW. Eighty-four percent is generated from hydropower at the cost of 5 cents/kWh and 16% from thermoelectric plants. Historically, demand has increased by 7% per year. (See Attachment D)

In May 1989, the Costa Rican government issued an Executive Decree allowing private power generation. A law to legalize private power production was further enacted by the legislature in 1990 and the power purchase agreement is now being negotiated.

Currently, ICE has an agreement with the California Energy Commission to provide assistance on a wind resource monitoring program for the purpose of large-scale wind development. The CEC selected Tejona as the best site of several potential sites. U.S. Windpower Company is the meteorological contractor for collection and analysis of the data. The measurement began January 1990 and is ongoing. The potential for a large-scale windfarm project as an outcome of this program is strong.

A rural electrification plan exists but does not appear to hold a high priority within the government. Nevertheless, some potential exists for small dispersed power systems in the rural areas since only 60% of the population has electricity but funding for them is a potential barrier.

INDIA

Participants: N. M. Patel
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Executive Engineer
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Since 1960, the electricity demand in India has been out pacing the increase in capacity, creating a shortfall in meeting the 50,000 MW demand currently. The government of India's response has been to establish a goal of 2000 MW of wind energy by the year 2000.

An extensive wind mapping program by the Dept. of New Energy Sources (DNES) identified the most prospective areas as Gujarat in the West, Tamil Nadu in the Southeast and Himachal Pradesh in the North.

With several years of Danish grants from DANIDA, India now has 37 MW of wind energy installed; 16 MW are in Gujarat. Consisting of 55 kw to 100 kW, these machines have been partially manufactured in India through licensing agreements. The first prototypes were installed in May 1988. Now the program is moving toward larger systems. Both 150 and 200 kW prototype machines are expected to be ready by March 1991.

A recently enacted government policy for purchase of private power gives some incentive to private power producers through a complex system of "banking" energy credits. Nevertheless, the major point of control of wind development remains with DNES and to a lesser degree with the regional energy boards.

More than any other country represented, the Indian guests exhibited a good understanding of the technology and a desire to learn about design and integration details which go beyond the content of the WEATS program.

INDONESIA

Participant: Dr. Lolo M. Panggabean
Head of Laboratory
UPT-LSDE/BPP Teknologi
J. Thamrin, No. 8
Jakarta, INDONESIA

Indonesia is poised to take off economically. The country is rich in oil, gas and coal, but the problem is in transforming theses resources into energy. Most of the oil is exported to meet foreign exchange needs. Previous energy demand was met by oil and hydro, but most recently coal-fired plants are being built.

Perusahaan Umum Listik Negara (PLN), the state-owned utility, with a generating capacity of 8,000 MW, provides electricity to only 30% of the population. Another 8,000 MW generated by captive power is encourage by PLN. To meet demand growing at 16% annually, Indonesia will need to add 2000 MW annually to the end of the decade. To make things worse, PLN's tariffs do not cover its costs. The head of systems planning at PLN, Nengah Sadja, stated in the Far East Business Review, "I don't think there will ever be private investment in the power sector."

Dr. Panggabean has been charged by the Minister of Energy Habibi with delivering a report on the potential of wind technology, 10 kW and 100 kW sizes, to contribute to Indonesia energy needs. His comments at the WEATS program indicate his surprise at the maturity of the technology. Nevertheless, the future of wind development at this time lies with Minister Habibi and his decision after receiving Dr. Panggabean's report.

The only current activity with wind is the testing of a 20 kW Aeroman turbine funded by the Germany. Performance results are said to look good.

The need to electrify many remote islands particularly in the eastern regions is part of the government development initiatives. The government has concluded that small scale PV would be cost-effective for household electricity needs. The lack of existing wind speed data is a limitation to promoting wind as another solution to this need. According to Dennis Elliott at PNL, the southern side of the islands are likely to have sufficient wind resources.

In a cooperative program with Japan from 1979 to 1987, 16 locations without access to the grid were monitored for wind speed. The data, however, was collected at a 10 meter height.

The first step to promoting wind energy development in Indonesia must include support for a wind measurement program to assess probable sites. Information on the cost of a measurement program and assistance with the proper collection and analysis of data would strengthen ties and help push Minister Habibi toward a

favorable opinion of the use of wind energy.

In addition, studies showing the most cost-effective applications for the technology and the potential for developing Indonesian manufacturing capability are another way to promote U.S. interests.

Additional key contacts in Indonesia include Ministry of Research and Technology, National Institute of Space and Aviation (LAPAN), and the Directorate General of Electricity and New Energy.

MALI

Participant: Vincent Hessou
Engineer/Project Officer
Centre Regional d'Energie Solaire (CRES)
Bamako, Mali, WEST AFRICA

The Centre Regional d'Energie Solaire (CRES) coordinates the public and private sector renewable energy activities for 11 West African nations. Seventy-five percent of the population areas they represent are rural with basic needs for water-pumping for human and animal drinking water and irrigation. Traditionally, hand pumps have been used. The ease of maintenance make hand pumps a first choice in many locations. Other applications for wind energy could be for grinding grain and for refrigeration of vaccines, meats and fish.

Wind speeds appear best along coastal regions (5 m/s), making Senegal, Mauritania and Cape Verde the countries for which wind is being given consideration. The resource is best known in Cape Verde (see individual country description above).

Two of the barriers to the use of wind are (1) the fact that no good resource data exists to pinpoint potential sites (last measurements were done in 1951-55) and (2) past failures of wind systems due to poor maintenance support which have discouraged further consideration of the technology. Mr Hessou indicated that prototype windmills have been installed in Mali, of the darrieus-type but the program stopped due to lack of maintenance support.

Studies have been done with multi-bladed mechanical windmills from CWD in Holland. Savonius-type vertical axis systems have also been investigated.

In a letter received soon after the event, Pr. Dan Dicko Dan Koulodo, CRES's Director, indicated an interest in coordination between his center and AWEA for

... feasibility studies for using wind electric pumping systems in Mauritania, Senegal, and Cape Verde

... feasibility studies for using mechanical windmill pumping systems in Niger, Mali, Burkina Faso, and Chad

... presentation by a U.S. wind expert at a coming seminar on hydro and wind technology.

The range of influence of CRES activities for most of West Africa make this relationship important and further information coordination and technical support are the key.

MEXICO

Participant: Arturo Whaley
General Director
Centro de Investigacion en Energeticos y Desarrollo
Gonzalez de Cossio 831
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Mexico is a top prospective market for U.S. wind industry exports. Obviously, the coming negotiations toward a free-trade agreement and Mexico's location as our close neighbor encourage a parallelling of interests.

In addition, the central government has launched a significant rural electrification program that has already affected the U.S. wind industry sales and holds even more project potential. At the conference, an order for $60,000 worth of wind equipment was placed.

Mexican government funding has been provided to private consultants in various regions to set up small dispersed systems for rural electrification. Recent correspondence with Mexican contacts indicates that windfarms may also be considered. The use of renewable energy sources has been given priority by the government even through Mexico is an important oil producing nation. Most of the oil produced goes to meet their high foreign debt obligations.

In the near future, Mexico is expected to be a key market for U.S. equipment and services and increased attention to building business relationships should pay good dividends to the industry.

PAKISTAN

Participants: M. Ajmal
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Water and Power Development Authority (WAPDA)
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Lahore, PAKISTAN

M. A. Shah
Director
Pakistan Council for Appropriate Technology (PCAT)
S.T. 10-A, Block 4, Gulshan-E-Iqbal
Karachi, PAKISTAN

S. A. Rizvi
Rizvi & Ahmed Associates
39C, Commercial Area
Nazimabad, Karachi, PAKISTAN

The country of Pakistan has been experiencing an increasing power demand and consequent shortfall to meet that demand. To keep pace with demand it will be necessary to add 1000 MW each year.

Predominant sources of generation are oil which must be imported, indigenous low-grade coal, and hydropower (50% of total) plentiful in the Northern region. One small nuclear plant is located near Karachi. Wind energy has the potential to match the need for electricity during the dry season when hydro plants are cut back.

The representative from WAPDA, Mr. Ajmal, advocates the use of renewable energy sources to supplement generating capacity and has gained agreement in principle from the Chairman to undertake a wind resource assessment program (see Attachment F). He indicated that the government meteorological department information he obtained had not been helpful and that he intends to administer the measurement program through WAPDA.

A previous investigation into the potential for use of wind energy in Pakistan was done in 1975 by an Australian consulting firm. That study determined that the windspeed was not sufficient for wind development in Pakistan. Until recently, most key decision-makers in WAPDA and the government had used that study to disregard the need to investigation wind energy potential any further.

During an AWEA-led technical mission to Pakistan in May 1990, new information was provided about technology advances and the government's interest in wind has been rekindled.

U.S. industry can be instrumental in shaping the WAPDA wind measurement program. A feasibility study managed by a U.S. wind professional would help guide the program in the best methods for collection and analysis of the data. The potential for grid-connected wind energy development depends largely on that program.

Private power production has been encourage and advanced by US/AID and several projects are on the drawing board. The potential for a profitable, equitable purchase price remains a question as well as concerns about the political stability of the country.

In respect to small wind systems, there is a great need to provide water and electricity for the 70% of the population that live in very small villages in vast remote areas of the country. One company in Karachi, Marin Limited, has manufactured over 40 multi-bladed mechanical windmills which have been installed in the desert areas but developing technical skills for maintenance of equipment in rural areas has been a problem.

Mr. Shah and Mr. Rizvi are engaged in a program that will install 100 small wind systems that can pumping drinking/irrigation water as well as charge batteries (see Attachment G). Each household would purchase a battery and take it to be recharged for a small fee when ever needed. In this way the system (maintenance) will be self-supporting.

The area of greatest rural need is also the area of greatest wind potential; the Baluchistan coast which lies West of Karachi. Vast regions have no power and the very low water table makes hand pumps unusable. A few small cities are served by expensive diesel mini-grids. Fuel transportation costs over poor roads make wind/diesel hybrid systems a potential cost-saving alternative.

Other key contacts for large systems are the Ministry of Water and Electricity, the Chairman of WAPDA, Gen. Lahid Ali Akbar, and WAPDA's Member of Power and Mr. Ajmal's superior, Javed Akhtar. For small systems, Dr. Junejo, Ministry of Science and Technology directs the activities of the Pakistan Center for Appropriate Technology.

PHILIPPINES

Participant: Jose Rene C. Roncesvalles
Project Manager
Local Water Utilities Administration (LWUA)
MWSS-LWUA Complex, Katipunan Rd, Balara, Diliman
Quezon City, PHILIPPINES

Like other Pacific Rim countries the growth of electricity demand has severely taxed the government's ability to build new generating capacity. Power outages are a frequent nuisance in the Manila area and many corporations are setting up captive generating capacity to meet their needs. The government utility bureaucracy does not appear interested in exploring wind for bulk power. The lack of wind data and the inaccuracy of that which is available have led to a generalized belief that the windspeed is not sufficient for this application.

With Japanese assistance money, a small windfarm (approximately a dozen 15 kW Yamaha turbines) has been installed on the north side of Luzon. No further information is available. The only other known wind equipment in the Philippines is a U.S. manufactured Enertech system that was never properly installed, is not working, and may be the reason that there is no serious interest in wind energy.

Regarding remote wind power potential, the Philippines as a nation of many small islands has the need for dispersed power systems. The rural electrification program which was active under Marcos was poorly managed and ineffective. The current government has lost interest in rural electrification.

The Local Water Utilities Administration, however, has been charged with providing potable water to the population on several remote Philippine islands. Through a German government funding, they are proceeding on a $1 Million program to use photovoltaics-powered water pumping at 15 sites. This will benefit 15-20 villages and a total of 100-200 households. Wind-powered water pumping could clearly offer a least-cost option in locations where the wind resource are determined sufficient. Mr. Roncesvalles seemed interested in wind-powered water pumping applications but voiced the necessity of convincing the government to investigate the technology.

A key government agency is the Office of Energy Affairs, which he indicated has as one of its purposes to consider and study alternative energy sources.

Assistance in preparing feasibility studies for 5-10 kW wind water-pumping systems and demonstrations of the technology as an alternative to diesel-powered systems is important for convincing policy-makers of wind's usefulness. Funding will need to come from US/AID or other sources for this.

SOMALIA

Participant: Ahmed Mohamed Jama
Director of Projects & Planning
National Agency for Electricity and Energy
P.O. Box 1
Mogadishu, SOMALIA

Somalia is reported to have the highest winds speeds in Africa. Located at the tip of the horn of Africa between Ethiopia and Kenya, the prevailing northeast winds are nearly permanent. The only exception is when the winds switch direction to the southwest during the monsoon season.

In 1985 under a UNDP program, RISO in Denmark began a pilot project. Since 1987, four 55 kW Bonus turbines have been installed in a diesel grid near Mogadishu, the capital.

Initial problems with corrosion in the hot, humid environment were eventually corrected with acid resistant stainless steel bolts and epoxy coatings. There has been a continuous mechanical and electrical training program and the results have shown wind energy to be competitive, especially since Somalia has to import its oil.

Average capacity factors of the Danish turbines were over 35% in 1988. The 1989 results were lower due to lower wind and some down-time on the equipment. The need for sufficient spare parts to be available was emphasized by Mr. Jama.

Mr. Jama is the principal person in charge if the wind program at the national utility. Plans for 1992-97 include a 5 MW of additional wind energy generation and extension of the grid. Funding has not been secured for this expansion. He is looking for support for further wind measurement equipment and funding for this 5 MW expansion. US/AID maintain a very small office with minimal funding support.

A World Bank study is currently being done by Kennedy & Donkin of U.K. This is expected to show wind as economically attractive but it is not a full feasibility study.

The unstable political climate in Somalia, however, is cause for concern. The present dictatorship continues to weaken and a widely supported rebel coalition may ultimately take over the government. The utility infrastructure is not expected to be affected by this and any changes at the top may not disrupt the function of government agencies. Even with a great wind resource, Somalia does not appear to be a top country prospect for U.S. companies.

TURKEY

Participant: Adnan Temiz
Head, Wind Energy Unit
General Directorate of Electric Power Resources
Survey and Development Administration
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The General Directorate of Electric Power Resources (EIE) has been actively investigating the use of wind energy since 1983. National wind data has been collected at 114 stations by the state meteorological organization and with the help of the Turkish Scientific and Technical Research Institute (TUBITAK) a wind map of Turkey has been prepared.

Several demonstration programs have been underway

(1) using 1.1 kW three-bladed Darrieus type wind turbine with battery storage for rural electrification.

(2) using a 20 kW HAWT system for farm lighting and water-pumping.

(3) using a 6-bladed mechanical windmill to investigate pumping capacity and operational problems.

Another organization in Turkey studying the use of wind energy is Istanbul Technical University. In the private sector, a 55 kW Vestas turbine from Denmark was installed in 1984 to supply power directly into industrial facilities at Altinyunus.

Although all of the systems mentioned are foreign-manufactured, several local manufacturers in western Turkey make crude mechanical windmills.

Mr. Temiz's English language ability was very limited and hindered further exchange of information. He did, however, indicate reliability problems with anemometers purchased in the U.S. and asked for assistance.

It appears that a genuine interest in wind energy exists in Turkey. The potential for U.S. involvement in Turkey's development will require developing a closer flow of communication with Mr. Temiz and other interested decision-makers.

ATTACHMENT A

AGENDA: WIND ENERGY APPLICATIONS AND TRAINING SYMPOSIUM

SAN FRANCISCO, CA — Wednesday, Sept. 19

Welcome Reception:	6:30-8:30 PM

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SAN FRANCISCO, CA — Thursday, Sept. 20

Welcome: *Dianne Eppler/American Wind Energy Association*	8:30 AM
Overview of the Development of Wind Energy in the U.S.: Energy Crisis, Tax Incentives, PURPA *Tim Olsen/California Energy Commission*	8:45 AM
International Guest Presentations:	9:30 AM
---Coffee Break---	10:30 AM
Role of Government Research & Development: *Palmer Carlin/SERI*	10:45 AM
International Guest Presentations:	11:15 AM
---Luncheon-Speaker: *Tim Olsen/California Energy Commission*	12:00 Noon
Utility Perspective - Interconnection Issues and Safety: *Bill Steeley/Pacific Gas & Electric Co.*	1:00 PM
International Guest Presentations:	1:30 PM
---Coffee/Soft Drink Break---	3:00 PM
Elements of a Windfarm: *Bob Gates/Zond Systems*	3:15 PM
International Guest Presentations:	4:15 PM

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SAN FRANCISCO, CA: — Friday, Sept. 21

Resource Assessment/Siting Considerations: *Ed McCarthy/U.S. Windpower* *Bob Baker/AeroVironment Northwest*	8:30 AM
---Coffee/Tea Break---	9:45 AM
Operations, Maintenance and Training: *Bob Lynette/R. Lynette & Associates*	10:00 AM
California Windfarm Performance: *Bob Lynette/R. Lynette & Associates* *Sam Rashkin/California Energy Commission*	10:30 AM
---Lunch Break---	11:30 AM
WINDFARM TOUR of Altamont Pass	12:30 PM

AMARILLO, TX: Saturday, Sept. 22

Remote, Stand-Alone Wind Energy Applications: 3:00 PM
Overview of Applications:
Nolan Clark/US Dept of Agriculture

Mechanical Water-Pumping:
Jim Lane/Aermotor Windmill Company

Electrical Water-Pumping Systems and Case Study-Morocco:
Mike Bergey/Bergey Windpower

Hybrid Systems - Wind/Diesel/PV:

SITE TOUR of Water-Pumping Demonstration: USDA Bushland site 5:00 PM

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WASHINGTON, DC: Monday, Sept. 24

Technology Transfer: 8:30 AM
Mike Bergey/Bergey Windpower

Economic Analysis: 9:00 AM
Robert Poore/R. Lynette & Assoc.

U.S. Technical Assistance: 10:00 AM
Ron Pate, Sandia Design Assistance Center

Panel Discussion: U.S. Financial Assistance: 10:30 AM
Moderator: *Ralph Burr/Dept. of Energy*
Panel: *James Sullivan/Agency for International Development*
Steve Klein/Agency for International Development
Priscilla Rabb-Ayres/Trade and Development Program
John Wisniewski/Export-Import Bank

---Luncheon Break--- 12:00 Noon

Panel Discussion: Creating a Successful Project 1:00 PM
Moderator: *Les Garden, Dept. of Commerce*
Panel: Prefeasibility - *Robert Poore, R. Lynette & Assoc.*
Feasibility - *Pete Smith/World Bank*
Financing - *John Besant-Jones/World Bank*
Larry Carpenter/ESI Energy
Turnkey Operations - *Neal Emmerton/SeaWest*

---Coffee/Soft Drink Break--- 3:00 PM

Symposium Wrap-up: 3:15 PM
Individual Country Discussions

Closing Remarks: 4:30 PM

Windpower '90 Conference - Opening Reception: 6:30 PM

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Tuesday, September 25

Open day for personal interests such as sightseeing.

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See the "Windpower '90" Conference Brochure for rest of weeks events.

ATTACHMENT B

GUESTS: 1990 WIND ENERGY APPLICATIONS & TRAINING SYMPOSIUM

CAPE VERDE

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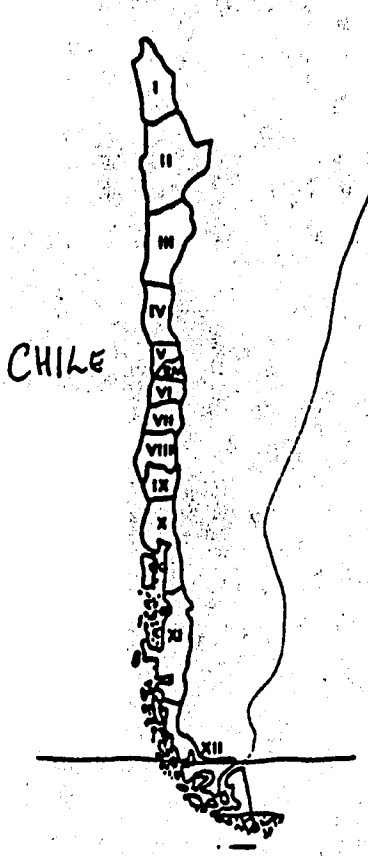
ATTACHMENT C

CHILEAN POPULATION AND

GROSS DOMESTIC PRODUCT (GDP)

1. Population : 13.000.000
2. GDP : US$ 25 billion (1989, aprox.)



REGIONS	POPULATION %	GDP %
Far north	2,63	3,2
	2,94	5,4
	1,54	2,1
	3,72	2,1
	10,61	10,2
Central	39,41	41,5
	4,97	5,9
	6,40	4,0
South	12,87	9,7
	6,03	3,2
	7,13	4,7
	0,60	0,5
Magallanes	1,18	2,8
	100,00	100,0

ELECTRICAL SUPPLY

IN CHILE

1. Electric Energy Consumption : 16.000 million KWH/año

2. Electrical Supply

- Central Region:

  - 20 hydroelectric plants, y 4 thermical plants, with an installed power of 3.000 MW and 2.000 Km. of Central Interconnected System.
  - It concentrates 80% of total population and most economic activity.

3.000 MI

- Northern Region:

  - No hydraulic resources; production of energy based on coal, heavy oil and diesel, with an installed capacity of 700.~~000~~ MW. 700 MW
  - Important mining activity with great consumption of energy of 1.800.000 MWH.

700 MI

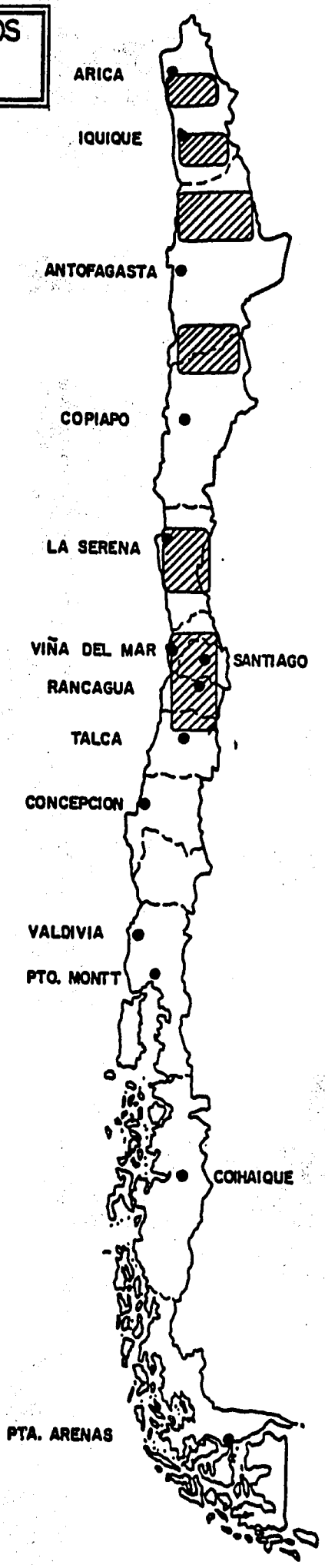
Southern Region:

  - Production of energy based on diesel oil and natural gas, and some small hydroelectric plants. The installed power is 97.000 KW and 190.000 MWH of production.
  - Low population density; the most important city is Punta Arenas, 100.000 inhabitants.

100 MW

Tot: 3.800 MW

SISTEMAS ELECTRICOS DE CHILE



ZONA ATENDIDA POR EL SISTEMA NORTE (SING) Generación Termica.

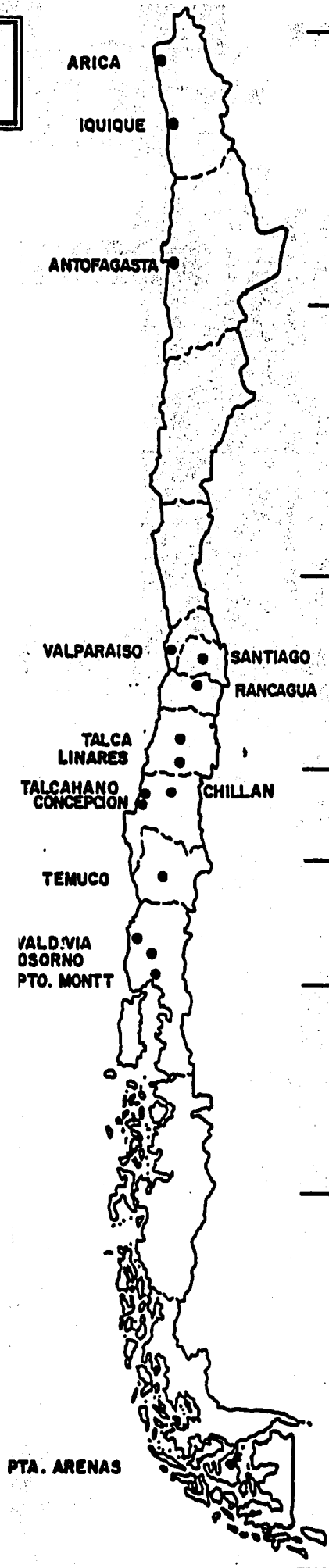
ZONA ATENDIDA POR EL SISTEMA CENTRAL (SIC) Generación Hidraulica.

SISTEMA AYSEN Generación Hidraulica.

SISTEMA MAGALLANES Generación Térmica

AREAS DE ALTO CONSUMO MINERO E INDUSTRIAL

POBLACION Y CONSUMOS ELECTRICOS



1ra. ZONA ELECTRICA

Consumo : 2.240.000.000 KW H/a.

2da. ZONA ELECTRICA

Consumo : 1.260.000.000 KW H / año

3ra. ZONA ELECTRICA

Consumo : 8.850.000.000 KW H/a

4ta. ZONA ELECTRICA

Consumo : 2.520.000.000 KW H/ año

5ta. ZONA ELECTRICA

Consumo : 560.000.000 KW H/año

6ta. ZONA ELECTRICA

Consumo : 65.000.000 KW H / año.

7ma. ZONA ELECTRICA

Consumo : 148.000.000 KW H /año.

CIUDADES CON MAS DE 100.000 HABITANTES.

ESTUDIOS DISPONIBLES SOBRE APROVECHAMIENTO DE VIENTOS

LUGAR	AÑO	EJECUTOR
1. CHUQUICAMATA	1986 A 89	U. de Chile. Facultad de Ciencias, Departamento Eléctrico.
2. VALPARAISO	1982	Universidad Católica de Valparaiso, Inst. de Matemáticas y Físicas.
3. CONCEPCION	1981	Universidad de Concepción, Facultad de Ciencias.
4. ISLA DE PASCUA	1981	Universidad Técnica F. Santa María, Depto. Ingeniería Mecánica.
5. VALPARAISO	1984	Universidad Técnica F. Santa María, Depto. Ingeniería Mecánica.

LUGARES CON PERSPECTIVAS

1. CHUQUICAMATA

- Alto costo de generación (US$ 5,9 ctd/KWH), basado en combustibles que tiene alto costo de transporte.
- Alto consumo por la actividad minera (1.400.000 MWH/año).
- Posibilidad de sustituir un 1% del consumo (14.000 MWH/año) con la instalación de aerogeneradores de 300 KW cada uno.
- Velocidad media del viento: 8,5 m/seg. durante 12 horas al dia.

2. ISLA DE PASCUA

- Alto costo de generación (US$ 10 ctd/kwh), basado en petróleo que debe ser transportado a la isla.
- Consumo eléctrico 2.200 MWH/año.
- Posibilidad de instalar 5 aerogeneradores de 50 KW cada uno, lo que sustituiria el 30% de la generación térmica.
- Velocidad media del viento: 6,0 m/seg. durante 6 horas al dia.

REGISTROS DE VIENTO EN DISTINTOS LUGARES DE CHILE Y COSTO ACTUAL DE GENERACION

	Lugar	Veloc. Media (*) m/s	Tiempo en que la velocidad es superior a la media. Horas	Costo Generación. cUS$/KWH
NORTE	Arica	4,5	6	7,5
	Iquique	3,8	6	4,6
	Calama	5,3	6	6,0
	Caldera	4,0	12	4,5
	Potrerillos	4,0	12	4,5
Centro Sur	Isla Juan Fernández	6,0	18	10,0
	Punta Los Andes	7,2	12	s.c
	Punta Tumbes	6,8	12	s.c
	Ancud	7,7	6	2,0
	Isla Guafo	7,2	12	s.c
	Balmaceda	8,7	12	8,2
	Chile Chico	9,5	6	4,0
Extremo Sur	San Pedro	9,0	18	s.c
	Isla Evangelista	13,0	18	s.c
	Punta Dunguenes	8,5	18	s.c
	Punta Arenas	9,7	12	4,0
	Isla Diego Ramirez	12,5	18	s.c

(*) Datos proporcionados por Universidad Fed. Santa Maria
s.c. : sin consumo

USOS DE ENERGIA EOLICA

EN PEQUEÑA ESCALA

- Existen 200.000 viviendas en sector rural que carecen de servicio eléctrico, debido a su lejanía de los centros de distribución y su baja capacidad económica.

- El recurso eólico no está suficientemente estudiado en el país, ni tampoco en estos lugares.

- Se estima interesante estudiar un programa de generación eólica para atender necesidades domésticas y de algunas faenas productivas.

  Por ejemplo : iluminación, radio y TV.
  bombeo de agua
  molienda de granos
  refrigeración de pesca artesanal.

ATTACHMENT D

STUDY OF WIND POTENTIAL IN COSTA RICA

The Instituto Costarricense de Electricidad (ICE) is the national electric utility of Costa Rica and it has been responsible, during the last 40 years, of the development and expansion of the National Electric System (N.E.S). The natural conditions of the country, mainly the abundant hydraulic resources, has made it possible to develop hidroelectric resources at a comparatively low cost (U.S. $0.05/KWh) and the transmission and distribution lines have been extended to practically every corner of the country.

The N.E.S is currently consisting of a generation sub-system based on hidroelectric power plants located at the northwest, southeast and west part of the central area, the largest consumption of the center of the country, a 230 kv and 138 kv transmission sub-system and a 34.5 kv and 13.8 kv distribution sub-system.

Up to date, an electrification index in order of 90% has been achieved (100% of urban covering and 60% of rural covering), with an installed capacity of 866 MW. 823 MW of this total capacity (95%) belongs to ICE and the rest to some distribution companies. Last year, the N.E.S. generated a total energy of 3349 GWh, 93.5% of ICE production. The 84% of the installed capacity (724 MW) is mainly hidroelectric power plants and 16% thermoelectric plants. However, during last 10

years the thermoelectric production was less than 3% of the total energy production.

Historically, the demand for electricity has been growing at the rate of about 7%, which means that by the beginning of the next century, the country will be ne about 1600 MW. The development program up to the year 2000 considering a 65% hidroelectric, 13% geothermal and 22% thermo-electric plants using imported petroleum.

During last decade, in the period from 1981 to 1983, ICE started a preliminary study on a nationwide level, of the areas having the greatest aeolian potential, for which purpose, use was made of existing weather stations and a few auxiliary ones, which were temporarily installed for such purpose.

During the course of this study, ICE was assisted by the Swiss consulting firm ELECTROWATT I.C.. Here are some details of this study.

The most thorough compilation of data which documents the possible wind resource was presented in a report prepared by Electrowatt. In this report, it presents a summary of wind data collected at 16 long term permanent stations and 17 short-term stations. The period of time which data were collected at the permanent stations ranges from one to ten

years with the average for the better locations being approximately three years. None of these locations, however, were selected or designed to collect meteorological data to document a potential wind energy resource.

Electrowatt recognized the limitations of these two sets of data, but still attempted to correlate the short term data with the permanent data in order to estimate the possible annual mean wind velocity at each short term station. They also used the vertical profile measurements at some of the short term stations to estimate the vertical wind profile at the permanent stations.

The data collected at the permanent and short term monitoring locations, along with the correlation estimates, do identify five locations with a good potential for an economic wind resource. These locations are Tejona, La Fortuna, Rio Naranjo km 26, Rio Naranjo km 21, and Vista de Mar. In addition, ICE had supplemental meteorological data at Tejona and La Fortuna which further identified these two sites as having a likely wind resource.

In May, 1988, a cooperative agreement was signed with California Energy Commission (C.E.C.) for the latter organization to provide technical advice to ICE in initiating a pilot program that will give us the necessary technical

elements to determine whether a project on a larger scale is possible in our country.

The main objective of this initiative is to develop a program to study the technical and economic feasibility of using wind power as an alternative for the commercial generation of electricity at selected sites.

In May, 1989, officials of the C.E.C. visited Costa Rica for the purpose of starting the above mentioned advisory service.

The officials made a review of the existing meteorogical data and mentioned some of the aspects that follow the exposition.

The C.E.C. officials concluded that the best location for a commercial wind energy project in Costa Rica would be at the Tejona site.

Three of the remaining sites which were reviewed, La Fortuna, Rio Naranjo km 26 and Rio Naranjo km 21 all showed some promise of having a good wind energy resource which could be feasible for development.

The disadvantage of these sites, as compared to the Tejona site are:

1-. each site has a fewer existing meterorological data,

2-. the monitoring locations at La Fortuna and Rio Naranjo km 26 had questionable exposure, and

3-. the measured calculated wind velocities at these sites were approximately 30 percent less than Tejona site.

These three sites do, however, have slightly smoother terrain which makes them somewhat more desirable for construction. These sites also have adequate transmission capacity nearby and existing land use which should be compatible with wind energy development.

ICE, as a C.E.C. officials recommendation, started on January 1990 the wind resource monitoring at the Tejona site. This resource monitoring is under the active direction of ICE with the U.S. WINDPOWER, INC. as a qualified meteorological contractor coordinating the collection and analysis of the data.

ICE considers it advisable to go further into the studies of Tejona, La Fortuna and Rio Naranjo sites since the wind is a renewable source of power and which, because of the features of its annual distribution, could be adequately supplemented with hidroelectric generation. since the hydraulic resource is less, precisely during the months when wind power is greater.

On May 1989, the Costa Rican Government issued an Executive Decree to allow private entrepreneurs to generate electricity on a co-generation basis with ICE and the wind power is a good possibility to generate elctricity on a commercial basis and it could be carried out by private entrepreneurs.

THIRD WIND ENERGY APPLICATIONS AND TRAINING SYMPOSIUM SEPTEMBER 19 - 25 - 1990
SAN FRANCISCO, ANARILLO, DALLAS, WASHINGTON

ATTACHMENT E

L'EOLIENNE : UNE TECHNOLOGIE APPROPRIEE POUR LE DEVELOPPEMENT RURAL DANS LES PAYS DE LA REGION CEAO/CILSS

PAR MR Vincent Hessou

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Centre Régional d'Energie Solaire

Bamako - Mali

Septembre 1990

36

I. INTRODUCTION

Devant les nombreux problèmes bien connus auxquels les pays en développement sont confrontés (lourde facture pétrolière, dégradation des termes de l'échange, crise de l'endettement, démographie galopante, secheresse, disparition progressive des ressources forestières etc), le développement de l'utilisation de technologies d'énergies renouvelables fiables et présentant des rapport coûts/avantages favorables apparait :

- comme une démarche rationnelle dans la recherche d'une large indépendance énergétique,
- comme un moteur pour le décollage économique du monde rural en faveur des couches les plus sensibles de la population (femmes et enfants notamment)
- comme une alternative pour un développement endogène et autocentré respectant les équilibres fondamentaux de l'environnement naturel.

C'est pourquoi les pays membres de la CEAO et du CILSS se sont engagés résolument dans la voie de la prospection des possibilités d'utilisation des énergie renouvelables, singulièremebt depuis le premier choc pétrolier en 1973. La volonté politique existe, mais on sait que les problèmes évoqués ci-dessus sont actuellement si aïgus qu'ils bloquent toute perspective de développement industriel et socio-économique et partant toute perspective de développement de programmes étendus dans le domaine des énergies renouvelables.

Comment peut-il en être autrement quand ces pays consacrent 40 à 70 % de leurs revenus en dévises à la facture pétrolière et 80 % au service de la dette ?

En conséquence, sans une assistance technique et un soutien financier solide de la communauté internationale, ces pays ne pourront pas faire des énergies renouvelables un fer de lance du développement rural.

Qu'en est-il plus particulièrement de la technologie éolienne objet du présent symposium ? Est-elle une technologie appropriée pour les pays de la zone CEAO/CILSS.

Certainement, pour les raisons suivantes :

- Comme on le verra dans la suite, bien qu'étant de loin moins abondante et moins répandue que l'énergie solaire, l'énergie éolienne disponible dans ces pays permet d'envisager une dissémination d'éoliennes multipales de pompage dans pratiquement toute la zone CEAO/CILSS, comme une contribution à la maîtrise de l'eau priorité fondamentale pour tous ces pays ainsi que d'aérogénérateurs de faibles et moyennes puissances dans la bande cotière en vue de l'électrification de communautés rurales et de petites unités industrielles isolées.

.../....

- Les éoliennes de pompage et les aérogénérateurs de faibles et moyenne puissances sont actuellement des produits parfaitement au point, techniquement fiables et performants. En outre, l'énergie éolienne lorsqu'elle est rationnellement mise en oeuvre est économiquement plus compétitive que les solutions concurrentes (diesel et photovoltaïque notamment) tant pour l'exhaure de l'eau que pour la production d'électricité.

- La fabrication locale des éoliennes multipales est facile à mettre en place (quelques atéliers de fabrication sont déjà fonctionnels). Quant aux aérogénérateurs, compte tenu de leur niveau élevé de technicité et de l'étroitesse d'un marché potentiel, seule une unité régionale est envisageable. Le transfert de technologie est donc possible.

- La gestion et la maintenance des éoliennes de pompage peuvent s'intégrer facilement dans l'organisation décentralisée de la maintenance des pompes à motricité humaine mise en place dans le cadre des programmes d'hydraulique villageoise et qui donne de bons résultats. Quant aux aérogénérateurs, des équipes itinérantes de techniciens spécialisés seront nécessaires.

Dans ces conditions relativement favorables, il apparaît intéressant pour les pays de la zone CEAO/CILSS de tirer les leçons des expériences passée et de mettre au point des programmes d'actions visant à utiliser au mieux l'énergie éolienne.

Plusieurs organismes s'attèlent déja à cette tâche, parmi lesquels figure le Centre Régional d'Energie Solaire qui sera présenté à la fin de cet article.

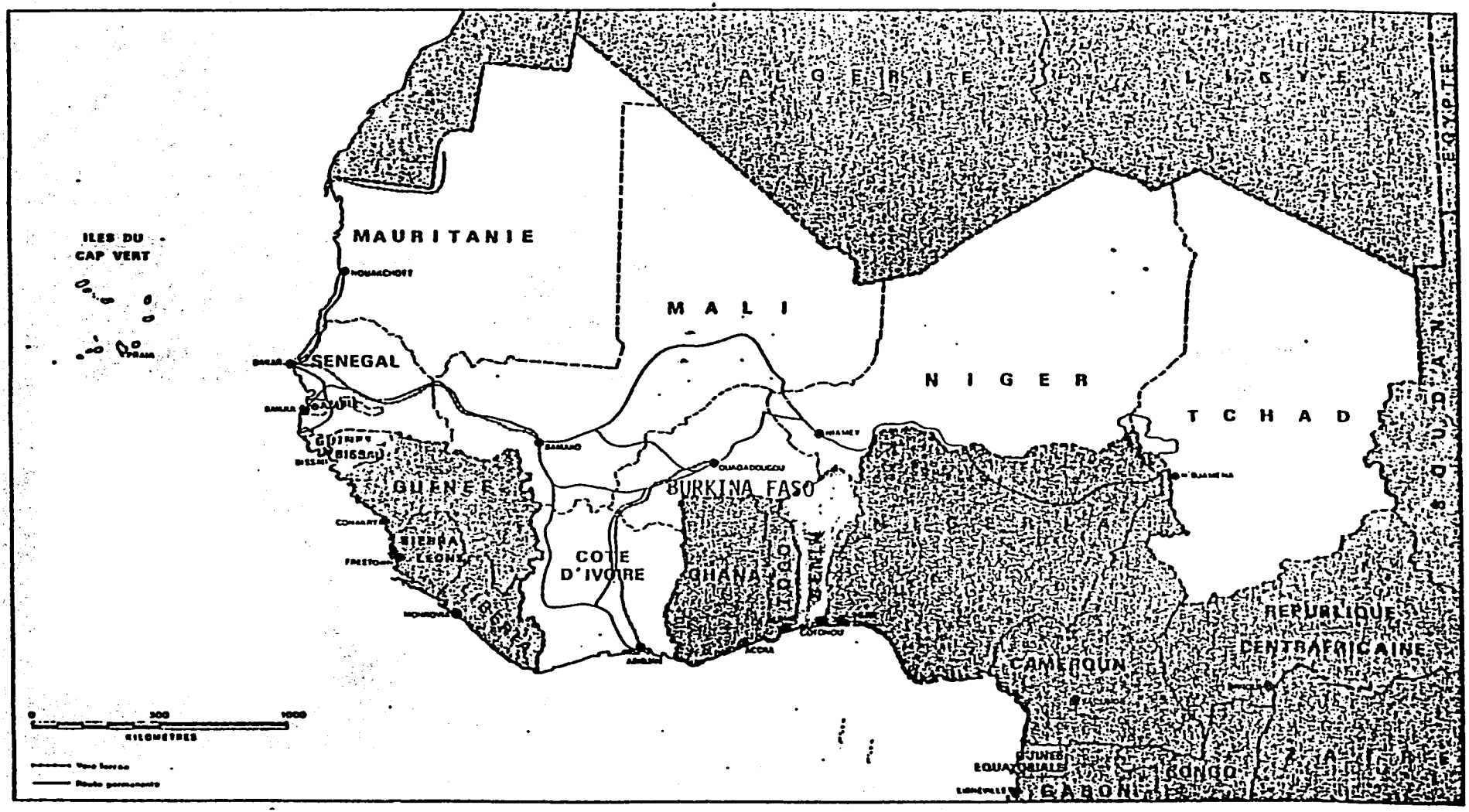
II. PRESENTATION DE LA REGION CEAO/CILSS

La région CEAO/CILSS se compose de 11 pays en développement (FIG 1) couvrant une superficie de 5,8 millions de Km2 avec une population de 55 millions d'habitants. Neuf des 11 états de la Région CEAO/CILSS appartiennent à la zone du Sahel avec une pluviométrie faible (moins de 600 mn par an) irrégulière et concentrée sur une courte saison humide suivie d'une très longue saison sèche. La secheresse presque chronique qui sévit dans cette zone depuis 1973 a mis en relief l'extrême fragilité des économies et des écosystèmes de ces pays.

Le tableau2donne les indicateurs physiques et économiques de base pour les pays de la zone CEAO/CILSS. Ils font tous partie des pays à faible revenu sauf la Côte d'Ivoire et le Sénégal qui sont des pays à revenu intermédiaire.

.../...

CARTE 1 : Les pays de la région CEAO/CILSS



Pays	Superficie 103 km2	Population 10^6 habitants	PNB par habitant USD 1987	Exportation 10^6 USD	Importation 10^6 USD	Balance Commerciale 10^6 USD
BENIN	113	4,3	310	168	418	-250
BURKINA	274	8,3	270	202	540	-338
CAP-VERT	4	0,42	-	-	-	-
COTE D'IVOIRE	322	11,1	740	2982	2168	+814
GAMBIE	11	0,85	-	-	-	-
GUINEE-BISSAU	36	0,9	-	-	-	-
MALI	1240	7,8	210	216	447	-231
MAURITANIE	1031	1,9	440	428	474	-46
NIGER	1267	6,8	260	361	417	-56
SENEGAL	196	7,0	520	645	1174	-529
TCHAD	1284	5,3	150	-	-	-
TOTAL	5778	54,67				

TABLEAU 2 : INDICATEURS DE BASE POUR LES PAYS CEAO/CILSS

SOURCE : BANQUE MONDIALE (1989)

Le tableau n°3 rappelle quelques chiffres significatifs du contexte énergétique de certains pays de la région CEAO/CILSS, chiffres qui démontrent leur taux élevé de dépendance et la sensibilité de leurs économies nationales aux fluctuations des coûts du pétrole. La facture pétrolière est lourde alors que la part des énergies commerciales dans la consommation totale d'énergie est très faible (moins de 10 % pour les PMA). Parmi les idées forces actuellement retenus pour endiguer cette situation, figurent en très bonnes places :

- le développement des énergies renouvelables
- la maîtrise des consommations et l'utilisation rationnelle de l'énergie.

C'est pour atteindre ces objectifs que les pays de la zone CEAO/CILSS ont décidé en(1978) de créer en commun le Centre Régional d'Energie Solaire.

III. LE POTENTIEL EOLIEN DE LA REGION CEAO - CILSS

Les principaux courants aériens qui déterminent le régime des vents en Afriqu Occcidental sont (FIG 4) :

- l'alizé maritime boréal issu de l'antocyclone des Açores, intéresse principalement les côtes Sénégalaises et Mauritaniennes pendant la saison sèche.

De direction générale Nord, il a une vitesse moyenne de l'ordre de 8m/s.

- l'alizé continental ou air saharien, vent moderé, provenant de l'anticyclon continental boréal souffle sur les régions sahariennes et sahéliennes au coeur de la saison sèche.

- l'harmattan, vent sec et froid, de vitesse faible ou modérée,provient également de l'anticyclone continental boréal et intéresse toute la partie de l'Afrique Occidentale située au Nord du Front Intertropical (FIT).

- la mousson, vent chaud et humide de vitesse faible, provient de l'anticyclo austral de Sainte-Hélène et intéresse toute la région située au Sud du FIT.

- l'alizé austral de même provenance que la mousson souffle sur la Côte Sud de l'Afrique Occidental essentiellement pendant la petite saison sèche.

Les caractéristiques de ces courants indiquent déjà globalement le régime des vents auxquel on peut s'attendre.

Plus d'une centaine de stations appartenant en général aux services de la météorologie mesurent la vitesse et la direction du vent. Mais la fiabilité de ce système de mesures destiné en fait à la sécurité de la navigation aérienne, est très insuffisante. En effet :

- les mesures sont ponctuelles et effectuées au bout d'intervalles de trois (3) heures. La valeur instantanée ainsi obtenue étant assimilée à la moyenne trihoraire.

.../...

PAYS	Fact.pétro-lière (MFF)	Part des énerg.commerc	Energie totale TEP (1978)	Superficie Km2	Part du petrole en mois expert	Densité énergétique TEP/Km2
BENIN	276	< 10 %	880 000	113	2,5	7,8
BURKINA FASO	446	< 10 %	1 600 000	274	6,4	5,8
COTE D'IVOIRE	2 605	< 40 %	3 320 000	322	1,6	10,3
MALI	450	< 10 %	1 260 000	1 240	4,3	1,0
NIGER	764	< 10 %	1 160 000	1 267	3,6	0,9
SENEGAL	1 620	< 50 %	2 020 000	196	5,1	10,3
	1	2	2		3	

TABLEAU 3 : CHIFFRES SIGNIFICATIFS DU CONTEXTE ENERGETIQUE DANS LA REGION CEAO/CILSS.

SOURCE = GERME 87 - AFME

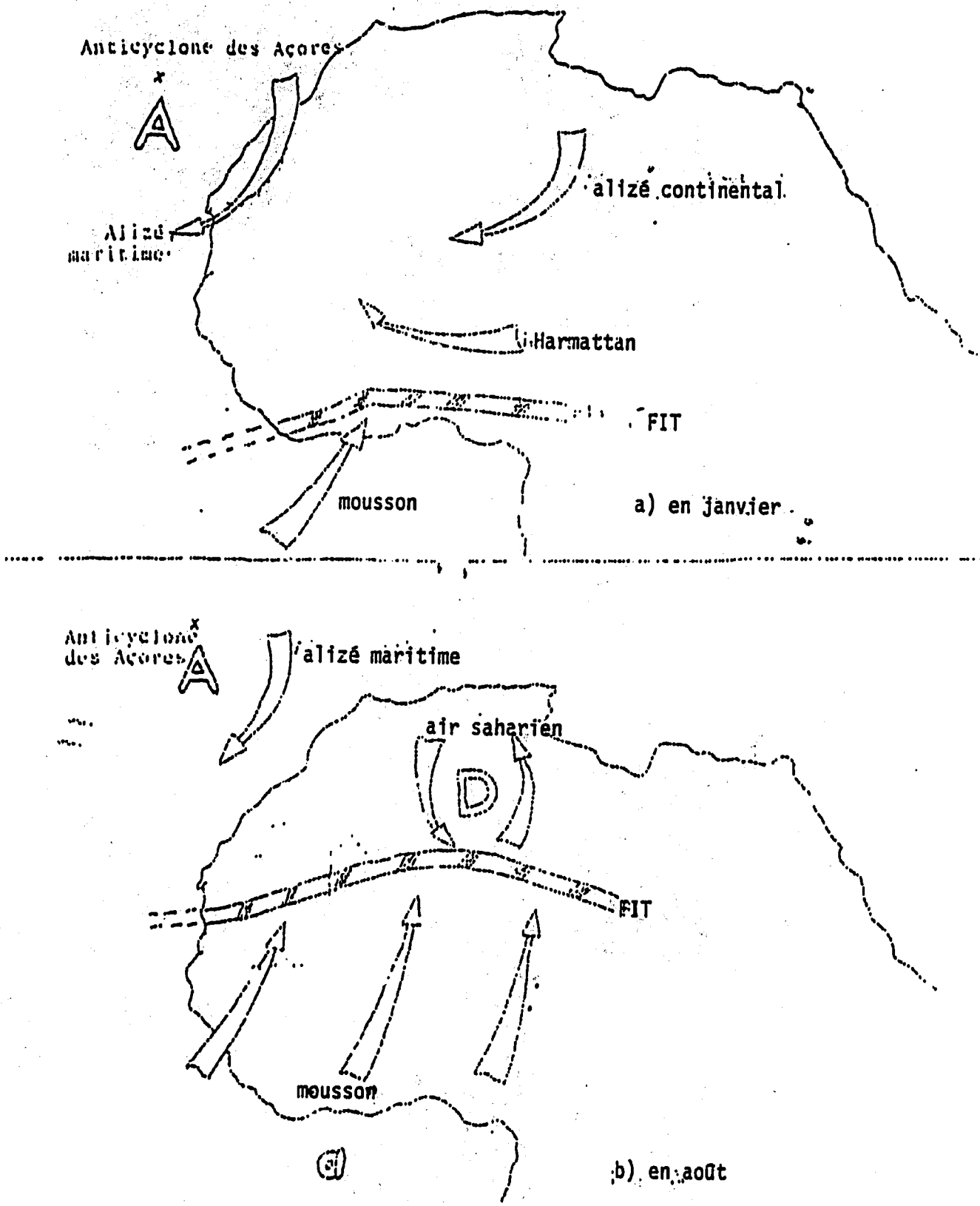


FIG 4 : PRINCIPAUX COURANTS AERIENS EN AFRIQUE OCCIDENTALE

- les hauteurs des anémomètres sont très différentes d'une station à l'autre et sont au plus égales à 10 m. Or on sait que le potentiel éolien ne devient intéressant qu'à partir de 10 mètres.

- la position de certaines anémomètres mal dégagéees des obstacles environnants, fausse parfois les résultats.

Le système de mesures actuel n'est donc pas adapté à une évaluation correcte du potentiel éolien qu'il tend nettement à sous-estimer.

Quelques résultats établis à partir des données existants sont indiqués ci-après

. Mr Cheret (1), à partir des relevés des stations météorologiques de l'Afrique de l'Ouest de 1951-1955 completés par une campagne spécifique de mesures, a dressé la carte des isotaches annuelles du vent (FIG5). Dans le rapport de Mr Cheret on peut noter que les valeurs du coéfficient de structure énergétique $\left(\frac{\sum^{n} v_i^3}{n v^3}\right)$ trouvées pour deux villes, Louga (Sénégal) et Tillabery (Niger) se situent autour de 1,20.

Ce qui confirme que les moyennes relevées tendent à sous-estimer le potentiel éolien réellement disponible. A partir de la carte des isotaches on constate que les régions intéressantes sont :

- la zone au Nord de la latitude 15°
- une bande côtière de 30 à 70 km selon les pays

Dans ces régions la vitesse moyenne annuelle du vent est supérieure à 3 m/s, limite rationnelle de compétitivité de l'énergie éolienne.

Les régions les plus ventées, sont donc la Mauritanie, les Iles du Cap-Vert, le Nord du Sénégal et le Nord du Mali, tandis que la Côte d'Ivoire, le Sud du Mali, le Burkina Faso et le Bénin sont peu ventés.

. La figure 6 donne la répartition moyenne mensuelle pour 7 villes de la région Les mois les plus ventés sont les mois de Janvier et Mai.

. La figure 7 compare la distribution annuelle des vitesses du vent dans une ville située dans la région ventée (Praïa au Cap Vert) et dans une ville peu ventée (Bobo-Dioulasso au Burkina Faso).

IV. APPLICATIONS MAJEURES DE L'ENERGIE EOLIENNE ET CHOIX TECHNOLOGIQUES

La population de la région CEAO/CILSS est à plus de 70% rurale. Les applicatio de l'énergie éolienne devront donc interesser prioritairement les zones rurales à vocation agro-pastorale, non électrifiées ou les besoins fondamentaux sont : l'exhaur de l'eau, la mouture du grain, la réfrigération et la production d'électricité pour différents usages.

.../...

FIGURE 5 : Isotaches de vent (Services Météorologiques)

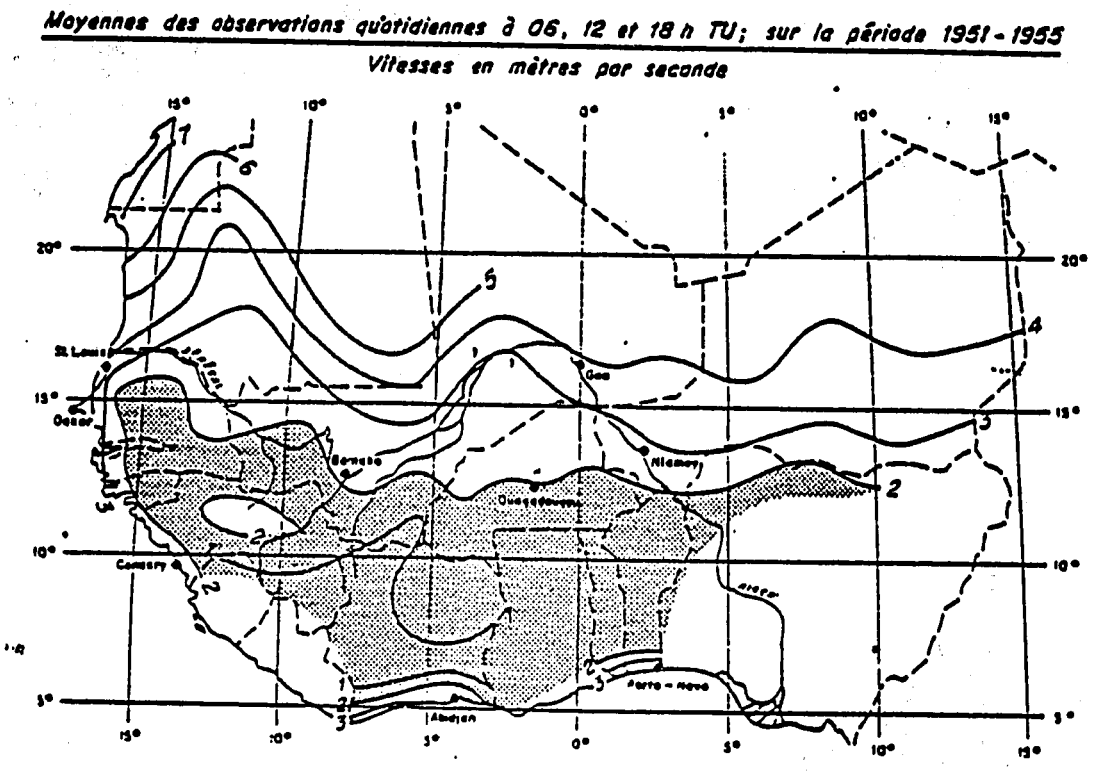


FIGURE 6 : Moyennes mensuelles de la vitesse des vents

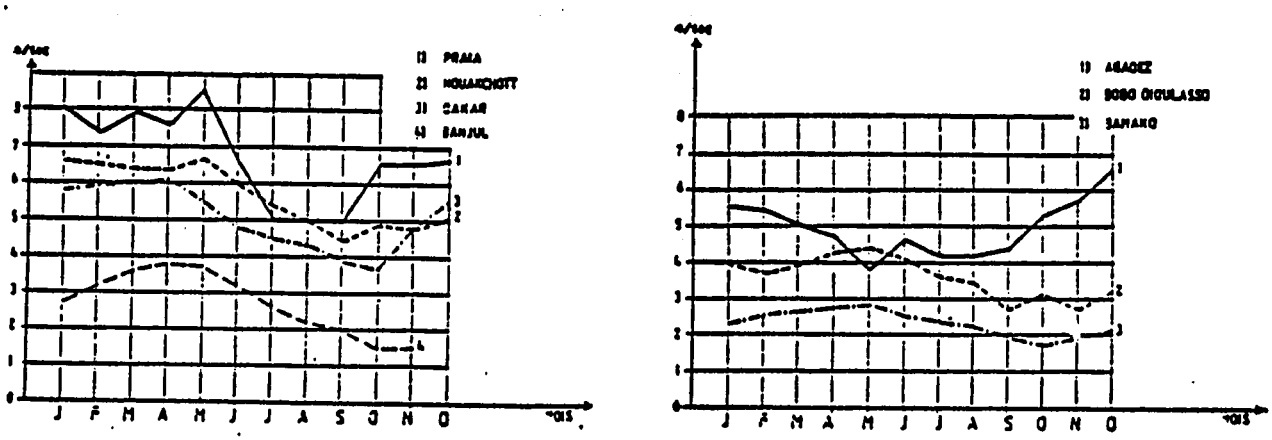
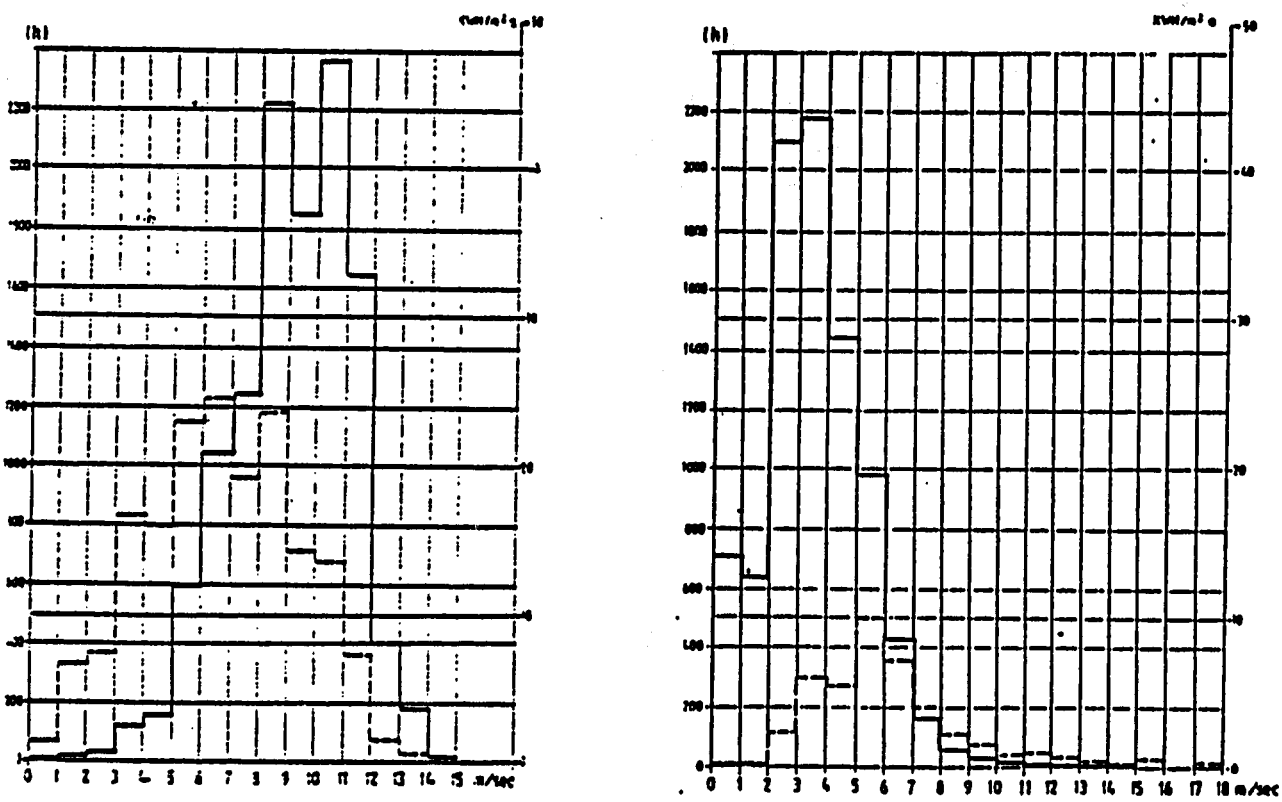


FIGURE 7 : Heures de vent et énergie développée par tranche de vitesse



Praia (CAP VERT) Bobo Dioulasso (BURKINA FASO)

—— heures de vent par tranche de vitesse

.... énergie développée par tranche de vitesse

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4.1. L'EXHAURE DE L'EAU

Pour les pays de la région CEAO/CILSS dont la plupart sont en zones arides, la maîtrise de l'eau est une préoccupation fondamentale. Elle vise à mobiliser l'eau en quantité et en qualité suffisantes pour les besoins de :

- l'irrigation notamment de petits périmètres maraichers, vivriers et forestiers,
- l'alimentation en eau des hommes
- l'abreuvement du bétail

Aussi les problèmes d'exhaure de l'eau sont-ils aïgus. Ils sont actuellement résolus essentiellement par l'utilisation,

- des pompes à motricité humaine : Elles ont un coût initial bas et bénéficient d'une bonne organisation de la maintenance ;
  leurs inconvénients : nécessité d'un effort physique assuré en général par la population féminine, pannes fréquentes, et surtout limitation, des quantités d'eau mobilisables (environ 8m3/j)
- des motopompes diesel de coût initial relativement peu élevé mais présentant d'importants inconvénients : dépendance énergétique, lourdes charges recurrentes, faible fiabilité, nécessité d'un personnel qualifié, risques de rupture de pièces détachées et carburant etc. Cette solution est de plus en plus marginalisée.
- des pompes solaires photovoltaïques : Cette solution élégante est de plus en plus utilisée. Elles sont fiables, à faibles charges récurrentes, reposant sur l'utilisation d'une énergie abondante et gratuite comme l'énergie éolienne. Elles présentent l'inconvénient majeur d'avoir un coût initial très élevé hors de la portée des populations rurales.

Les éoliennes de pompage ont naturellement leur place à coté des pompes solaires qu'elles peuvent compléter d'ailleurs, l'énergie solaire et l'énergie éolienne étant souvent complémentaires. Quoique de maintenance plus exigeante que les pompes solaires, les éoliennes de pompage présentent l'avantage d'avoir un coût initial bas et elles peuvent en outre être fabriquées localement.

Mais quels types d'éoliennes conviennent au pompage dans la région ?

a/ Les ressources en eau et leurs conditions d'exploitation

Les ressources en eau sont réparties en deux catégories :

- les eaux de surfaces provenant des cours d'eaux perennes ou des retenues réalisées au moyen de digues sur les cours d'eau à écoulement temporaire

Elles sont en général destinées à l'irrigation. Les hauteurs de relèvement des eaux nécessaires à l'irrigation à partir des eaux de surface sont en général comprise entre 10 et 20 mètres.

- les nappes souterraines qui peuvent être utilisées pour l'irrigation mais sont plus fréquemment utilisées pour l'alimentation en eau potable et l'abreuvement du bétail.

Elles sont exploitées par puits et forages. Le niveau statique est variable suivant la nature de la nappe et peu atteindre 100 m dans la région.

La carte de la FIG 8 donne les principales nappes de la région et les niveaux statiques qui y sont observés.

En conclusion, pour répondre à la plupart des problèmes rencontrés, le dispositif éolien doit être capable d'assurer l'exhaure de l'eau entre 10 et 100 mètres.

Il doit donc présenter un important couple de demarrage.

b - <u>Les rotors appropriés</u> ' ,

Le couple moteur developpé par une éolienne s'exprime par :

$M = \frac{1}{2} \rho V^2 \pi R^3 \frac{C_P}{\lambda}$ où les grandeurs ont leur significatio classique

Le rotor approprié doit donc possèder les caractéristiques suivantes :

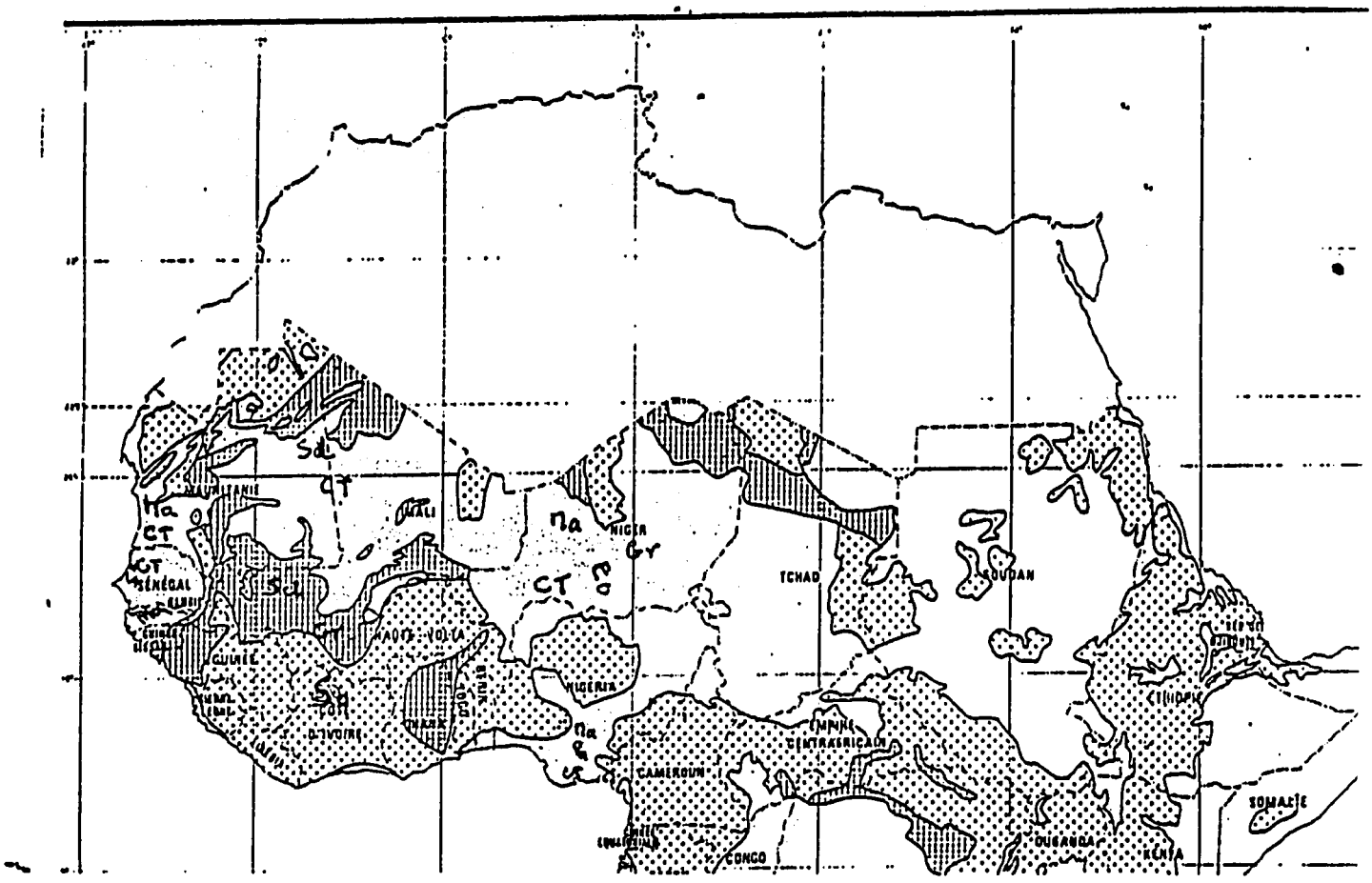
- le coéfficient de vitesse doit être petit. C'est donc un rotor à vitesse lente qui convient
- ses performances doivent être maximales pour les vitesses observées dans la région 3 - 5 m/s.
- Il doit être robuste et de faible entretien
- le transfert de technologie doit être possible.

Essentiellement, deux types de capteurs éoliens peuvent être retenus FIG 9.

- <u>Le rotor multipale à axe horizontal et à vitesse lente</u>

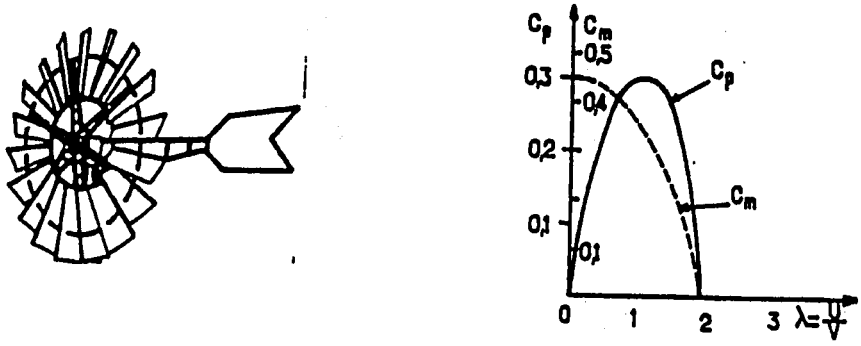
Les plus repandus sont ceux de fabrication américaine et hollandaise. Il bénéficie d'une très longue expérience. Ses principaux inconvenients sont : chute rapide de rendement pour des vents forts ou de direction rapidement variable ; nécessité d'un mécanisme de renvoi d'angle.
Il est très bien connu dans la région ou il a été introduit dans les années 50.

.../...



Nappes	NS (m)
Continental terminal (CT)	5 - 80
Paléocène (Pa)	10 - 30
Eocène (Eo)	10 - 30
Maestrichien (Ma)	5 - 100
Schistes fissurés (sch)	10 - 30
Grès (Gr)	10 - 30
Sables dunaires (sd)	10 - 50
Socle cristallin (SO)	5 - 20

FIG 8 ESQUISSE GEOLOGIQUE ET PRINCIPALES NAPPES DE L'AFRIQUE OCCIDENTALE



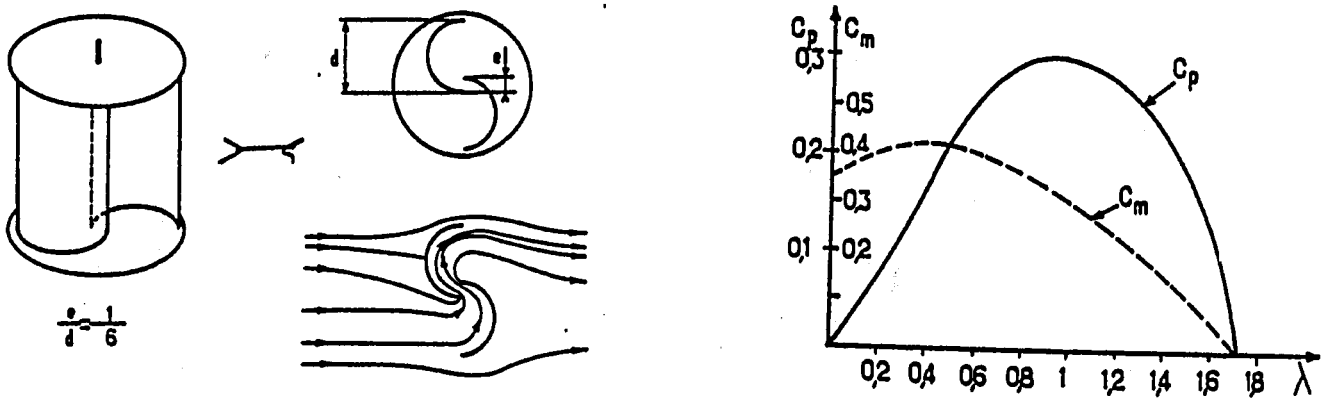


FIG 9 : Cp et Cm pour rotor multipale et rotor Savonius

. Le rotor à axe vertical de Savonius : De construction simple, il ne pose pas de problème d'orientation. Son rendement est plus faible que celui du rotor à axe horizontal mais reste bon pour des vents de direction rapidement variable. Il peut en outre supporter des rafales de 30 m/s. Mais les expériences d'intégration de ce rotor en milieu rural, faites dans la région notamment au Sénégal, ont été très peu concluantes sur le plan de la fiabilité.

c- . Choix de la pompe

Ce sont les pompes Volumétriques qui conviennent aux éoliennes lentes Il existe dans la région plusieurs types de pompes Volumétriques à motricité humaine bien intégrées et bénéficiant de structures décentralisées et éfficaces de maintenance (FIG 10). Une voie d'investigation intéressante serait donc d'adapter les rotors éoliens à ces pompes déjà connues et correctement exploitées ou bien de concevoir des pompes de mêmes structures mécaniques. Des expériences assez concluantes ont été faites avec des rotors multipales et savonius couplé à l'hydropompe Vergnet (2), (3).

d- Autre solution possible pour l'exhaure éolien

Pour les régions ventées, où l'on dispose d'une bonne fréquence de vents de vitesse supérieure à 5 m/s on pourrait envisager de coupler mécaniquement une éolienne rapide (bipale ou tripale) à une pompe centrifuge. Il paraît plus intéressant dans ces cas, d'utiliser un aérogénérateur pour produire du courant électrique qui alimentera une pompe électrique.

e- Compétivité économique de l'exhaure éolien

Il apparaît d'après les références (4) et (5) que :

- pour l'irrigation de pétits périmètres de moins d'un ha, l'éolienne multipale de pompage est plus économique que le pompage Diesel pour des vitesses de vent supérieures à 3,5 m/s (FIG 11).

- le pompage éolien à partir d'un aérogénérateur est plus compétitive que le pompage Diesel et le pompage photovoltaïque pour des vitesses de vent supérieures à 5 m/s (FIG 11).

Ces résultats sont incomplets mais couvrent des cas d'applications assez fréquents.

f- Conclusions

Des produits éoliens techniquement et économiquement performants existent donc pour répondre à la plupart des problèmes d'exhaure de l'eau dans la région.

La zone située au Nord de 15e parallèle et les régions côtières semblent être naturellement privilégiées Toutefois des expériences de pompage éolien menées dans des régions à priori peu ventées ont été très concluantes.

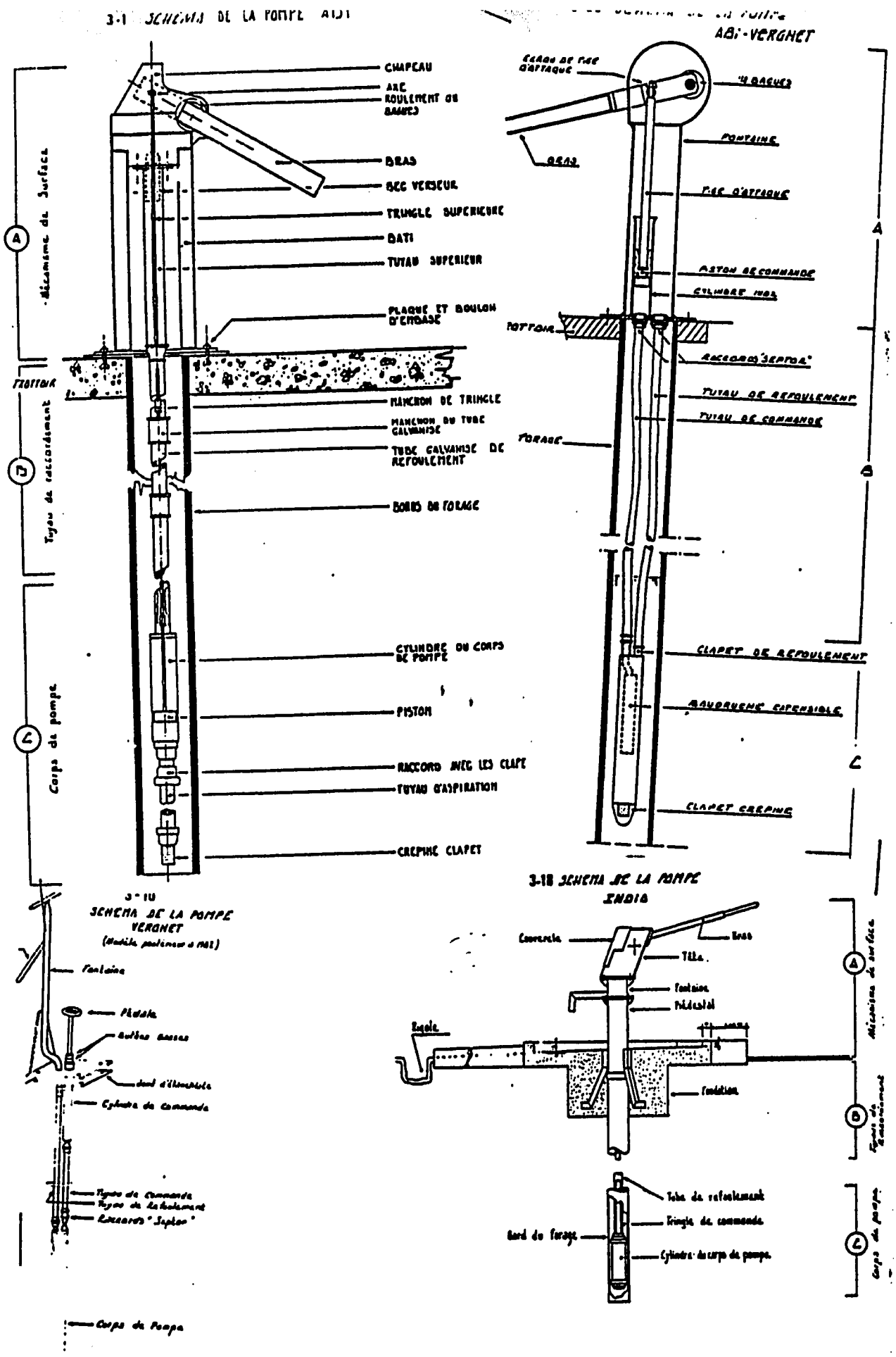


FIG 10 - POMPES A MOTRICITE HUMAINE UTILISE DANS LA REGION

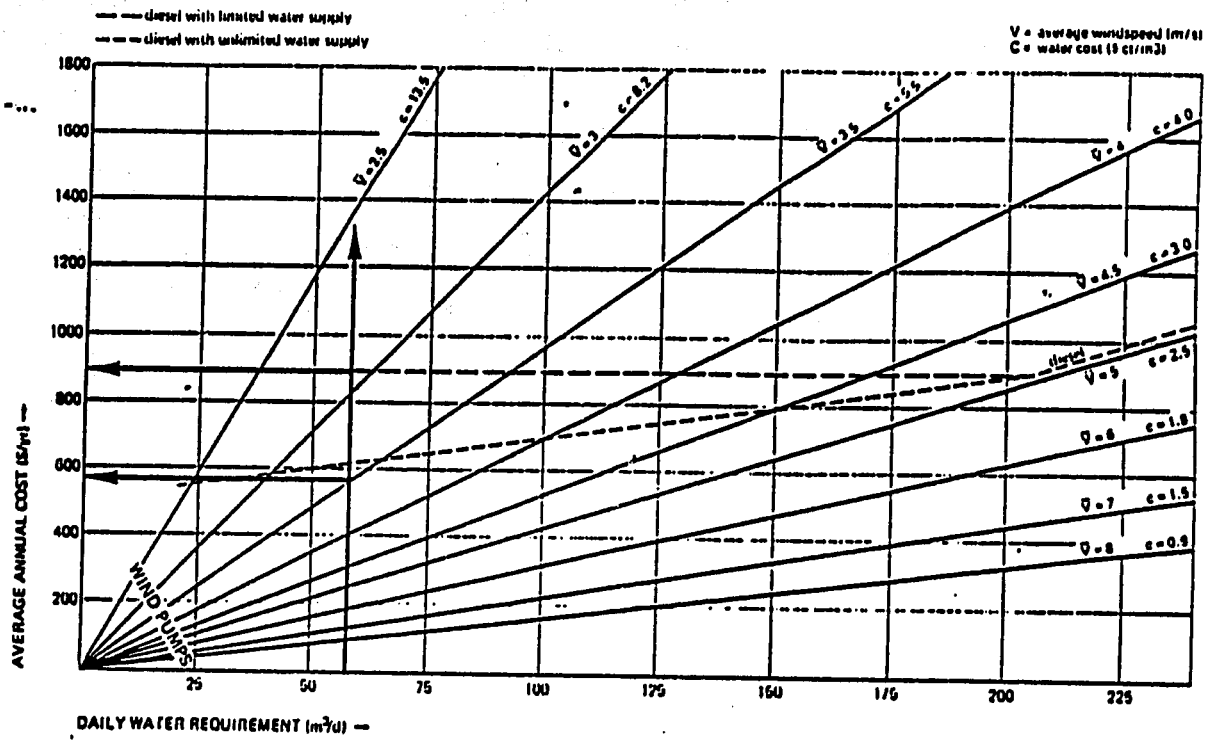


FIG 1: 7m STATIC LIFT; CWD WIND PUMPS AND DIESEL POWERED SUCTION PUMPS

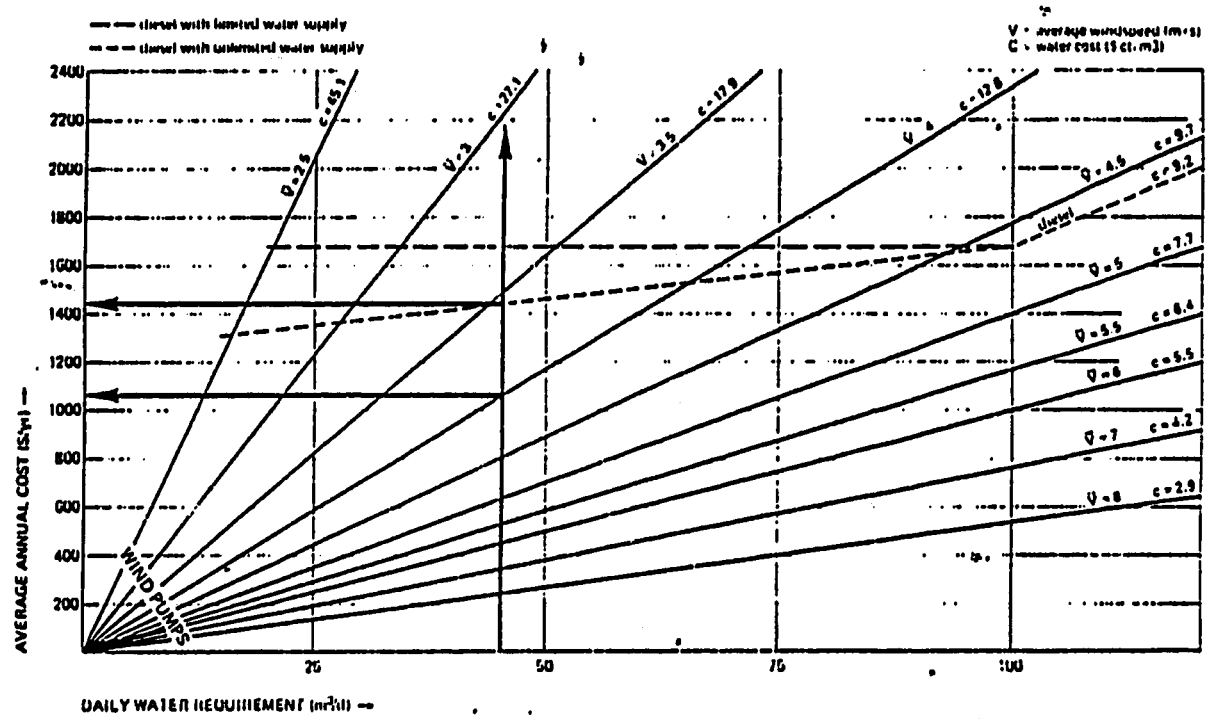
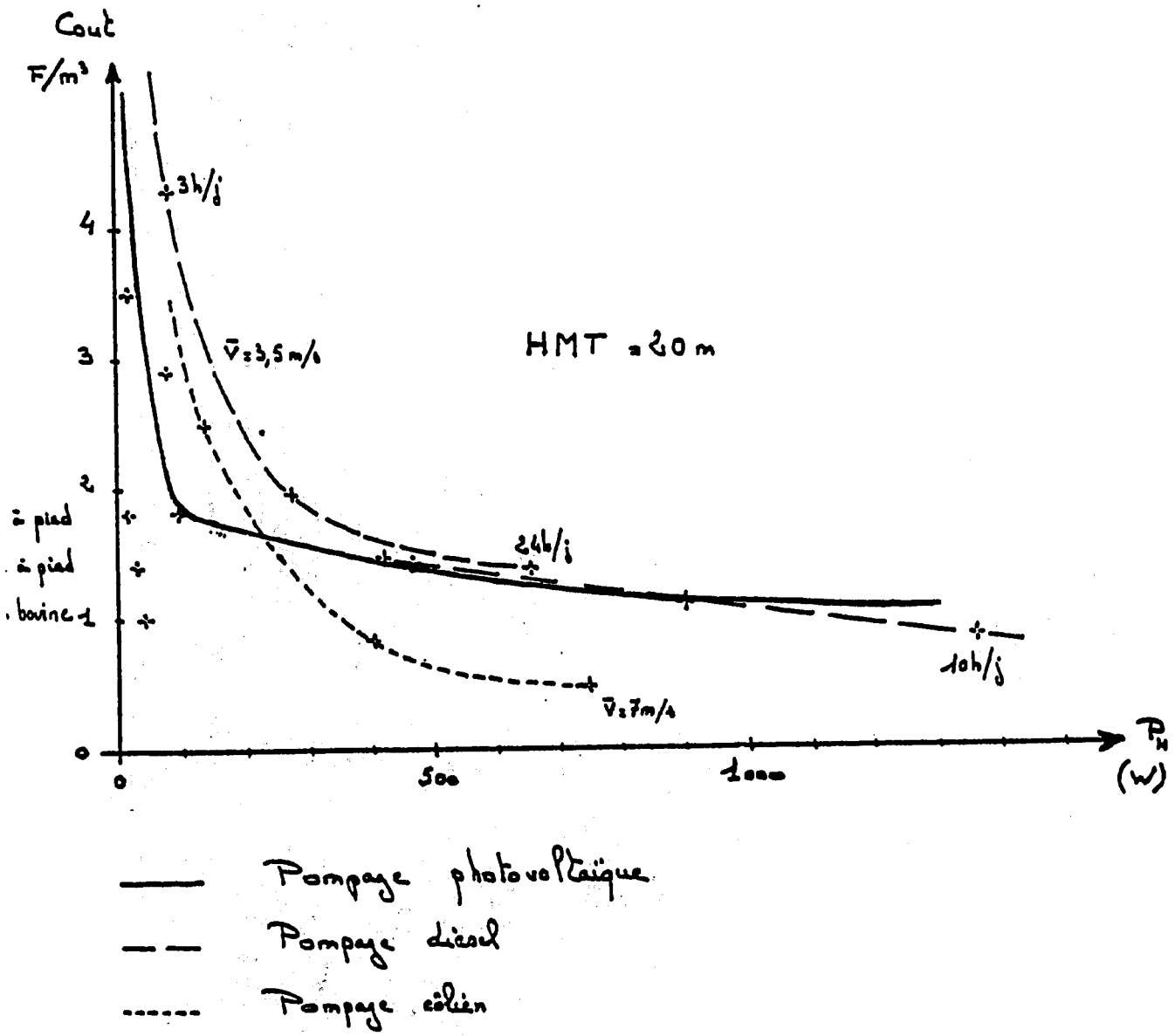


FIG 2: 15m STATIC LIFT; 'AMERICAN' WIND PUMPS AND DIESEL POWERED DEEPWELL PUMPS

FIG 11 a

FIG 11 b

Coût du m³ d'eau en fonction de la puissance hydraulique moyenne
(Février 1984)



4.2. LA MOUTURE DU GRAIN

C'est une activité qui nécessite une importante dépense d'énergie quotidienne de la part de la population féminine. L'entrainement des meules contrarotatives par une éolienne lente est une solution possible et facile à mettre en oeuvre. Cependant pour être pleinement utilisée l'éolienne doit être polyvalente.

4.3. LA PRODUCTION DE FROID

La conservation de vaccins et de médicaments ainsi que de denrées alimentaires (viandes et de poissons notamment) pose des problèmes en milieu rural. On pourrait envisager une réfrigération électrique à partir d'un aérogénérateur, mais la solution la plus économique est l'entrainement mécanique direct en rotation d'un compresseur ouvert par une éolienne multipale, le stockage de froid se faisant sous forme de glace (6), (7).

4.4. LA PRODUCTION D'ELECTRICITE

C'est la forme la plus noble de transformation de l'énergie éolienne, car l'électricité s'adapte à presque tous les usages : pompage, entraînement de moteurs, production de froid, éclairage, climatisation etc...

Devant entraîner des génératrices électriques, les rotors éoliens adaptés à la production d'électricité doivent être à vitesse rapide.

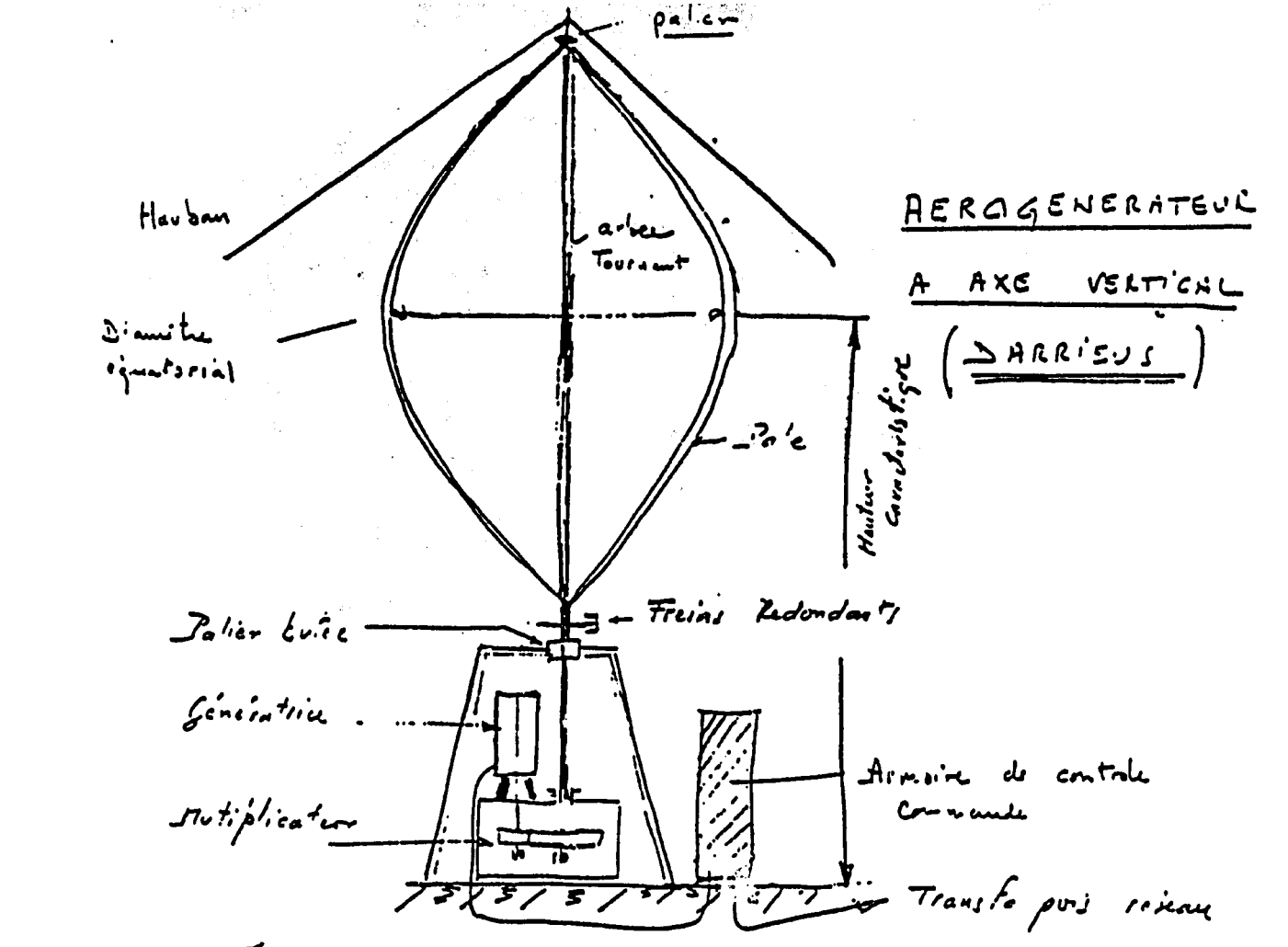
Des deux rotors qui conviennent le mieux à cette application à savoir (FIG 12) :

. rotor rapide bipale ou tripale à axe horizontal
. et rotor Darrieus à axe vertical,

le rotor Darrieus paraît le mieux adapté à une utilisation en milieu rural à cause de sa simplicité, sa robustesse, sa faible sensibilité aux variations du vent.

Mais sa courbe de rendement est nettement moins favorable et le ratio puissance/poids d'un aérogénérateur Darrieus est plus faible que celui d'un aérogénérateur à axe horizontal.

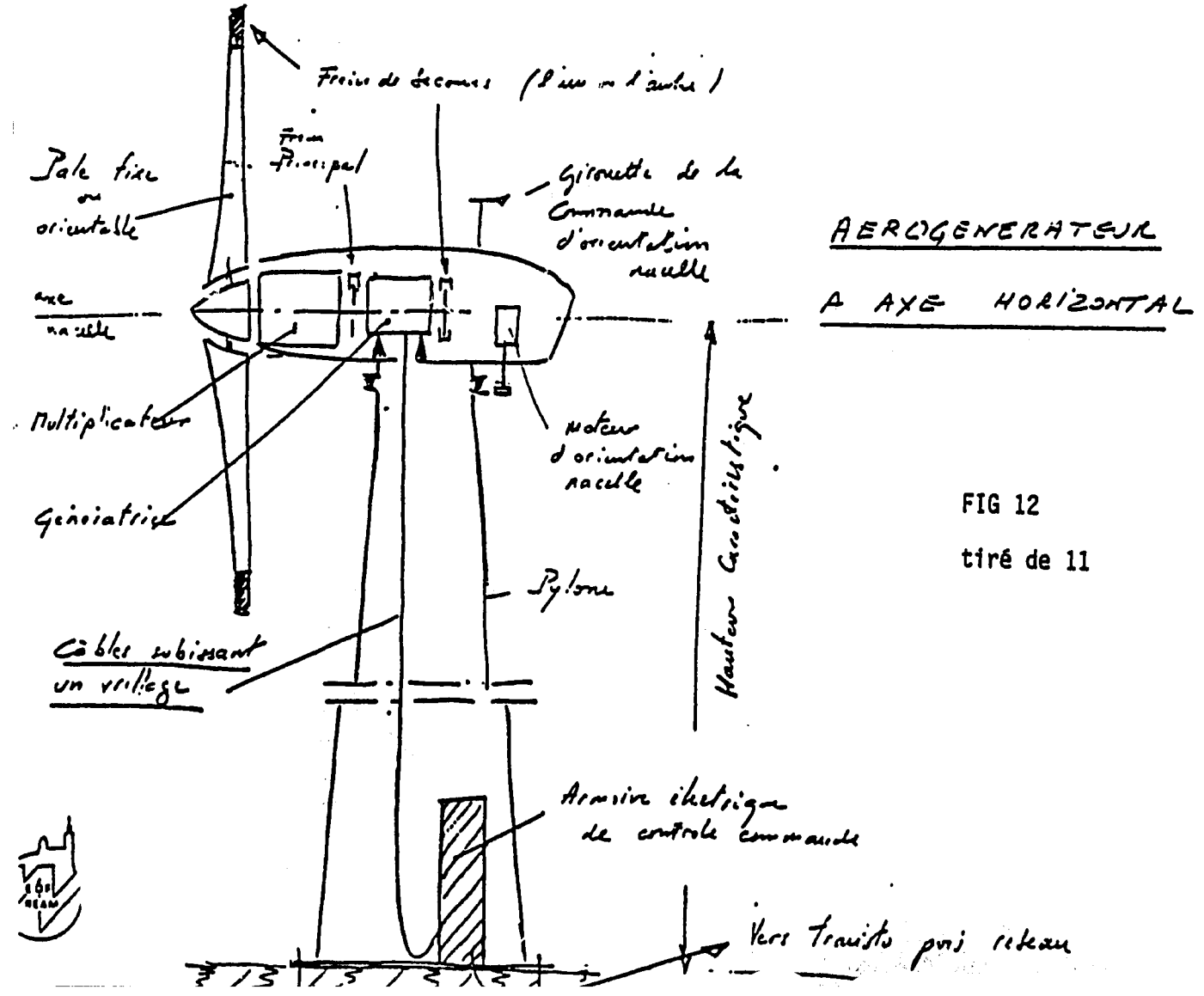
Seuls le Nord du Sénégal, la Mauritanie et le Cap Vert possèdent un potentiel éolien justifiant l'exploitation systématique d'aérogénérateurs dans des conditions techniques et économiques rationnelles. Toutefois dans le reste de la bande cotière, des aérogénérateurs de petite puissance produisant du courant continu pour des usages spécifiques peuvent être intéressants.



AEROGENERATEUR

A AXE VERTICAL

(DARRIEUS)



AEROGENERATEUR

A AXE HORIZONTAL

FIG 12

tiré de 11

V - EXPERIENCES REGIONALES DANS L'UTILISATION DE L'ENERGIE EOLIENNE

La région CEAO/CILSS a surtout connu beaucoup de tentatives d'implantation d'éoliennes de pompage.

Dans les années 50, l'administration coloniale a installé dans le Nord du Mali notamment dans la région de GAO des éoliennes de pompage "Aermotor" et "Came" pour les besoins de l'hydraulique pastorale. L'echec de cette expérience résulte essentiellement du manque d'une organisation rationnelle de la maintenance.

Avec la grande sécheresse des années 70, beaucoup de projets éoliens ont été réalisés, notamment au Sénégal au Burkina Faso et au Mali. Très peu ont réussi par défaut d'adaptation du matériel utilisé aux conditions locales et surtout par défaut de mise en place d'une structure de maintenance post-projet.

Une mention spéciale doit être faite aux Iles du Cap-Vert où l'utilisation des éoliennes de pompage est généralisée. On y dénombre des centaines d'éoliennes de pompage. Les problèmes rencontrés sont : corrosion du matériel, problème de rupture de tige et resonnance, inadaptation au régime local du vent etc.

Les éoliennes Savonius de pompage ont soulevé beaucoup d'espoir à cause de leur rusticité et de leur adaptation aux faibles vents. Mais les expérience tentées dans 13 villages dont 3 au Burkina Faso et 10 au Sénégal ont montré que beaucoup d'amëliorations restent à faire pour les rendre fiables.

Les expériences d'aérogénérateurs sont très limités (Sénégal, Cap-Vert Mauritanie essentiellement). On peut citer comme exemple, le projet de réalisation de deux aérogénérateurs de 55 Kw couplés sur le réseau électrique de Praïa au Cap-Vert (1984).

En matière de recherche-développement les expériences les plus intéressantes sont :

. le développement par le Laboratoire d'Energie Solaire (LESO) du Mali d'une gamme d'éoliennes multipales de pompage adaptées aux conditions locales avec l'assistance technique et financière de l'USAID (3) . Une trentaine d'éoliennes "LESO" sont actuellement opérationnelles sur sites.

. le couplage du rotor savonius avec l'hydropompe Vergnet à l'IUT de DAKAR et au CIEH de Ouagadougou (2)

. le développement de plusieurs modèles de rotor Savonius à l'IUT de Dakar.

. le développement d'un rotor mixte Savonius-Darrius pour la production d'électricité à l'IUT de DAKAR (8).

La fabrication locale d'éoliennes est encore très peu structurée.

Deux leçons essentielles se dégagent de ces expériences :

1. le succès des projets exige la mise en place d'actions d'accompagnements : structure de maintenance, formation, évaluation-corrections.

2. il ne faut retenir que des produits éoliens technologiquement mûrs, de fabrication industrielle, testés et bénéficiant d'une expérience d'utilisation susbstantielle.

VI- PROGRAMMES REGIONAUX D'ACTIONS

Le Centre Régional d'Energie Solaire a élaboré en 1986 un programme régional d'équipements en énergies renouvelables visant à généraliser l'utilisation des technologies d'énergies renouvelables dans les secteurs prioritaires du dévéloppement : hydraulique, santé, éducation-culture, télécommunications.Ce programme est à prépondérance solaire et surtout solaire photovoltaïque.(12).

Le développement de l'énergie éolienne n'est pas apparue comme prioritaire étant donné que très peu de projets éoliens ont été inscrits au titre de ce programme régional. Toutefois pratiquement tous les états ont inscrit l'évaluation du gisement éolien dans les actions d'accompagnement du programme.

Les projets éoliens retenus dans le Programme Régional sont :

- Pour tous les états : Evaluation du potentiel éolien. Coût approximatif = 400 000 USD
- CAP-VERT : Installation sur cinq ans de 95 éoliennes de pompage et de 51 aérogénérateurs pour les secteurs de l'hydraulique, éducation et santé. Coût approximatif = 4 000 000 USD/5 ans
- Mali : Installation sur 10 ans de 400 éoliennes de pompage. Coût approximatif = 8 000 000 USD/10 ans

Un autre programme à caractère régional et digne d'intérêt est le proje Canadien intitulé : "Utilisation de l'énergie éolienne pour l'exhaure d'eau au Sahel" piloté par l'université de Waterloo au Canada et qui intéresse le Niger, le Mali et l Burkina-Faso. Il comporte deux phases :

- une phase pilote (1987-1991) visant à maitriser tous les aspects techniques, organisationnels et sociaux de l'intégration de l'énergie éolienne au Sahel.éssentiellement les éoliennes de pompage (9).

- la deuxième phase est la phase de vulgarisation à raison de 100 unit. éoliennes de pompage par an. Le coût du projet a été estimé à environ 750 000 USD.

Les évaluations de la phase I paraissent concluantes.(10).

VII - CONCLUSIONS

Une sous-évaluation du potentiel éolien et l'effet néfaste de nombreuses expériences négatives ont sans doute freiné le développement de l'utilisation de l'énergie éolienne dans la région CEAO/CILSS.

Mais un programme régional basé sur des actions d'accompagnement appropriées visant à maitriser tous les aspects de la technologie, doit pouvoir permettre à l'énergie éolienne de trouver une place de choix dans le développement rural des pays de la région CEAO/CILSS.

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ATTACHMENT F

CREATION OF WIND ENERGY DEVELOPMENT ORGANIZATION: A STEP TOWARDS ECONOMICAL SOLUTION TO OUR ENERGY PROBLEMS

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CREATION OF WIND ENERGY DEVELOPMENT ORGANIZATION -A STEP TOWARDS ECONOMICAL SOLUTION TO OUR ENERGY PROBLEMS

1. INTRODUCTION

1.1 WAPDA and KESC have the responsibility of Development and Distribution of Power in the country. Owing to the factors beyond their control the gap between generation and the total national requirement of power has widened during the past years, the adverse effects of which are now being felt in every sphere of our life. The present easy approach to base the solution of energy crises in the installation of more Thermal Power Stations is no doubt the only course left to check the widening gap between supply and demand of power but this will add to our financial miseries. As a result the energy tarrif which is already very high is bound to shoot up further which will not only multiply the difficulties of the common man but will also make our agricultural and industrial products incompetitive in the world market resulting in big set backs to our foreign exchange earnings.

1.2 In the past all along our efforts have been confined to the Development of Thermal and Hydel means of power generation. Some how no effort was under taken to explore the possibility of harnessing Wind Energy to produce cheap Electricity in Pakistan. I therefore venture to highlight the available wind potential with the hope for its exploitation. Before going on to the actual subject it is appropriate to state statistically the prevelent energy situation alongwith the future energy forecast.

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-	Generation capacity of WARDA & KESC= (in the year 1988-89.)	7179 MW
-	Total Energy generated by WAPDA & KESC (1988-89) =	37619 Million KWH or Million Units.
-	Total energy sold from WAPDA & KESC= (1988-89)	26747 Million KWH Units.
-	Required generation capacity in 1999-2000. =	17157 MW
-	Energy required to be generated in the year 1999-2000. =	94227 KWH
-	Expected sale of energy in 1999-2000. =	75335 Million Units

1.3. It is evident from the above figures that a target of 17157 MW in generating capacity in the year 1999-2000 will have to be achieved within the next 10 years adding at least 1000 MW to the system annually.

2.0 JUSTIFICATION OF WIND ENERGY DEVELOPMENT.

2.1 To over come the anticipated energy crisis partially, our energy planners had eyes on the proposed 2400 MW. Kala Bagh Hydro Electric Project which has been made a controvercial issue. Presently with the exception of a 1000 MW Ghazi-Gharial Project which is to come up in 1997, there is'nt any substantial addition to the existing hydel potential. Even if the controvercy on Kala Bagh gets resolved, this project cannot come up before 1997 and that too if a decision to go ahead with that project gets through before the end of 1989. Bhasha, if every thing goes well will materialize in the year 2004. Similarly other Hydro electric schemes such as Neelam-Jehlum-Kohala Hydro-Electric project and Taunsa, Jinnah, Guddu and Rohri, the low-head Hydel Projects are

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still in a fluid stage and may take more than a decade before coming to reality. About the provision of more units at Tarbela there is no doubt that the existing installed capacity will be increased but it is doubted that they will augment the system with an additional power in commensurate with the capital outlay on them. Of course these will contribute effectively if Kala Bagh Project materialises. Thus the bulk of energy proposed to be generated is by Thermal means, mainly by using coal, oil and gas as the fuels.

2.2 It has been calculated that in 1986-87* WAPDA and KESC spent Rs. 6194 Million on the purchase of fuel (about 80% being gas) to generate 12960 M.KWH (Million Units) of energy from Thermal Power Stations.

2.3. With the installation of more Thermal Power Stations, if we continue using gas with the fuel ratio of the year 1986-87 in the coming years as well, there is strong possibility of depletion of our gas reserves in less than the anticipated period which will be suicidal for the nation. The coal of Lakhra being of a low calorific value and with large sulpher contents is not coming up as a very welcomed economical proposition. Hence if we keep our gas reserves intact for other industrial uses all the Thermal Stations whether they be in public sector as they presently are or be in private sector will have to function on imported oil or coal. In that case we will have to live with ever increasing foreign indebtness.

* = Figure for 1987-88 and 1988-89 of KESC were not available.

2.4. In order to effectively supplement the existing efforts to cope up with the future energy requirements besides arresting the ever inflating foreign indebtness we must concentrate to exploit every thing under our skies to get a watt of electricity for our system. Wind energy being a potent renewable energy source is in abundance in our coastal areas encompassing about 200,000 sq. K.M of Sind and Baluchistan. If exploited in right earnest it can offset major blocks of electricity produced through expensive thermal means. Unlike Hydel generation, Wind Turbines can be installed within a very short time. In fact this is the only source of energy which is capable of fulfilling our immediate power requirements.

3.0 FACTORS WHICH OBSTRUCTED THE DEVELOPMENT OF WIND POTENTIAL IN THE PAST

3.1 In order to examine the exploitation of Wind potential the basic input is the wind velocity data of different places. The only agency known for collecting Wind data in the country is Meteorological Department. The Wind data collected by Met. Dept. at Karachi, Chhor and Ormara - the maximum wind stations as per the record of Met. Dept, has been tabulated below. This was recorded at heights between 6 to 10 meters above ground level (Annex.A1, A2, A3)

	KARACHI (MAURIPUR)	CHHORE	ORMARA
	Miles/ Hour.	Miles Hour.	Knot/ Hour.
JAN:	5.0	3.8	4.8
FEB:	4.0	3.5	6.9
MAR:	6.5	4.5	9.5
APR:	7.6	5.7	12.0
MAY:	9.5	9.2	13.5
JUNE:	12.1	11.5	11.5
JULY:	11.1	11.3	10.5
AUG:	10.7	9.5	10.3
SEP:	7.2	7.2	11.0
OCT:	5.1	4.0	8.4
NOV:	4.2	2.4	4.8
DEC:	4.5	2.7	4.14

3.2 The cut-in Wind speed required for most of the Wind Turbine Generators in the past was about 7 miles/hour, while the wind speed for rated output used to be over 14.5 miles/hour. An analysis of the above data indicates that an average Wind speed of 7 miles/hours or more prevails for at least 50% time in a year at Karachi and a wind speed of 14.5 miles/hour or more is generally non-existant there. Therefore no wind energy development programe in the past was found feasible for power generation.

The important factor which used to be neglected in this respect was that the Westerlies encounter lot of obstructions before hitting the observatory buildings situated in towns and therefore their recorded impact is much weaker. Further the recording of the data of Meteorological Department has been done at lower heights (6 meters to 10 meters above ground level) where the winds remain weak. Thus the above data does not offer the true figures of the available wind potential. It rather reflects the wind pattern prevelent in a particular area.

3.3 Some individual efforts were made to install/fabricate the wind turbines but these did not make any headway either. So all the failures from time to time in the past have somehow been instrumental in creating the impression that there is no sufficient wind potential to justify the installation of wind turbiens in Pakistan. This view is now practically obstructing the way for a fresh reappraisal of the whole situation.

3.4 In order to counter the earlier apprehensions about the vaibility of Wind Energy Projects a better view of the Wind Velocity Data is now at hand. Also such Wind Turbines are now available whose technical characteristics are compatible with our Wind Data. But before going on to that subject it is appropriate to lay bare the International views on the wind potential in our area and thr ugency of its early development.

4.0 INTERNATIONAL ASSESSMENT OF WIND POTENTIAL IN PAKISTAN AND THE IMPORTANCE OF ITS DEVELOPMENT.

4.1 The Wind Energy Development, has of late emerged as a vital economic & abundant source of energy on the world scene. A recent article appearing in the U.N. Development Forums (Annex-B) has spelled out the need to tap this source. A summary of the important points is highlighted below:-

"i. The U.S. Department of Energy and the World Bank have recently completed a comprehensive study identifying a set of 13 developing nations (Jordan, India, Pakistan, China, Mauritania, Morocco, Chile, Sri Lanka, Jamica, Syria, Yemen P.D.R.,

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Romania and Tanzania), that have the greatest potential for economic commercial wind energy development.

2. Gujerat one of the most intensively industrialised states in India, is besieged by power shortages and the state government is betting heavily on windpower to provide clean, cost effective, electrical power for the future. A model windfarm has been operational since January 1986, and the state electricity board is developing a policy of Energy Banking. This concept allows an industrialist who consumes power to set up a windfarm within the state and feed power into the grid. A record is kept of the amount of power the industrial unit consumes which is offset by the amount of power the windfarm generates.

3. Wind turbine manufacturers are stretching the tower heights to as high as 48.8 meters to take advantage of as much as 30 percent more power which translates into revenue at the increased hub height. One wind turbine manufacturer is designing a 97.5 meter high tower further to maximise the potential of the wind resource at positive shear wind sites.

4. The 25 KW average size wind turbines used at the beginning of the decade are now creeping into the

200 KW range and the cost per kilowatt has plummeted from $3,000 to less than $1,000.

5. In the 1990s it is forecast that OPEC will be producing at 66 percent of its capacity versus 80 percent today, resulting in spiralling oil prices. The oil importing developing countries, however, will not be able to withstand a stiff increase in oil prices. If many Third World oil importing nations cannot service their debt with the current depressed oil prices and low interest rates, what will happen when oil prices and interest rates skyrocket in the 1990s?

6. Wind and other renewable energy sources may soon become top priorities for developing countries as they confront the double edged problems of expensive fossil fuel imports and increased energy demands. The future demand for windpower in these countries could promise great long-term potential and rapid growth exceeding that demonstrated in California during the early 1980s".

3. AVAILABLE WIND POTENTIAL IN PAKISTAN.

3.1. Some efforts were made in Sixties to exploit Wind Energy. As a first step WAPDA (Water Wing) installed six pilot Wind Mills, gifted by Australian Government under Colombo Plan, for pumping water near Makran coast and in Lower Sind at the following places (Location map. Annexure-C).

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1.	Goth Fateh Mohammad	Baluchistan Province
2.	Khurkhera	
3.	Sakrani	
4.	Kallekhore	Sind Province.
5.	Jhangri	
6.	Thano Ahmad Khan	

5.2 The main consideration for selection of these sites was the availability of potable sub-soil water close to the habitations. All these wind mills were provided with instruments to record wind velocities. The height of the anaemometers was kept at 10 to 15 meters. The following table and its graphical presentation Annex-D shows the wind speed recorded by WAPDA at these six stations. In addition, the Wind Data of Karachi (Drig Road Air Base Observatory) with very encouraging results collected recently from Meteorological Department is also being tabulated in the last column here (Annex-E1, E2, E3).

	Goth Fateh Mohd. Miles/ Hour.	Khur-Khera Miles/ Hour.	Sak-rani Miles/ Hour.	Thano A. Khan Miles/ Hour.	Jhan-gri Miles/ Hour.	Kall-ekhor Miles/ Hour.	Kara-chi (Drig Road) Miles Hour.
JAN:	3.8	6.6	3.9	6.8	6.9	7.0	7.59
FEB:	4.8	6.6	4.9	8.6	7.2	7.1	7.47
MAR:	6.0	8.5	6.8	11.0	9.9	8.5	9.31
APR:	5.6	9.6	9.5	12.2	12.7	9.2	11.50
MAY:	6.4	10.7	11.8	14.5	14.8	10.8	14.95
JUN:	7.2	12.4	13.5	18.1	19.5	12.4	16.56
JUL:	10.3	13.1	13.9	18.7	18.9	14.5	16.90
AUG:	9.4	12.7	14.9	17.3	17.7	13.7	15.52
SEP:	8.1	10.0	11.5	15.1	14.2	10.04	14.14
OCT:	6.4	7.8	6.4	8.8	9.0	7.8	6.90
NOV:	5.1	6.0	3.1	6.5	6.4	6.0	6.30
DEC:	2.7	6.2	2.3	8.2	6.4	6.0	5.75

Against the availability of winds with the above velocities, the cut in wind speed requirements of most of the latest

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model Wind Turbines is 4.5 miles per hour, while the wind speed requirement for the rated out put is from 14.6 miles per hour and onwards. Wind Turbine characteristics of some of the models as depicted in the Wind Data Book 1987 are attached as Annex-F-1 to F-17.

From a careful examination of the above wind data and the characteristics of different Wind Turbines particularly those at Annex F2, F3, F6, F7 & F8, it is abundently clear that the Wind Turbines if installed at suitable locations in the costal areas of Pakistan will be able to function at their rated generation capacity for at least 42% time of the year. Here it is appropriate to point out that the firm generating capability of our Hydel Stations has never been more than 40% of their ratings. Annex F1 depicts the characteristics of wind turbine which generates heat only, while Annex F4, F5, F9 to F17 are attached to show the different ratings alongwith sizes of blade diameter in which the wind turbines are available.

Computerisation of Wind Turbines has made it possible to identify the faults, to synchronise the turbines with the system and to switch it off, in case the wind is very hostile or is below the cut off strength. A news item about Wind Turbine installed with computer controls in Barbados appeared in U.N's Development Forum (Annex-G) is produced to show that it is no longer a technical fantasy.

6.0 CAPITAL COST COMPARISON

6.1 Investing in wind is essential in our efforts to reduce national dependence on foreign oil, and also to save our gas reserves. The capital cost of each turbine is estimated to be

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recovered within three to four years with the prevailing energy cost. The turnkey cost of wind Turbines has come down considerably and according to UN Development forum it is less than US$ 1000 per KW and as per M/s. R.Lynette & Associates Washington USA, the World renound consultants on wind energy (Annexure-H) the wind turbine costs are expected to be US$ 500 to 600 per KW with turn key system from $700 to $850 per KW which means Rs 14000 to 17850 KW (assuming 1US$ = Rs. 21.00).

6.2. In contrast the estimated per KW cost of Kalabagh and Bhasha Hydel Projects as worked out by the Consultants three years back are Rs. 25,071 and Rs. 28,413 per KW respectively. The proposed Neelam-Jehlum Hydro Electric Power Project having maximum capability of 1000 M.W in Azad Kashmir is to cost 15 Billion Rupees. It has already been pointed out that the firm generation capability of our hydel system is never more than 40% of their installed capacity. When we take this factor into account the capital oulay on the Hydel Stations is not the one which is normally protrayed. Hence the case of wind generated energy as compared to Hydel means in terms of capital outlay and the annual capability of generation fares very well and is therefore justified.

6.3. At the prevailing international rates, a 200 KW wind Turbine can be installed at a cost of Rs 2.8 Million. With the most passimistic assumption of wind availability for 40 percent time of the year, when the turbine efficiency is 100 percent the units generated work out to be 700800 and for the rest of 60%

time of the year assuming the turbine efficiency on the average to be 50%, the generated units works out to be 525600. This means besides off-setting over 1200000 units produced through expensive thermal means, we will be in a position to save imported fuel amounting Rs. 6,74,520 annually at the FAC rate of 55 paisas per unit which is expected to shoot up with the addition of more thermal units. The best part of all this is that wind is an abundant and unlimited source of energy and our biggest load centre Karachi is exposed to very fast and at times violent wind thrusts which offers bright prospects for wind generated electricity.

7.0 RELEVANCE OF INDIAN WIND ENERGY PROJECT AND PREPARATION OF FEASIBILITY REPORT.

Being adjacent to the coastal belt of Gujrat and Maharashter states of India the weather pattern of coastal areas of Pakistan is more or less similar to the one prevailing in that part of India. The wind turbines are functioning there satisfactorily since 1986. Therefore there should be no difficulty in the operation of Wind Turbines if installed along the Sind and Makran Coast in Pakistan.

8.0 PREPARATION OF FEASIBILITY REPORT.

8.1 Notwithstanding the above passing observations I am conscious of the fact that in today's high risk environment, there is no room for costly mistakes. What is needed is expert consideration of both the technical and financial aspects of any project. Therefore the first step towards our goal of exploiting Wind Energy has to be the preparation of an unbaised feasibility report. For which a comprehensive data of the dependable wind speed at different locations of strong wind area is required.

8. 2 Unfortunately the only data available today in Pakistan is the one collected by meteorological department which besides being unreliable is too insufficient for our purposes. It has already been stated above that the wind speeds recorded by meteorological department are collected from the instruments installed at a maximum height of 10 meters above ground level where the wind speeds are comparatively low and are not compatible with the rated wind speeds of most of the Wind Turbines. The winds blowing at higher altitudes are however much faster. Therefore Wind velocity data of winds at higher altitudes will have to be collected to determine the optimum hub level of the Wind Turbine for maximum efficiency at every location.

8.3 For this purpose it is proposed to erect 150 to 200 ft. high structures at about 100 locations spread over an area of 2,00,000 Sq. Km having strong winds in the Provinces of Sind & Baluchistan. The wind speed recording instruments (self recording) should then be installed at an interval of every 25 ft. height on each structure. The wind data thus collected for two years can form the basis of our feasibility report.

9.0 INITIAL SET UP OF THE PROJECT

9.1 It is therefore strongly pleaded in the supreme National interest that Authority should take a decision to exploit the available Wind Potential in Pakistan without any further delay and order for the creation of a Wind Energy Development Project under the direct supervision of Chairman, WAPDA. If it is left to the mercy of a worked out or an ill-conceived personality it is likely to fizzle out in infancy as has been the case of Biogas Project in the past. The current

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exercise by National Institute of Power for Wind Energy Development has also met with initial failures and is likely to end up in fiasco solely because of ill-conceived, incompetent management.

9.2 It is further suggested that Authority may depute the designated Project Director alongwith some Senior Engineers for a month or so to U.S.A, Europe and India (states of Maharashter and Gujrat)to have an insight into their working approach, their organizational set up and to know the functional difficulties. On the basis of their observations and knowledge, a report may then be submitted for the approval of Authority about the proposed organization, the requirement of the staff, the financial implications etc. In this context perusal of last para of Annexure 'D/2' is relevant.

10.0 SOCIO POLITICAL IMPACT

10.1 Initially this project is to function in the Provinces of Sind and Baluchistan in public sector but eventually private investors are likely to come up which when fully operational will help liberate to an appreciable extent the lot of agricultural, Industrial and the domestic consumers of Electricity from the obligatory control of WAPDA or KESC. Therefore besides its benefits to off-set major blocks of electricity produced through expensive thermal means thereby improving the overall national economy, it can be very rightly projected as a public welfare oriented programme of the Government. It will not only open up new jobs for different types of personal at all levels, but will ultimately help establish Wind Turbine manufacturing units in the country with enormous socio-economic benefits accuring therefrom.

The Government thus can rightly boast for initiating a modern programme for the people.

11.0 FINANCING

It is hoped that funds will pose no problem. If these are not available from our own cash foreign exchange resources then it is hoped that the known International Financing Agencies will be ready to cooperate with us. United State Agency for International Development (US-AID) has already included the Development of Wind Power System in its Programme for assisting the Developing Nations. (Page-15 Annex-J)

12.0 RECOMMENDATIONS

a) Wind Energy Development Project for the Development of Wind Energy to produce Electricity in Pakistan may be created with immediate effect to function under the supervision of Chairman WAPDA.

b) Technical sanction to set up 100 observation posts each of 200 ft. high with 4 anemoneters-self recording on each post may be accorded.

c) Initially a revolving fund of One Million Rupees be made available for this project to meet the expenditure on salaries, office contingencies, TA/DA etc.

I am confident that a positive decision to embark on the development of Wind Energy will go a long way in our history as a major step towards our economic emancipation without which our political freedom has often been threatened.

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Fax 869349

ANNEXURES

BEST AVAILABLE COPY

Station: [illegible] (Estab: 1925)
[illegible] OF CLOUD, WIND SPEED & PRECIPITATION
(BASED ON DATA 1931-60)

LAT. 25° 13'N. LONG. 64° 37'E

Height of anemometer above gro[illegible]

WIND SPEED (Knots)				CLOUD AMOUNT (Oktas)						PRECIPITATION (m.m.)													
			Av. past 24 hrs.	All Clouds			Low Clouds			Mean Monthly total.			Mean No. of rainy days	Total in each / years Wettest 1931-60				Driest 1931-60				Mean 1931
00	03	12		00	03	12	00	03	12	03-12	12-03	03-03		Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.
45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
1.6	1.9	6.4	4.2	1.3	2.1	2.0	1.0	1.1	0.9	13.0	31.5	37.1	2.4	159.3	1943			0.0	-			[illegible]
2.1	2.0	8.0	5.6	0.6	1.9	1.7	0.5	0.7	0.5	2.5	5.6	35.1	1.5	211.3	1944			0.0	-			73.2
4.3	3.7	10.5	8.3	0.8	1.9	1.4	0.7	0.[illegible]	0.4	1.0	6.6	5.6	0.7	52.3	1960			0.0	-			31.0
5.2	5.0	12.5	10.3	1.0	1.8	0.9	0.9	1.2	0.3	0.5	1.8	5.0	0.4	76.7	1933			0.0	-			39.9
6.9	7.3	13.5	11.8	1.6	1.9	0.7	1.3	1.6	0.3	0.0	0.0	1.5	0.1	45.5	1944			0.0	-			35.8
5.4	6.1	11.6	10.0	2.7	3.5	0.8	2.4	2.8	0.7	0.3	1.5	5.6	0.2	137.2	1943			0.0	-			90.7
5.5	5.5	10.3	9.2	4.4	5.5	2.6	4.1	3.7	1.6	16.8	21.1	21.6	1.5	169.2	1956			0.0	-			57.4
5.5	5.5	10.6	9.0	4.7	5.7	2.1	4.5	4.4	1.4	0.3	5.6	2.9	0.6	109.5	1944			0.0	-			39.1
5.6	5.2	11.3	9.5	2.3	4.1	0.8	2.7	2.7	0.6	0.3	5.3	2.5	0.2	48.5	1959			0.0	-			20.3
2.9	2.7	9.0	7.3	0.9	1.6	0.3	0.8	0.9	.1	0.0	0.0	0.0	0.0	1.0	1935			0.0	-			1.0
1.3	1.0	6.6	4.2	0.5	0.9	0.7	0.4	0.3	.2	3.0	5.8	3.3	0.2	71.1	1959			0.0	-			45.3
[illegible]	1.2	5.3	3.6	1.0	1.6	1.5	0.7	0.6	.5	14.2	22.1	19.3	1.[illegible]	85.3	1959			0.0	-			70.9
[illegible]	1.9	9.6	7.7	1.9	2.7	1.3	1.7	1.7	.5	53.3	106.9	14[illegible].3	9.2	456.9	1944			15.3	-			[illegible].7
[illegible]		19	30	10	30	2[illegible]	10	1[illegible]		19	10	30	30	30								[illegible]

1 KNOT = 1.15 miles

BEST AVAILABLE COPY

Station: Ghent (Lat. 25°31'N, Long. 69°47'S)

Details of Cloud, Wind Speed and Precipitation

(Based on data 1931-60)

Height of anemometer above ground =

25° 31'N			LONG 69° 47'S																					
WIND SPEED (Knots)				CLOUD AMOUNT (Oktas)											PRECIPITATION (m.m.)									
			Av. past 24 hrs.	All Clouds			Low Clouds			Mean Monthly total			Mean No. of rainy days	Total in year/month.									
														Lowest 1931-60				Driest 1931-60						
00	03	12		00	03	12	00	03	12	03-12	12-03	03-03		Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	Amt.	Year	
45	46	47	43	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66			
0.9	1.8	4.3	3.3	0.9	1.8	1.9	0.1	0.4	0.3	0.3	0.8	1.3	0.2	9.9	1940			0.0	-					
0.9	1.5	4.1	3.1	0.9	1.8	1.7	0.1	0.2	0.1	0.3	0.5	3.8	0.3	39.1	1939			0.0	-					
1.4	2.7	5.4	3.9	1.1	1.8	1.8	0.1	0.2	0.3	0.3	0.3	2.0	0.3	15.5	1933			0.0	-					
2.1	4.3	5.6	5.0	0.8	1.3	1.5	0.1	0.2	0.3	0.0	0.8	0.3	0.0	5.1	1959			0.0	-					
4.3	7.3	7.9	8.0	1.4	1.5	0.9	0.9	1.1	0.3	0.0	2.0	2.8	0.2	23.1	1942			0.0	-					
6.2	7.2	7.0	10.0	2.4	3.0	1.3	1.5	2.2	0.3	4.1	10.7	8.4	0.5	51.0	1956			0.0	-					
6.2	7.9	8.9	9.6	4.1	5.0	4.0	2.3	2.9	2.7	19.1	42.7	62.5	4.0	195.1	1959			0.0	-					
5.5	7.3	7.8	8.3	4.3	5.3	4.2	2.8	3.1	2.9	12.9	57.7	50.3	2.9	207.5	1953			0.0	-					
3.3	5.8	6.4	6.3	2.0	3.1	2.5	1.3	1.6	1.8	11.2	28.4	23.9	1.5	169.7	1959			0.0	-					
1.0	2.6	3.4	3.5	0.6	1.2	0.8	0.5	0.8	0.7	1.0	2.5	2.5	0.2	33.8	1956			0.0	-					
0.4	1.1	1.9	2.1	0.5	1.0	1.0	0.2	0.4	0.2	1.0	2.3	2.0	0.2	27.7	1936			0.0	-					
0.3	1.1	2.2	2.4	1.2	1.7	1.8	0.2	0.3	0.4	1.0	1.0	1.8	0.2	13.7	1937			0.0	-					
2.7	4.4	5.4	5.5	1.7	2.4	1.9	0.8	1.1	0.9	8.5	149.9	151.5	10.5	406.1	1957			5.0	-					
10	13		22	10	23	21	10	12		10	23		23	23										

1 knot = 1.15 miles

BEST AVAILABLE COPY

Station: Karachi (Mauripur) Seteb: 1945
MONTHLY OF CLOUD, WIND SPEED AND PRECIPITATION
(BASED ON DATA 1931-60)

LAT. 24° 54' N LONG 66° 56' E Height of anemometer above ground:

MONTH	WIND SPEED (Knots) 00	03	12	Av. past 24 hrs.	CLOUD AMOUNT (Oktas) All Clouds 00	03	12	Low Clouds 00	03	12	PRECIPITATION Mean Monthly total 03-12	12-03	03-03	Mean No. of rainy days	Total in month / year Highest 1931-60		Driest 1931-60	
	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
Jan.	4.4	4.3	6.5	4.3	1.2	1.9	1.9	0.3	0.5	0.4	2.5	3.0	5.6	1.3	9.7	1957		3.[illegible]
Feb.	3.0	3.2	10.1	5.5	0.7	1.2	1.0	0.3	0.4	0.2	4.3	0.5	4.8	0.5	11.7	1959		0.0
Mar.	3.5	3.3	11.9	5.7	1.0	2.1	1.7	0.3	0.7	0.4	13.5	4.6	18.0	0.7	72.5	1960		0.[illegible]
Apr.	3.7	5.3	12.7	6.6	1.3	2.5	1.7	0.4	1.0	0.5	2.1	0.0	2.1	0.3	10.7	1957		0.0
May	6.1	8.5	14.2	9.3	1.0	2.5	1.3	0.7	1.9	0.7	0.0	0.0	0.0	0.0	0.0	-		0.0
June	7.3	9.5	14.1	10.5	2.9	4.5	2.4	2.6	4.0	1.9	0.5	1.3	1.8	0.3	5.1	1960		0.0
July	8.9	9.4	13.4	9.5	5.4	6.4	5.7	3.3	4.1	3.5	53.4	50.5	110.0	4.3	319.8	1959		6.[illegible]
Aug.	8.3	9.0	13.7	9.3	5.1	6.3	5.2	3.9	4.9	3.9	4.0	6.9	11.7	1.3	23.9	1959		0.3
Sept.	6.6	6.5	11.9	6.3	3.6	4.5	3.6	2.7	3.4	2.9	12.1	43.2	62.2	1.7	200.4	1959		0.0
Oct.	2.9	3.3	9.6	4.5	1.0	1.7	0.9	0.8	1.2	0.4	0.[illegible]	0.0	0.0	0.0	0.0	-		0.0
Nov.	3.3	3.7	7.7	3.7	0.7	1.3	0.9	0.1	0.3	0.3	[illegible]	6.7	13.7	1.0	52.3	1959		0.0
Dec.	4.2	4.0	7.5	3.9	[illegible]	2.3	2.5	0.1	0.5	0.4	[illegible]	12.4	25.7	1.5	55.3	1959		1.0
Year	5.1	5.9	11.3	6.0	[illegible]	3.1	2.4	1.3	1.9	1.3	[illegible]	17.3	256.3	12.9	621.0	1959		27.[illegible]
	4	4		4			4	4	4	4								

1 Knot = 1.15 miles

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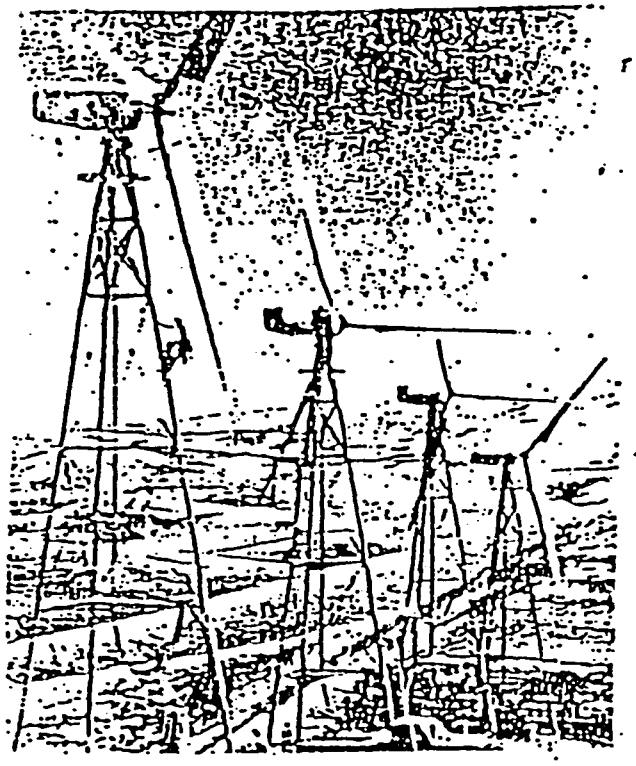
Windpower — an endless resource

PHILIP C. CRUVER



Advances in windpower technology in industrialised countries have greatly improved the competitiveness of this renewable energy source. The comparative advantages of windpower, both economic and ecological, have become increasingly clear to entrepreneurs and governments in both industrialised and developing regions

WHAT is the future for windpower now that the world markets are awash with low-priced oil? Extremely promising — since most energy planners recognise that the oil glut is only a temporary situation.

The technologies that have developed over the past decade are ripe for use throughout both the industrialised and developing regions. As the fastest growing source of renewable energy, the economics and efficiencies of the technology have produced commendable results. The 25 kW average size wind turbines used at the beginning of the decade are now creeping into the 200 kW range and the cost per kilowatt has plummeted from $3,000 to less than $1,000. Over 15,000 wind turbines installed in California windparks have a total capacity of nearly 1,400 megawatts and generated over 1.7 billion kWh of electricity in 1987 which represents 1 per cent of the state's consumption, or enough power to accommodate 280,000 homes.

In the 1990s it is forecast that OPEC will be producing at 80 per cent of its capacity versus 66 per cent today, resulting in spiralling oil prices. The oil-importing developing countries, however, will not be able to withstand a still increase in oil prices. If many Third World oil-importing nations cannot service their debt with the current depressed oil pices and low interest rates, what will happen when oil prices and interest rates skyrocket in the 1990s?

Wind and other renewable energy sources may soon become top priorities for developing countries as they confront the double-edged problem of expensive fossil fuel imports and increased energy demands. The future demand for windpower in these countries could promise great long-term potential and rapid growth exceeding that demonstrated in California during the early 1980s.

The windpower business in the U.S. has demonstrated that existing technology can be profitable and has great growth potential. The development of excess capacity on existing utility contracts with additional new wind turbines, and retrofitting existing wind turbines with engineering enhancements are two factors that guarantee a growing market and continuing technological improvements. This translates into less expensive start-up investments for developing countries which decide to tap their winds.

The recently developed Solar Energy Research Institute (SERI) airfoil theoretically promises to increase power output for low wind sites. SERI claims that aircraft airfoils are not suited for stall-regulated rotor blades, and the new family of airfoils will increase production and reduce loads. This could lead directly to lower manufacturing and maintenance costs.

Wind turbine manufacturers are stretching the tower heights to as high as 48.8 metres to take advantage of as much as 30 per cent more power which translates into revenue at the increased hub height.

The tall tower concept has another advantage: good windpark sites can be more densely packed with staggered short and tall tower wind turbines for optimal use of the property. One wind turbine manufacturer is designing a 97.5 metre high tower further to maximise the potential of the wind resource at positive shear wind sites. These towers also allow for easier maintenance of wind turbines and can be used to secure the machine in overseas regions where seasonable storms or hurricanes produce winds exceeding the design loads.

> The environmental impact of conventional electrical energy power sources is under extreme scrutiny today and will become more strictly regulated in the future. Carbon dioxide from fossil fuel combustion is the largest source of global warming. Nitrous oxide from coal combustion also contributes to the depletion of the ozone layer.

The success of windpower in California has influenced the energy policy of decision-makers in many countries that possess strong wind energy resources. Cost is, of course, the major consideration. According to a report by the California Energy Commission, windpower at US3.5c per Kwh, in 1987 dollars, is one of the lowest cost options for new electrical generation capacity. Its cost is competitive with that of oil and is substantially below the cost of nuclear power.

But ecological concerns are increasingly important as well. The beauty of windpower is that modern windmills do not add to the thermal pollution of the earth as do all fossil fuels and nuclear plants. The environmental impact of conventional electrical energy power sources is under extreme scrutiny today and will become more strictly regulated in the future.

Danish wind turbine manufacturers are promoting the benefits of wind energy for European utilities. Denmark currently has the largest single market for windpower outside California: approximately 70-80 per cent of Europe's windpower capacity is installed there while the country accounts for only 2 per cent of the total power consumed. It is estimated that 20 per cent of Britain's electricity could be produced from the wind. Public acceptance and proof of wind energy performance and economics will push Britain and other European countries from the research and development phase into the commercialisation phase within the next few years.

The U.S. Department of Energy and the World Bank have recently completed a comprehensive study identifying a set of developing countries that appear to have potential for the economical exploitation of their wind energy resources, as a complement to their existing conventional electric power systems. The initial phase of the study analysed available data concerning both the world wind resources and electrical generation data for all developing countries worldwide and identified 13 nations (Jordan, India, Pakistan, China, Mauritania, Morocco, Chile, Sri Lanka, Jamaica, Syria, Yemen P.D.R., Romania and Tanzania) that have the greatest potential for economic commercial wind energy development.

Gujerat, one of the most intensively industrialised states in India, is besieged by power shortages and the state government is betting heavily on windpower to provide clean, cost-effective, electrical power for the future. A model windfarm has been operational since January 1986, and the state electricity board is developing a policy of Energy Banking. This concept allows an industrialist who consumes power to set up a windfarm within the state and feed power into the grid. A record is kept of the amount of power the industrial unit

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Windpower

Continued from page 11

consumes which is offset by the amount of power the windfarm generates.

US AID has financed the development of a one megawatt windfarm at Ras Gareb near the Red Sea. The Egyptian Ministry of Defence is testing a one megawatt wind/diesel system near the Libyan border.

Jordan has a $4.5 million joint technology transfer programme with the California Energy Commission that calls for construction of a $4 million wind plant representing 25 turbines i Jordan and $500,000 fo monitoring equipment.

As the international marke develops, and as in-country demonstration projects prove the cost-effectiveness of windpower, nations with industrial capabilities and strong wind resources will demand that the wind systems be manufactured or assembled in-country to reduce the drain on foreign currency. Wind turbine manufacturers with proven track records are currently licensing their design to established manufacturers in various countries. — *Development Forum.*

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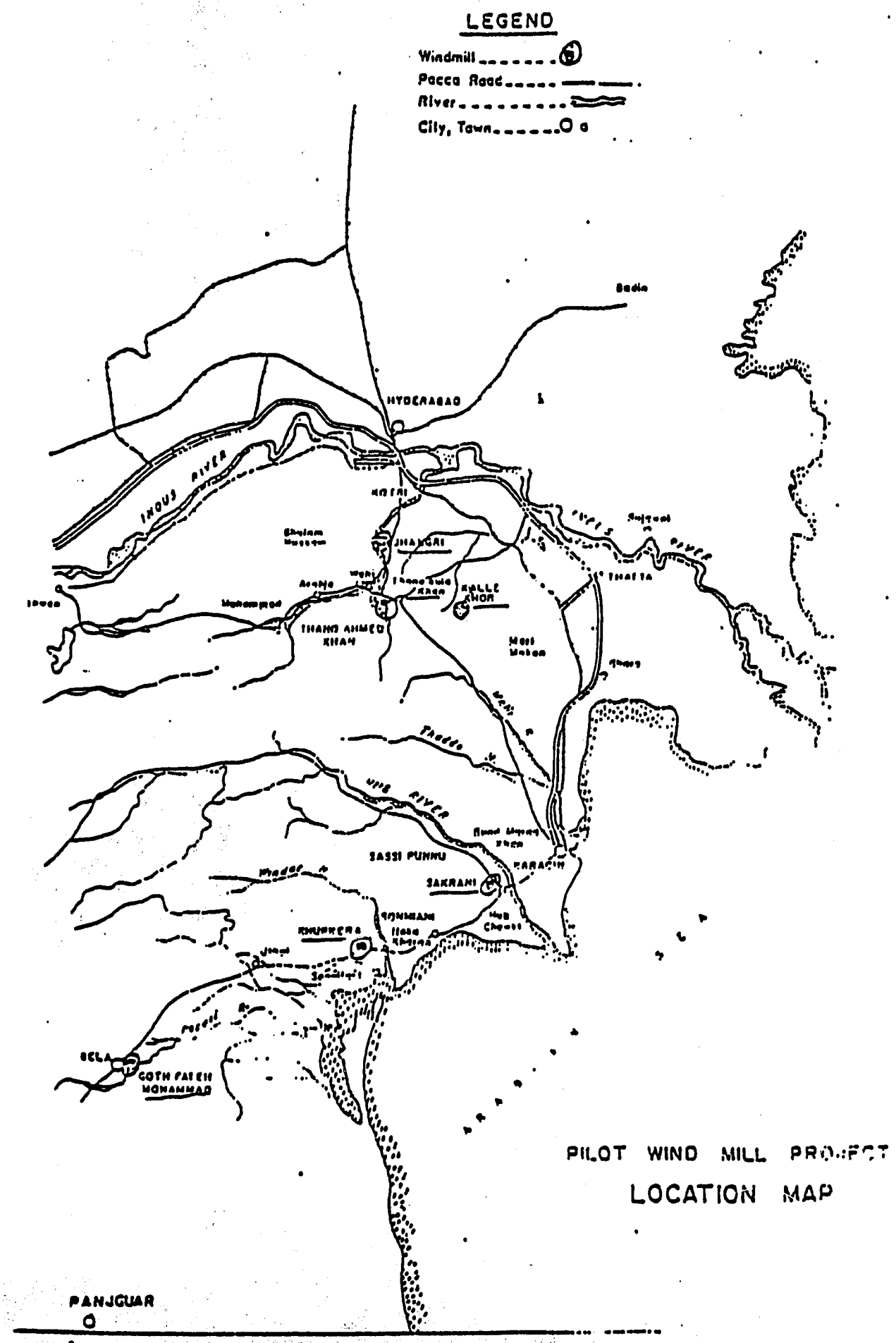
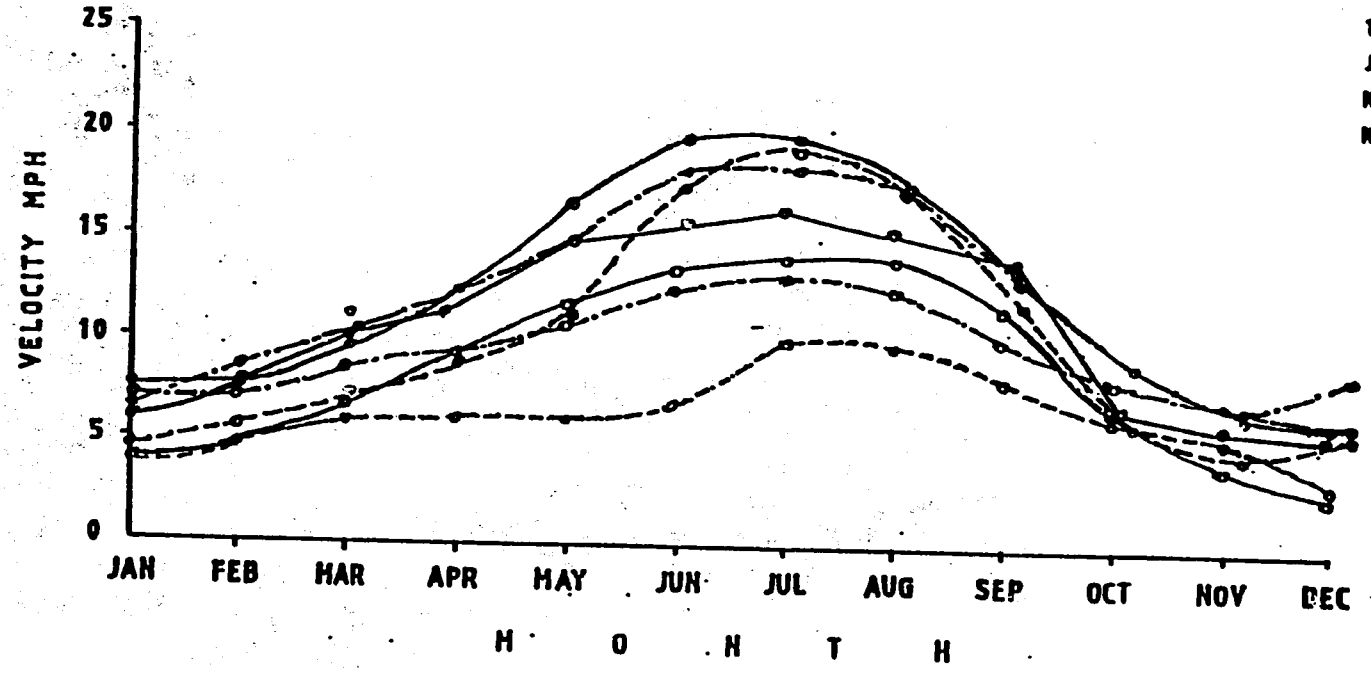

LEGEND
Windmill
Pacca Road
River
City, Town
HYDERABAD
INDUS RIVER
KOTRI
JHANGAI
THANO AHMED KHAN
KALLE KHOR
THATTA
SASSI PUNNU
SAKRANI
KHUDDERA
BELA
GOTH FAKEER MOHAMMAD
PANJGUAR
PILOT WIND MILL PROJECT
LOCATION MAP

MONTLY AVERAGE VELOCITY IN MEKRAN COASTAL AREA AND LOWER SIND



MAKRAN COASTAL AREA

- SAKRANI
- KHURKERA
- GOTH FATEH MUHAMMAD

LOWER SIND

- THANO A KHAN
- JHANGRI
- KALLEKHOR
- KARACHI

ANNEXURE-I

Station : Karachi (Drigh Road) (Extent 1954)
Details of CLOUD, WIND SPEED AND PRECIPITATION
(Based on data 1931-60)

Lat. 24° 53'N Long 67° 07'E

Height of anemometer above ground

Month	Wind Speed (Knots) 00	03	12	Av. past 24 hrs.	Cloud Amount (oktas) All Clouds 00	03	12	Low Clouds 00	03	12	Mean Monthly Total 03-12	12-03	03-03	Mean No. of Rainy days	Highest 1931-60 Amt.	Year	Highest in 24 hours 1931-60 Amt.	Year	Amt.
44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
[illegible]	4.6	4.9	10.0	6.6	1.3	1.9	1.8	0.4	0.5	0.4	1.0	10.2	11.2	1.3	30.5	1956			2.3 1956
[illegible]	3.1	3.5	11.3	5.5	0.8	1.3	1.3	0.3	0.4	0.3	[illegible]	9.4	10.9	1.0	42.4	1954			0.0 –
[illegible]	3.5	3.5	13.4	[illegible]	0.3	1.7	1.4	0.2	0.3	0.2	0.0	0.3	0.3	0.0	1.0	1955			0.0 –
[illegible]	3.9	5.0	15.5	10.0	[illegible]	1.7	1.3	0.4	0.[illegible]	0.3	[illegible]	0.0	2.3	0.3	7.4	1957			0.0 –
[illegible]	6.2	10.1	17.4	13.0	1.7	2.7	1.0	1.4	2.3	0.6	0.0	0.0	0.0	0.0	0.0	–			0.0 –
[illegible]	9.4	12.1	16.0	14.4	3.2	4.0	2.7	2.7	3.5	2.[illegible]	[illegible]	13.0	13.7	0.3	72.5	1956			0.0 –
[illegible]	10.9	12.4	[illegible]	14.7	5.2	5.3	5.1	3.6	4.0	3.7	35.[illegible]	79.5	115.6	4.7	347.7	1957			1.5 1955
[illegible]	9.8	11.1	16.7	13.5	4.[illegible]	5.9	5.1	4.1	4.4	3.9	[illegible].7	25.1	34.8	1.7	108.7	1956			0.0 –
[illegible]	6.3	9.1	15.3	12.3	3.5	4.5	3.0	2.9	3.2	2.7	23.1	25.7	49.0	1.4	190.0	1959			0.0 –
[illegible]	2.[illegible]	3.3	11.4	6.3	0.7	1.1	0.[illegible]	0.4	0.5	0.5	[illegible]	10.2	15.7	0.6	176.5	1956			0.0 –
[illegible]	[illegible].2	3.4	10.0	5.5	.3	0.6	0.7	[illegible]	0.2	0.2	[illegible]	0.[illegible]	0.[illegible]	0.2	3.0	1957			0.0 –
[illegible]	4.0	3.[illegible]	8.7	5.[illegible]	1.0	1.9	1.[illegible]	0.[illegible]	0.4	0.4	[illegible]	2.3	9.9	1.2	[illegible]	1955			0.0 –
[illegible]	5.7	6.9	13.[illegible]	9.7	2.0	2.[illegible]	2.2	[illegible]	1.7	1.3	[illegible]	176.0	254.2	13.2	463.9	1955			39.3 1957
	6		3	5	5	5	4	6	5	6		5	6	6					5

1 KNOT = 1.15 miles

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Table No.2A:

AVERAGE MONTHLY WIND VELOCITIES
(SIND)

MONTH	THANO A. KHAN 64 Miles from Sea Coast	JHANGRI 70 Miles from Sea Coast	KALLEKHOR 50 Miles from Sea Coast
JAN:	6.8	6.9	7.0
FEB:	8.6	7.2	7.1
MAR:	11.0	9.9	8.5
APR:	12.2	12.7	9.2
MAY:	14.5	14.8	10.8
JUN:	18.1	19.5	12.4
JUL:	18.7	18.9	14.5
AUG:	17.3	17.7	13.7
SEP:	13.1	14.2	10.0
OCT:	8.8	9.0	7.8
NOV:	6.5	6.4	6.0
DEC:	8.2	6.4	6.0

An extract from a publication of WAPDA Hydro-electric Planning Department

Table No.2

AVERAGE MONTHLY WIND VELOCITIES
(BALUCHISTAN)

MONTH	GOTH FATEH MOHD	KHURKHERA	SAKRANI
	50 Miles from Sea Coast	12 Miles from Sea Coast	10 Miles from Sea Coast
JAN:	3.8	6.6	3.9
FEB:	4.8	6.6	4.9
MAR:	6.0	8.5	6.8
APR:	5.6	9.6	9.5
MAY:	6.4	10.7	11.8
JUN:	7.2	12.4	13.5
JUL:	10.3	13.1	13.9
AUG:	9.4	12.7	14.9
SEP:	8.1	10.0	11.5
OCT:	6.4	7.8	6.4
NOV:	5.1	6.0	3.1
DEC:	2.7	6.2	2.3

An extract from a publication of WAPDA
Hydro-electric Planning Department

Aeolus

United Kingdom Europe

Address: Aeolus, Ltd.
c/o Nat. Wind Turbine Ctr.
Nat. Eng. Lab.
East Kilbride, Glasgow
G75OQU United Kingdom
Telephone: 03552-20222
Telex:

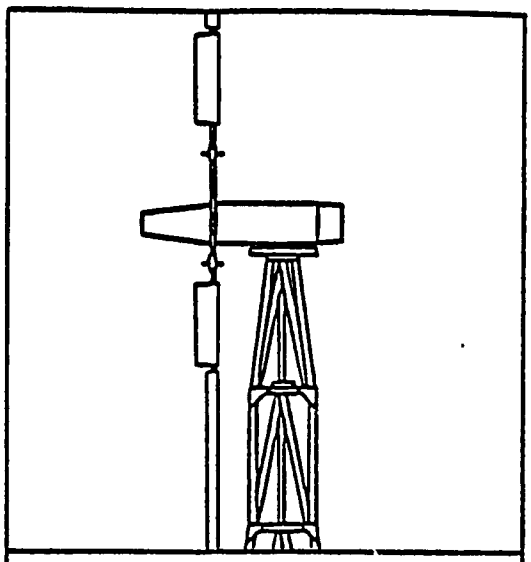
Entered wind industry: 1980
Wind business areas: Wind turbines

1985 Wind-related sales volume (US $million):

Corporate affiliations:

Major business areas: Wind turbines

1985 Sales Volume (US $million):



Aeolus 7.0 m

Model	7M
Nameplate rating	22 kW
Electrical output	Heat only
Type	Down-wind HAWT 3-Bladed
Rotor diameter	7.0 m
Blade composition	FRP
Hub type	Rigid
Cut-in wind speed	
Rated wind speed	
Power regulation	Full span pitch
Overspeed control	Full span pitch
Yaw control	Passive
Weight (w/out tower)	
Transmission	2-Stage, helical
Generator rating	22 kW
Generator type	Hydraulic pump
Comments	Unique hydraulic heat conversion system
Status	Prototype
Year introduced	1986
Units shipped	Under 5

Aeritalia

Italy Europe

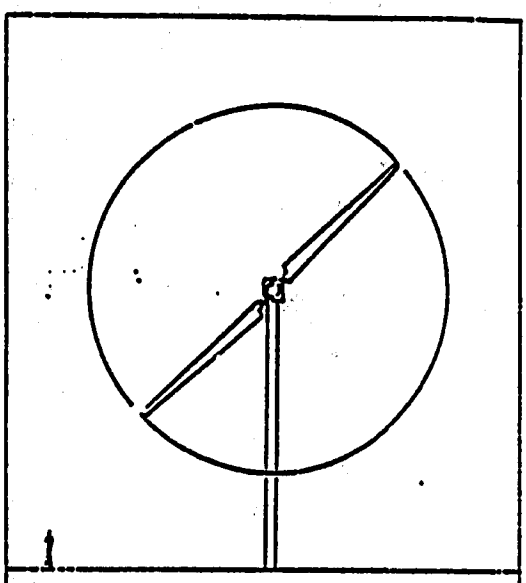
Address: Aeritalia S.A.I. S.p.A
Unita Organizzativa Energie Alt.
Via Archimede 156
00137 Roma
Italy
Telephone: 6805549
Telex: 611395

Entered wind industry: 1979
Wind business areas: Wind turbines, components, assessment services, systems integration
1985 Wind-related sales volume (US $million): Between 0.1 & 1

Corporate affiliations: Associated with Fiat Aviazione in consortium for wind energy in coordination with ENEA and ENEL

Major business areas: Aerospace

1985 Sales Volume (US $million): Over 500



Aeritalia 32.0 m

Model	AIT03	AIT03EN	AIT02	Gamma 60
Nameplate rating	15-25 kW	22 kW	225 kW	1000 kW
Electrical output	50 Hz	50 Hz	50 Hz	50 Hz
Type	Down-wind HAWT 2-Bladed	Down-wind HAWT 2-Bladed	Up-wind HAWT 2-Bladed	Up-wind HAWT 2-Bladed
Rotor diameter	8.0 m	10.0 m	32.0 m	60.0 m
Blade composition	FRP	FRP	FRP	
Hub type	Rigid	Rigid	Rigid	Hinged
Cut-in wind speed	5.0 m/s	4.0 m/s	4.2 m/s	3.1 m/s = 16.9 miles/hrs
Rated wind speed	13.0 m/s	10.0 m/s	10.1 m/s	8.5 m/s = 19.1 " "
Power regulation	Full span pitch	Stall regulated	Full span pitch	Full span pitch
Overspeed control	Full span pitch	Blade tip-feathered	Full span pitch	Full span pitch
Yaw control		Passive		
Weight (w/out tower)				
Transmission		2-Stage, coaxial		
Generator rating	15-25 kW	31 kW	225 kW	1000 kW
Generator type	Synchronous	Synchronous	Induction	Induction
Comments				
Status	Production	Production	Prototype	Design
Year introduced	1985	1987	1986	1986
Units shipped	Between 5 and 20	Under 5	Under 5	

90

C.E.M.E.L. 83

Italy Europe

Address: C.E.M.E.L. 83 s.n.c.
Via Corniolo 33
Porano
Italy

Telephone: 0763-65268
Telex:

Entered wind industry: 1984
Wind business areas: Wind turbines

1985 Wind-related sales volume (US $million): Under 0.1

Corporate affiliations:

Major business areas: Construction

1985 Sales Volume (US $million): Between 1 & 10

Model	48211
Nameplate rating	3 kW
Electrical output	DC
Type	Up-wind HAWT
	36-Bladed
Rotor diameter	1.8 m
Blade composition	Steel
Hub type	Rigid
Cut-in wind speed	1.3 m/s = 2-7 miles/hrs.
Rated wind speed	
Power regulation	VARCS
Overspeed control	
Yaw control	
Weight (w/out tower)	300 kg
Transmission	2-Stage, coaxial
Generator rating	3 kW
Generator type	Direct current

Comments

Status	Prototype
Year introduced	1986
Units shipped	Under 5

F-4

GEMZ

Spain Europe

Address: GEMZ
Plaza Cataluna 5
San Baudilio de Llobregat
Spain

Telephone: 36610370
Telex:

Entered wind industry: 1932
Wind business areas: Wind turbines

1985 Wind-related sales volume (US $million): Under 0.1

Corporate affiliations:

Major business areas: Metal fabrication

1985 Sales Volume (US $million): Under 1

Model	500W	1800W	2000W
Nameplate rating	0.5 kW	1.8 kW	~~2 kW~~
Electrical output	DC	DC	DC
Type	Up-wind HAWT 3-Bladed	Up-wind HAWT 4-Bladed	Up-wind HAWT 4-Bladed
Rotor diameter	2.6 m	3.6 m	3.6 m
Blade composition	Wood	Wood	Wood
Hub type	Rigid	Rigid.	Rigid
Cut-in wind speed	2.0 m/s	2.0 m/s	~~2.0 m/s~~ = 4.5 miles/hr.
Rated wind speed	7.0 m/s	7.0 m/s	~~7.0 m/s~~ = 15.7 miles/hr.
Power regulation	Full span pitch	Full span pitch	Full span pitch
Overspeed control	Manual brake	Manual brake	Manual brake
Yaw control	Passive	Passive	Passive
Weight (w/out tower)	160 kg	240 kg	240 kg
Transmission	Direct drive,electrical	Direct drive,electrical	Direct drive,electrical
Generator rating	0.5 kW	1.8 kW	2 kW
Generator type	Dynamo	Dynamo	Dynamo
Comments			
Status	Production	Production	Production
Year introduced	pre-1981	pre-1981	pre-1981
Units shipped	Between 20 and 50	Between 5 and 20	Between 5 and 20

92

Keller

Germany FR Europe

Address: W. Keller Aero Construct GmbH
Industriestr. 5
6749 Vieslautern
West Germany

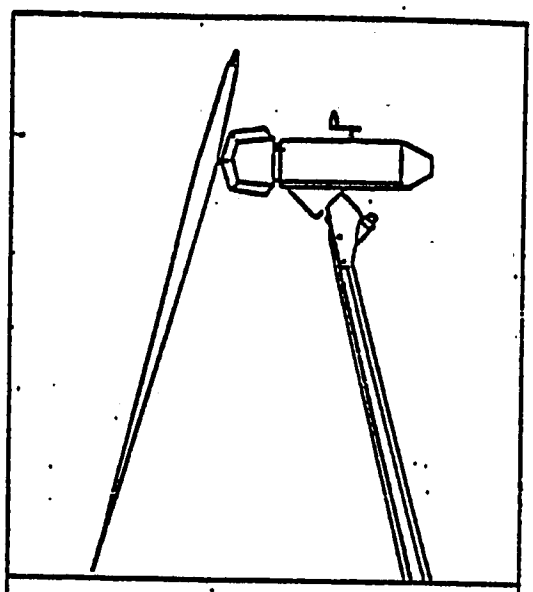
Telephone: 06394-1568
Telex: 451708

Entered wind industry: 1979
Wind business areas: Wind turbines, components

1985 Wind related sales volume (US $million): Between 0.1 & 1

Corporate affiliations:

Major business areas: Aerospace and wind energy components in fibreglass and carbon fibrecomposite.
1985 Sales Volume (US $million): Between 1 & 10



Keller 8.0 m

Model	Flair 8
Nameplate rating	5 kW
Electrical output	AC
Type	Down-wind HAWT 1-bladed
Rotor diameter	8.0 m
Blade composition	FRP
Hub type	
Cut-in wind speed	2.0 m/s = 4.5 miles/hr
Rated wind speed	9.0 m/s = 20.2 "
Power regulation	Full span pitch
Overspeed control	Full span pitch
Yaw control	Passive
Weight (w/out tower)	120 kg
Transmission	2-Stage, planetary
Generator rating	5.1 kW
Generator type	Asynchronous
Comments	
Status	Prototype
Year introduced	1986
Units shipped	Under 5

Koster

Germany FR Europe

Address: Friedrich Koster GmbH & Co. KG
Friedrichswerk 1-7
2240 Heide
West Germany

Telephone: 048171005
Telex: 28802

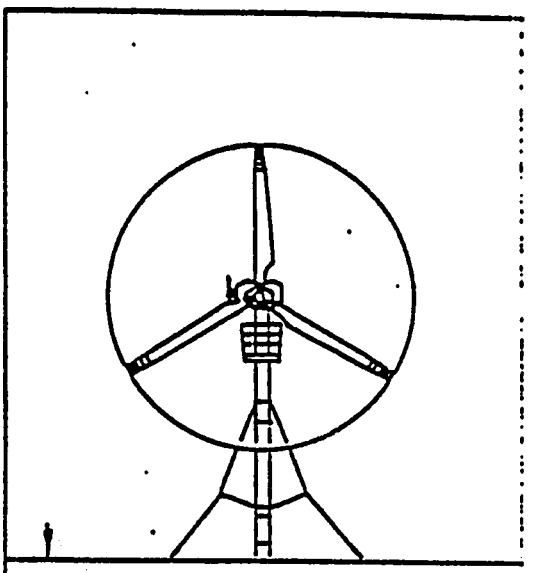
Entered wind industry: 1985
Wind business areas: Wind turbines, components

1985 Wind-related sales volume (US $million): Under 0.1

Corporate affiliations:

Major business areas: Machinery fabrication

1985 Sales Volume (US $million): Between 1 & 10



Koster 25.0 m

Model	Adler 25
Nameplate rating	100 kW
Electrical output	50 Hz
Type	Down-wind HAWT 3-Bladed
Rotor diameter	25.0 m
Blade composition	FRP
Hub type	Rigid
Cut-in wind speed	3.4 m/s
Rated wind speed	6.5 m/s
Power regulation	Full span pitch
Overspeed control	Full span pitch
Yaw control	Electro-mechanical
Weight (w/out tower)	7400 kg
Transmission	2-Stage, helical
Generator rating	55/45 kW
Generator type	Asynchronous
Comments	DFVLR Design
Status	Prototype
Year introduced	1984
Units shipped	Under 5

MMEW

United Kingdom Europe

Address: MMEW, Ltd.
1 Albert Square
Third Floor
Dundee DD1 1DD
United Kingdom
Telephone: 0382-28742
Telex:

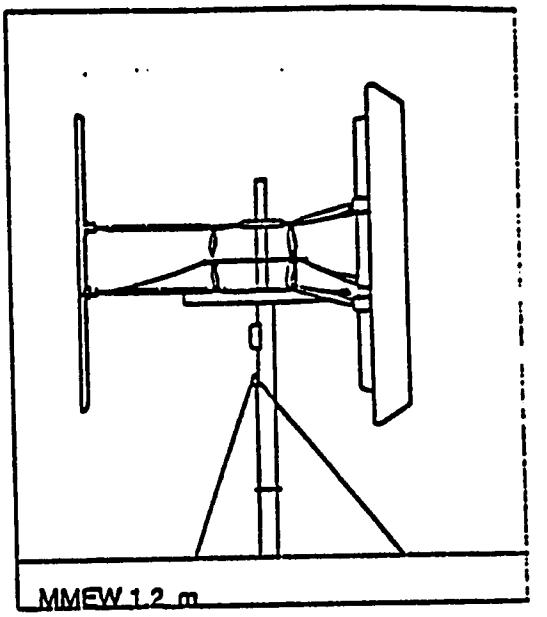
Entered wind industry: 1983
Wind business areas: Wind turbines, components

1985 Wind-related sales volume (US $million): Under 0.1

Corporate affiliations:

Major business areas: Wind Turbines

1985 Sales Volume (US $million): Under 1



Model	Vertax DD	Vertax HD	9/15kW
Nameplate rating	0.07 kW	0.4 kW	15 kW
Electrical output	DC	DC	50 Hz
Type	VAWT 3-Bladed	VAWT 3-Bladed	VAWT 3-Bladed
Rotor diameter	1.2 m	3.0 m	9.0 m
Blade composition	Aluminum	Aluminum	Aluminum
Hub type			
Cut-in wind speed	2.0 m/s	2.0 m/s	2.0 m/s
Rated wind speed			
Power regulation	Self-governing hinge	Self-governing hinge	Self-governing hinge
Overspeed control	Self-governing hinge	Self-governing hinge	Self-governing hinge
Yaw control			
Weight (w/out tower)	30 kg		2476 kg
Transmission	2-Stage, helical	2-Stage, helical	2-Stage, helical
Generator rating	0.072 kW	0.4 kW	15 kW
Generator type	Air gap alternator	Air gap alternator	Air gap alternator
Comments			
Status	Production	Prototype	Prototype
Year introduced	1985	1986	1986
Units shipped	Under 5	Under 5	Under 5

Samsoe

Denmark Europe

Address: Samsoe Vind Energy I.S.
Ballen Maskinfabrik
Ballenvej 50
8791 Tranebjerg
Samsoe, Denmark
Telephone: 06590730
Telex:

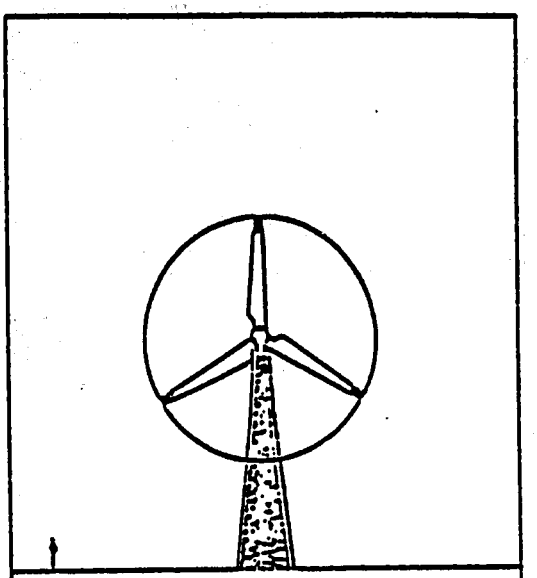
Entered wind industry: 1985
Wind business areas: Wind turbines

1985 Wind-related sales volume (US $million): Under 0.1

Corporate affiliations:

Major business areas: Wind turbines

1985 Sales Volume (US $million): Under 1



Samsoe 18.7 m

Model	80KW
Nameplate rating	80 kW
Electrical output	50 Hz
Type	Up-wind HAWT 3-Bladed
Rotor diameter	18.7 m
Blade composition	FRP
Hub type	Rigid
Cut-in wind speed	4.0 m/s
Rated wind speed	6.5 m/s
Power regulation	Stall regulated
Overspeed control	Mechanical brake
Yaw control	Mechanical
Weight (w/out tower)	8000 kg
Transmission	3-Stage, helical
Generator rating	80/18 kW
Generator type	Induction
Comments	
Status	Production
Year introduced	1986
Units shipped	Under 5

Fayette

United States North America

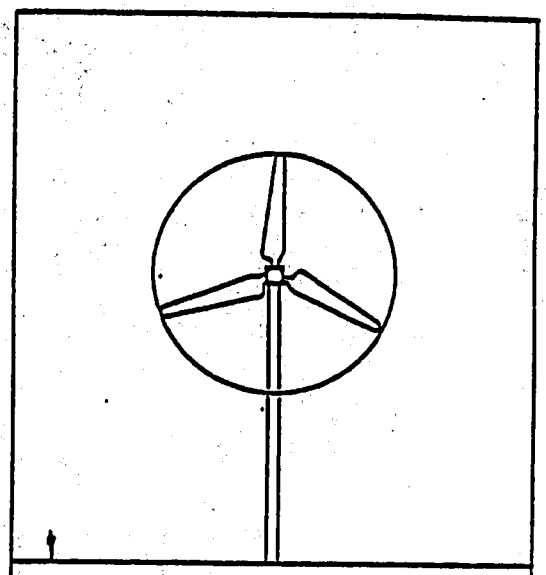
Address: Fayette Manufacturing Corporation
P.O. Box 1149
Tracy, CA 95376-1149
USA

Telephone: 209-836-5100
Telex:

Entered wind industry: 1981
Wind business areas: Wind turbines,windfarm development/operation
1985 Wind-related sales volume (US $million): Between 10 & 50

Corporate affiliations:

Major business areas: Wind turbines and windfarm operation and maintenance
1985 Sales Volume (US $million): Between 10 & 50



Fayette 19.4 m

Model	95IIS	100kW	250kW
Nameplate rating	95 kW	100 kW	250 kW
Electrical output	60 Hz	50(60) Hz	60 Hz
Type	Down-wind HAWT 3-Bladed	Up-wind HAWT 3-Bladed	Down-wind HAWT 3-Bladed
Rotor diameter	5.0 m	19.4 m	24.4 m
Blade composition	FRP	FRP	FRP
Hub type			
Cut-in wind speed	4.4 m/s	3.5 m/s	3.5 m/s
Rated wind speed	17.5 m/s	15.6 m/s	15.6 m/s
Power regulation	Full span pitch		Full span pitch
Overspeed control	Blade tip-feathered	Tip-feathered, mech.	Tip-feathered, mech.
Yaw control	Mechanical		Mechanical
Weight (w/out tower)	2565 kg		12150 kg
Transmission	2-Stage, helical	3-Stage, planetary	3-Stage, planetary
Generator rating	95 kW	100 kW	250 kW
Generator type	Induction	Induction	Induction
Comments			
Status	Production	Prototype	Production
Year introduced	1983	1986	1985
Units shipped	Above 500	Under 5	Under 5

Flowind

United States North America

Address: Flowind Corporation
1183 Quarry Lane
Pleasanton, CA 94566
USA

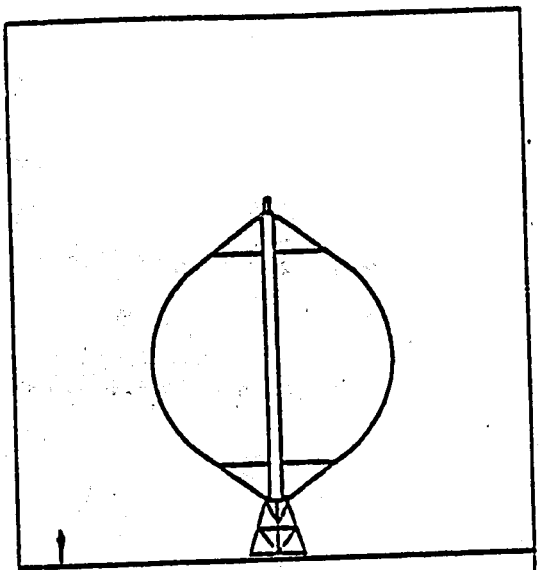
Telephone: 415-484-3300
Telex:

Entered wind industry: 1982
Wind business areas: Wind turbines, components, windfarm development/operation
1985 Wind-related sales volume (US $million): Between 10 & 50

Corporate affiliations: Subsidiary of Flow Industries, Inc.

Major business areas: Wind turbines

1985 Sales Volume (US $million): Between 10 & 50



Flowind 19.0 m

Model	F-19	F-25
Nameplate rating	300 kW	450 kW
Electrical output	60 Hz	60 Hz
Type	VAWT	VAWT
	2-Bladed	2-Bladed
Rotor diameter	19.0 m	25.0 m
Blade composition	Aluminum	Aluminum
Hub type		
Cut-in wind speed	6.0 m/s	6.0 m/s
Rated wind speed	20.0 m/s	20.0 m/s
Power regulation	Stall regulated	Stall regulated
Overspeed control		
Yaw control		
Weight (w/out tower)	9000 kg	13500 kg
Transmission	2-Stage, helical	2-Stage, helical
Generator rating	300 kW	450 kW
Generator type	Induction	Induction
Comments		
Status	Prototype	Production
Year introduced	1984	1985
Units shipped	Between 100 and 500	Under 5

99

International Dynergy

United States North America

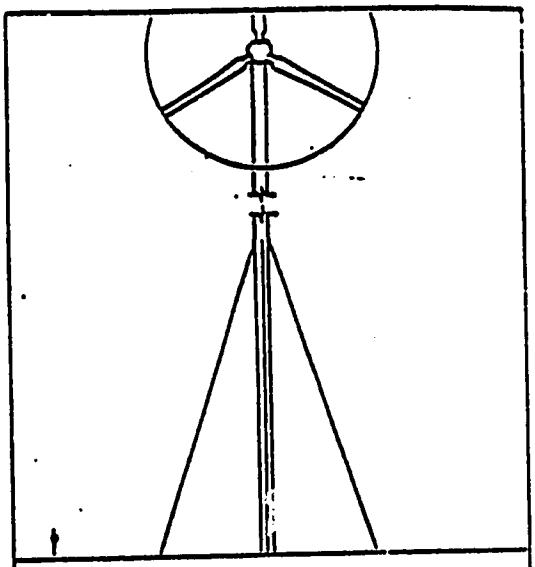
Address: International Dynergy Inc.
400 South Farrell Drive
Suite 8202
Palm Springs, CA 92262
USA
Telephone: 619-322-0400
Telex:

Entered wind industry: 1983
Wind business areas: Wind turbines, assessment services

1985 Wind-related sales volume (US $million): Between 10 & 50

Corporate affiliations:

Major business areas: Wind turbine and cogeneration development
1985 Sales Volume (US $million): Between 10 & 50



International Dynergy 19.8 m

Model	65/180	225KW
Nameplate rating	180 kW	225 kW
Electrical output	60 Hz	60 Hz
Type	Down-wind HAWT 3-Bladed	Down-wind HAWT 3-Bladed
Rotor diameter	19.8 m	21.6 m
Blade composition	FRP	FRP
Hub type	Rigid	Rigid
Cut-in wind speed	4.9 m/s	4.9 m/s
Rated wind speed	16.7 m/s	16.7 m/s
Power regulation	Stall regulated	Stall regulated
Overspeed control	Mechanical brake	Mechanical brake
Yaw control	Mechanical	Mechanical
Weight (w/out tower)	2500 kg	2750 kg
Transmission	3-Stage, helical	3-Stage, helical
Generator rating	180 kW	225 kW
Generator type	Induction	Induction
Comments	225 KW model is being manufactured by Daewoo Heavy Industries (South Korea)	
Status	Production	Prototype
Year introduced	1985	1986
Units shipped	Between 100 and 500	Under 5

Nordtank

Denmark Europe

Address: Nordtank A/S
Nyballevej 8
8444 Balle
Denmark

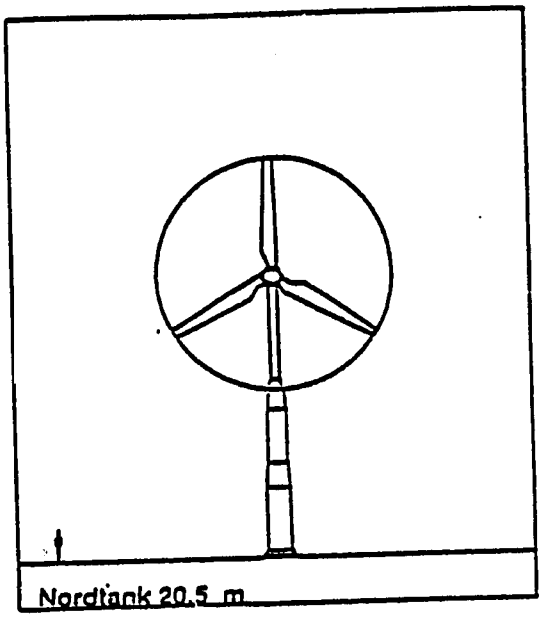
Telephone: 06337200
Telex: 63405

Entered wind industry: 1981
Wind business areas: Wind turbines, assessment services, windfarm development/operation
1985 Wind-related sales volume (US $million): Between 10 & 50

Corporate affiliations:

Major business areas: Wind turbines

1985 Sales Volume (US $million): Between 50 & 500



Model	NTK 55/11	NTK 65/13	NTK 75	NTK 99
Nameplate rating	55 kW	65 kW	75 kW	99 kW
Electrical output	50 Hz	60 Hz	50(60) Hz	50 Hz
Type	Up-wind HAWT 3-Bladed	Up-wind HAWT 3-Bladed	Up-wind HAWT 3-Bladed	Up-wind HAWT 3-Bladed
Rotor diameter	16.0 m	18.0 m	18.6 m	20.5 m
Blade composition	FRP	FRP	FRP	FRP
Hub type	Rigid	Rigid	Rigid	Rigid
Cut-in wind speed	3.7 m/s	3.7 m/s	3.7 m/s	3.7 m/s
Rated wind speed	18.0 m/s	18.0 m/s	18.0 m/s	18.0 m/s
Power regulation	Stall regulated	Stall regulated	Stall regulated	Stall regulated
Overspeed control	Mechanical brake	Mechanical brake	Mechanical brake	Full span pitch
Yaw control	Mechanical	Mechanical	Mechanical	Mechanical
Weight (w/out tower)	3600 kg	3600 kg	3600 kg	4500 kg
Transmission	2-Stage, helical	2-Stage, helical	2-Stage, helical	2-Stage, planetary
Generator rating	55/11 kW	65/13 kW	75 kW	110 kW
Generator type	Asynchronous	Asynchronous	Asynchronous	Asynchronous
Comments				
Status	Production	Production	Production	Production
Year introduced	1981	1981	1985	1986
Units shipped	Between 100 and 500	Between 100 and 500	Above 500	Between 50 and 100

100

Nordtank

Denmark Europe

Address: Nordtank A/S
Nyballevej 8
8444 Balle
Denmark

Telephone: 06337200
Telex: 63405

Entered wind industry: 1981
Wind business areas: Wind turbines, assessment services, windfarm development/operation
1985 Wind-related sales volume (US $million): Between 10 & 50

Corporate affiliations:

Major business areas: Wind turbines

1985 Sales Volume (US $million): Between 50 & 500

Model	NTK 130	NTK 150
Nameplate rating	130 kW	150 kW
Electrical output	50 Hz	60 Hz
Type	Up-wind HAWT 3-Bladed	Up-wind HAWT 3-Bladed
Rotor diameter	20.5 m	20.5 m
Blade composition	FRP	FRP
Hub type	Rigid	Rigid
Cut-in wind speed	3.7 m/s	3.7 m/s
Rated wind speed	18.0 m/s	18.0 m/s
Power regulation	Stall regulated	Stall regulated
Overspeed control		
Yaw control	Mechanical	Mechanical
Weight (w/out tower)	4500 kg	4500 kg
Transmission	2-Stage, planetary	2-Stage, planetary
Generator rating	130 kW	150 kW
Generator type	Asynchronous	Asynchronous
Comments		
Status	Production	Production
Year introduced	1986	1986
Units shipped	Under 5	Between 100 and 500

U.S. Windpower

United States North America

Address: U.S. Windpower, Inc.
500 Sansome St. #600
San Francisco, CA 94111
USA

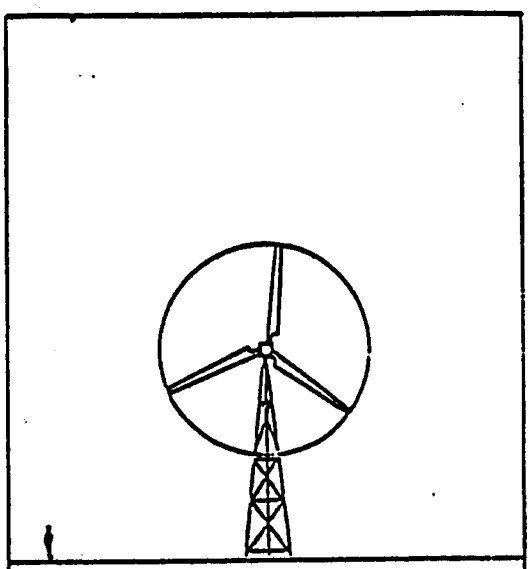
Telephone: 415-398-3825
Telex: 650-202-0019

Entered wind industry: 1974
Wind business areas: Wind turbines, components, assessment services, windfarm development/operation
1985 Wind-related sales volume (US $million): Over 50

Corporate affiliations: Fiberblade Corporation is a subsidiary.

Major business areas: Wind energy

1985 Sales Volume (US $million): Between 50 & 500



U.S. Windpower 17.0 m

Model	56-100
Nameplate rating	100 kW
Electrical output	60 Hz
Type	Down-wind HAWT 3-Bladed
Rotor diameter	17.0 m
Blade composition	FRP
Hub type	Rigid
Cut-in wind speed	5.4 m/s
Rated wind speed	13.0 m/s
Power regulation	Full span pitch
Overspeed control	Full span pitch
Yaw control	Passive
Weight (w/out tower)	2945 kg
Transmission	2-Stage, helical
Generator rating	100 kW
Generator type	Induction
Comments	
Status	Production
Year introduced	1983
Units shipped	Above 500

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Vestas

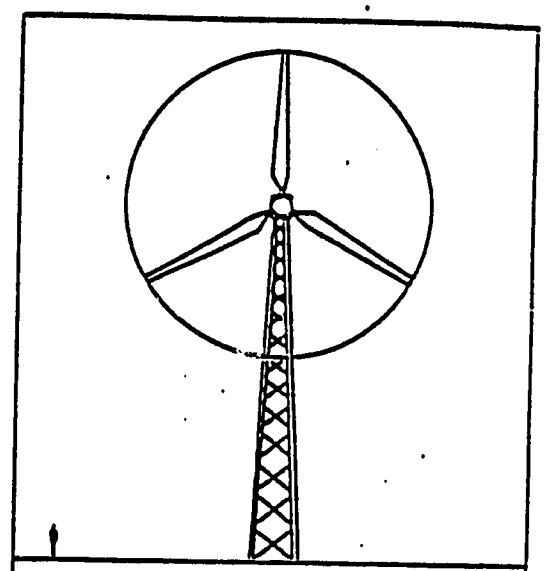
Denmark Europe

Address: Vestas Wind Systems A/S
Smed Hansens Veg 27
P.O. Box 42
Lem DK-6940
Denmark
Telephone: 7-34-1188
Telex: 60733

Entered wind industry: 1978
Wind business areas: Wind turbines, components, assessment services, windfarm development/operation
1985 Wind-related sales volume (US $million): Over 50

Corporate affiliations: Established in 1987 from reorganization of Vestas Energy A/S

Major business areas: Wind turbines and hydraulic equipment manufacture
1985 Sales Volume (US $million): Between 50 & 500



Vestas 25.0 m

Model	V-17	V-19	V-25
Nameplate rating	75(90) kW	90(125) kW	200 kW
Electrical output	50(60) Hz	50(60) Hz	50(60) Hz
Type	Up-wind HAWT 3-Bladed	Up-wind HAWT 3-Bladed	Up-wind HAWT 3-Bladed
Rotor diameter	17.0 m	19.0 m	25.0 m
Blade composition	FRP	FRP	FRP
Hub type			
Cut-in wind speed	3.6 m/s	3.6 m/s	3.6 m/s
Rated wind speed	16.8 m/s	16.8 m/s	13.8 m/s
Power regulation	Stall regulated	Stall regulated	Partial span pitch
Overspeed control	Blade tip-feathered	Blade tip-feathered	Blade tip-feathered
Yaw control	Mechanical	Mechanical	Mechanical
Weight (w/out tower)	6300 kg	7000 kg	10300 kg
Transmission	2-Stage, helical	2-Stage, helical	2-Stage, helical
Generator rating	90/17(110/22) kW	90/19(125/22) kW	200/30 kW
Generator type	Asynchronous	Asynchronous	Asynchronous
Comments			
Status	Production	Production	Production
Year introduced	1984	1986	1986
Units shipped	Above 500	Between 20 and 50	Under 5

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6 development forum july-august 1989

Electric breezes

BARBADOS IS ABOUT to begin operation of a wind turbine electricity generator which is expected to lower the country's energy bill by about US$110,000 annually.

The generator has been erected in the northern parish of St. Lucy, which is swept by Atlantic breezes. The cost of generating is estimated to be 16 US cents per kilowatt in comparison with the residual fuel output of the Barbados Light and Power Company's 28 US cents per kilowatt.

Two senior engineers from the UK and US have visited Barbados to train people to operate and maintain the generator after it is handed over.

The turbine is mounted on a 30-metre high (100-foot) tower and the generator has a fully automatic computer system, which will check and log all faults during the day.

When the wind speed is higher than 80 kilometres (50 miles) per hour, the generator automatically shuts down. It does so also when the wind speed is too low.

If this generator performs successfully, the government may acquire eight more turbines, which could provide power for isolated communities and the whole of the northern parishes. MMS ☐

R. LYNETTE & ASSOCIATES

Energy Consultants
15012 N.E. 40th Street, Suite 206
Redmond, Washington 98052 U.S.A.
PHONE 206/881-0206
FAX. 206/881-8168

ANNEXURE-H

April 4, 1989

Mr. Mohammad Ajmal
Director, Generation Contracts WAPDA
Pakistan Water and Power Development Authority
630-WAPDA House
Lahore
PAKISTAN

Dear Mr. Ajmal:

Thank you for your letter, Development of Wind Energy to Produce Electricity in Pakistan. Unfortunately, no wind speed table was included with the letter. Also, your summary of the table was not clear to us. Specifically, 6748 + 4262 + 1416 = 12,426 hours, but there are only 8760 hours in a year, so we cannot judge your wind resources.

Wind turbine costs continue to decrease, and I expect wind turbine costs of $500-600 per kW within two to three years, with turnkey systems costs of $700-850 (includes all other costs associated with a wind power station).

We are advisors to several European/Mid-East governments regarding their wind energy programs. My advise to them has been to concentrate on wind resource assessments for one to three years before installing wind turbines. Unless you have a very firm idea of your wind resources, I would make the same suggestion to you. From the limited data we have on your wind resources, development of wind stations appears attractive in some areas.

I have enclosed some literature about our firm and some general wind power information. We would be glad to suggest a low-cost wind resource assessment program for Pakistan if you desire. This would require that you fund a trip to Pakistan and pay for our expert's labor. Alternately, may I suggest that you consider sending a technical expert to the United States for one to two week to sit down and learn about our experiences with wind energy over the past nine years. We would show him the wind farms, proper anemometry, how to do the economics, etc. Our charge for this would be approximately $4,000.

Sincerely,

Robert Lynette
President

RL:em:OG

Enclosures

POTENTIAL FOR WIND MILL APPLICATION IN PAKISTAN

M.A.SHAH AND S.A.RIZVI

PAKISTAN

GENERAL

Pakistan is situated in the South West of Asia and surrounded by Iran in the West, Afghanistan in the North West, China in the North east, India on the east, and Arabian sea in the South.

Pakistan consists of four provinces, NWFP, Punjab, Sind and Baluchistan.

Pakistan has an area of 800,000 sq/km, there is a 900 Km long sea coast line. The population as per statistic of 1988 is 105 million. Since the country's economy is based on agriculture therefore 85% of the population depends on agriculture and lives in rural areas, however due to the industrialization the public trend is changing towards migration to the big cities. Main cities of the Pakistan are Islamabad (Capital) Rawalpindi, Lahore, Multan and Hyderabad whereas the city of Karachi is a main trade centre and largest in population.

The literacy ratio in Pakistan, for both sexes from the age 10-55 years is 21.7%.

CLIMATE

The climate of Pakistan is rather heterogeneous as regards Seasons as well as regions. It lies on the Western margin of one of the major climatic regions of the world, the monsoon region. In the coastal areas the influence of the Sea results in moderate temperature and strong Sea breezes, which are a result of the large temperature difference between mainland and relatively cool sea.

The seasonal reversal of winds & associated rains is most, pronounced in the eastern part of the country, where high wind results in rainfall during the summer season.

ENERGY SITUATION

The electricity generation in Pakistan is based on hydroelectric generation & thermal plants. These stations are located in the Southern and in the northern part of the country. These are interconnected. In the province of Baluchistan there is only one thermal station which is in Quetta. This is also Connected to the national grid. In the coastal area of Sind electricity is widespread while in Baluchistan this is limited to only towns. The main constraint for rural electrification is the high cost.

The total energy production was 7,000 MW in 1989, whereas the forthcoming requirement up until 1999-2000 is estimated 17,157 MW. The power is mostly provided to the big cities and as such the far rural and remote areas of Pakistan still unknown with the light.

The Solar energy is abundantly available in Pakistan. It can be utilized for electrification and water pumping for rural areas. But the high capital cost of photovoltaic system hinders the exploitation of this energy conversion system.

Wind energy is being utilized in some parts of Sind and Baluchistan. A great deal of exploitation can be done by proper utilization of this energy system especially in the coastal area of Pakistan.

COST COMPARISON

The areas of Pakistan which are far away from the main grid line are most deprived of the basic human needs, like electricity and drinking water.

To provide the infrastructure effectively to these areas, the cost involved will make it uneconomical and in fact the electrification by thermal or Hydel systems would be much higher, as these areas are far away from the National grid line. Alternative systems have to be taken into account. The most cost effective method would be utilization of wind energy.

COST OF ELECTRICITY GENERATED BY A SMALL WIND GENERATOR

An estimate is made of the cost of electricity generated by a small 3 metre diameter battery charger. The price of electricity is mainly determined by the investment cost of Wind generator and the batteries for electricity storage.

The output of a small wind mill generating electricity in the wind regimes of Karachi and Jiwani is presented. It has a 12 metres high tower. The out put is 24 volts. The production of electricity is roughly speaking proportional to the swept area of the rotor. The results of these calculations are more or less representative for the electricity production of other battery wind electricity of the same rotor size.

MONTH	WIND (M/S)	KAR POWER (W)	ENERGY (KWH)	JIWANI POWER (W)	ENERGY (KWH)	WIND (m/s
JAN	3.6	119	88	104	78	3.8
FEB	3.4	103	70	90	61	3.6
MARCH	4.4	165	123	111	83	3.9
APRIL	5.2	218	157	159	115	4.7
MAY	7.1	332	247	128	95	4.2
JUNE	7.6	361	259	133	96	4.3
JULY	7.8	378	280	141	105	4.4
AUG	7.4	360	268	132	98	4.4
SEPT	6.6	300	216	4.1	120	86
OCT	3.9	146	108	3.3	74	56
NOV	3.4	110	79	3.1	65	47
DEC	3.5	114	85	3.1	69	52
ANNUAL	5.3	226	1981	3.9	111	971

It is seen that the same wind mill produces 2000 KWH in Karachi area, while it produces only 1000 KWH in Jiwani. Assuming that the value of the average wind speed does not affect the windmill's life time, the electricity will be twice as expensive in Jiwani as it is in the Karachi wind regime.

When the electricity is used for lighting the demand peak is concentrated in the evening hours. The energy that is produced during the day time must be stored in batteries for use in the evening hours. When high wind speeds coincide with the high demand, this saves batteries and reduces the price of the system considerably.

In case 2000 KWH are produced (Kar) the price is 0.225 $/KWH, in case 1000 KWH are produced the price is 0.45 $/KWH.

COMPARISON WITH SMALL GENERATOR SET

In small villages little Kerosene generator sets are sometimes used to produce electricity of around 400 - 800 watts. The price is determined by the investment cost and the fuel consumption.

ASSUMPTION:

OMR - Operating/Maintenance limit cost

Cost of generator	:	600$
Fuel consumption	:	1 litre/kWh
Fuel price	:	0.3 $/litre
Life time	:	5000 running Hrs
Interest	:	10%
OMR	:	10% of fuel price.

Using these assumptions the electricity price is 0.85 $/kWh when the set is used for 4 hrs per day. The price is decreases to 0.8 $/kWh when set used during 24 Hrs/day.

COMPARISON WITH WATER PUMPING

The pumping systems are compared on the basis of cost per unit water ($/m3). For motor pumps it is calculated what it would cost to pumps the same amount of water with a certain windmill.

Avg wind speed 4m/s	Annual output	Unit cost windpump	Unit cost 3h.p petrol pump	Unit Cost 12 h.p diesel pump
Windpump type	m3	$/m3	$/m3	$/m3
W.M of 2m,dia	5840	0.088	0.067	0.086
W.M.of 3m,dia	14016	0.052	0.062	0.050
W.M.of 5m,dia	40880	0.031	0.060	0.035
W.M.of 6.1m,dia	16060	0.143	0.061	0.046

The table shows that the Windmills are competitive as compared to the diesel & petrol pumps.

WIND PATTERN

The coastal areas are dominated by sea breezes, which have a strong diurnal pattern. The sea breeze first starts in a narrow coastal zone but penetrates inland during the day, usually some 20-40 km, but in exceptional cases where the temperature gradient becomes very large such as in the coastal areas of Baluchistan, up to 100 km. The sea breeze starts in the afternoon, reaching its maximum

speed late in the afternoon. In the evening at about 11 pm when the temperature difference decreases the sea breeze fades away. From the wind data of Karachi, it is clearly visible that a strong diurnal pattern exists, which peaks at 12.00 GMT. The difference between day and night windspeed is approximately 4 m/s all the year round. However, a difference exists in the average daily windspeed over the seasons. During the winter months the average windspeeds are moderate, but in the monsoon season, from May to October, the average windspeed is considerably higher, with the highest peak occurring in the months of June and July where the average windspeed is approximately 7 m/s. Here the frequency distribution is rather broad due to the large diurnal pattern. At Jiwani also a strong diurnal pattern exists, which peaks at 12.00 GMT. The difference between day and night windspeed is approximately 4 m/s all the year round. There is hardly any difference in windspeed noticeable among the seasons.

The frequency distribution at Jiwani is rather broad due to the large diurnal pattern.

The Baluchistan and Lower Sind coastal areas have a strong sea breeze wind regime. In Lower Sind there is also a strong monsoon influence.

From the limited records available, it is concluded with reservation, that a considerable wind potential exists along the coast.

KARACHI: airport hourly wind data 1951-1960 height
windmeter: 7m (uncertain)
zO= 0.03
vpotentia 11.07
frequency

m/s	0.08	2.4	4.1	6.3	9.6	12.3	15.6	18.9	22.7	sum
Jan	148	152	155	181	79	22	6	0	0	743
Feb	140	159	147	152	62	15	4	0	0	679
Mar	124	124	121	199	128	39	7	2	0	744
Apr	77	94	108	186	187	60	7	1	0	720
May	29	22	65	198	269	126	28	5	2	744
Jun	15	16	41	194	266	142	41	4	0	719
Jul	13	16	35	165	323	146	37	7	0	742
Aug	12	18	30	191	357	112	23	1	1	745
Sep	23	31	67	234	262	91	12	0	0	720
Oct	161	128	115	184	124	28	3	0	0	743
Nov	182	156	131	149	76	21	5	0	0	720
Dec	185	146	145	163	74	27	4	1	0	745
Year	1109	1062	1160	2196	2207	829	177	21	3	8764
Mons (apr-sep)	169	197	346	1168	1664	677	148	18	3	4390
n-mon (oct-mar)	940	865	814	1028	543	152	29	3	0	4374

JIWANI
height windmeter: 6m (Uncertain)
zO= 0.10
vpotentia 11.19
frequency

m/s	2.1	5.2	8.3	11.3	14.4	17.5	20.5	sum
Jan	198	396	118	22	7	1	1	743
Feb	189	377	98	12	2	1	0	679
Mar	192	394	120	28	10	1	0	745
Apr	93	372	200	49	5	2	0	721
May	128	400	201	13	2	1	0	745
Jun	125	381	188	19	6	1	0	720
Jul	97	403	224	18	3	0	0	745
Aug	85	443	196	15	3	1	1	744
Sep	116	432	144	26	2	1	0	721
Oct	226	428	84	7	0	0	0	745
Nov	253	399	62	7	0	0	0	721
Dec	281	386	61	10	7	0	0	745
Year	1983	4811	1696	226	47	9	2	8774

WIND MILL HISTORY IN PAKISTAN

Water and power development authority (WAPDA) and Agriculture development bank of Pakistan (ADBP) installed in 1960's some water pumping windmills in the province of Sind and Baluchistan which were imported from U.S.A. and Australia. Later on a local firm with the help of PCAT (Pakistan Council of Appropriate Technology) and ITDG (INTERMEDIATE TECHNOLOGY DEVELOPMENT GROUP) started manufacturing water pumping windmills. They have so far produced and installed 40 windmills. Out of all these only few are in working conditions which are being maintained by the user. From the imported mills only two windmills are in operation which are also maintained by the users themselves. The remaining windmills are out of order/totally damaged due to lack of maintenance.

The energy resources cell has installed a 2 KW experimental wind generator of Northern power system of U.S.A., complete with storage battery system for supplying electricity to remote areas/villages. This windmill is also out of order due to lack of proper maintenance.

PCAT (Pakistan Council for Appropriate Technology) a government organization under the Ministry of Science and Technology. Its activities are comprised of wind energy, biogas, biomass, cook stoves, solar energy, food and agriculture, low cost construction, rural water supply and sanitation.

Since 1985 PCAT has been involved in the development of wind energy technology suitable for local manufacture, field tests and some wind data collection. In cooperation with NIP prototypes of water pumping windmills were designed and tested. After evaluation PCAT

was not satisfied with the prototypes and has sought cooperation with foreign organizations.

Together with Miami University a program was started for the mathematical modelling of the wind regime along the Makran coast. PCAT is responsible for the collection of wind data in this program.

Some scattered activities comprise the installing of a small wind generator of chinese origin and the installation of a small combined electricity generating and water pumping windmill from Netherlands.

INDUSTRY RELATED TO WIND ENERGY:

There is at present only one manufacturer of windmills in Pakistan in private sector. The company has three models in production with rotor size of 2 meter, 3 meters and 5 meters. These windmills are of slow speed, multi-bladed water pumping type.

Wind generators are not produced in Pakistan yet, however, major component can be produced locally with foreign collaboration.

The total production of wind mills during the past 8 years amounts to 40.

"BARQ-AAB" (WATER AND POWER SCHEME)

A scheme for providing light and water for 100 villages by installing dual function wind turbines along the Makran coast (Lyari to Pasni). This scheme is under process by Govt. of Baluchistan, Pakistan Council of Appropriate Technology and US-AID.

This scheme will benefit 72,000 people and generate employment for 400 persons.

CONCLUSION:

1. Interest in windmill is all over vivid.

2. Application possibilities in windmills are available for
   Water pumping
   Power generation.

3. Windmill generating farms can also be used for supplying power to national grid system near Karachi.

4. Wind energy system is economically viable.

5. Local manufacturing of windmill is possible.

6. As experienced with the present installed windmills in Pakistan. It can be said that a windmill system can only be successful if it is backed by a well organized maintenance organization.

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   By H.Cleyne, TU Eindhoven, J.Hoevenaars, ILR Ivageningen

2. Pakistan Statistics year book.

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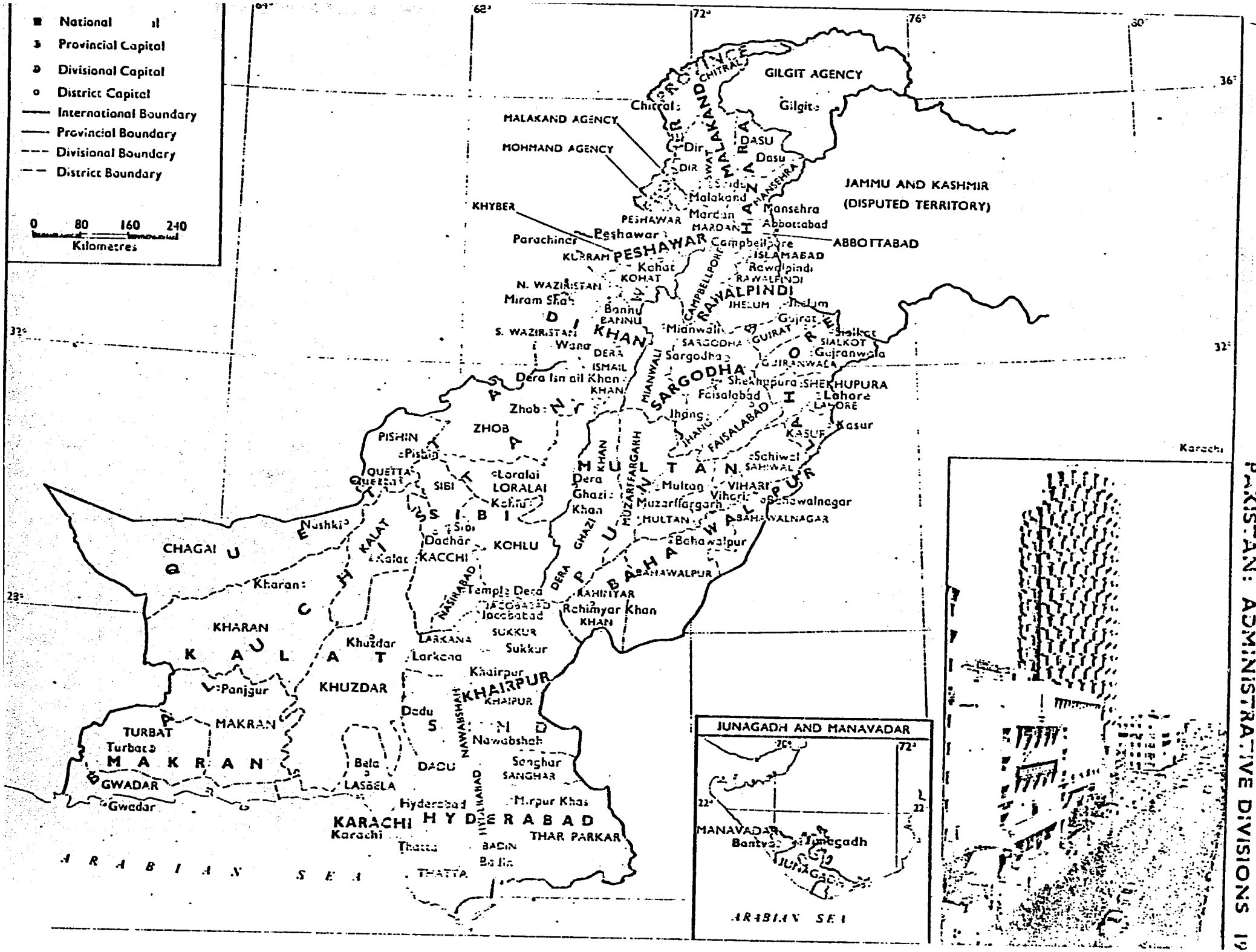
LIST OF SOME OF THE WATER PUMPING WINDMILLS MANUFACTURED AND INSTALLED BY LOCAL MANUFACTURERS, AGROTOOL 'F' DIVISION.

YEAR	OWNER'S NAME	LOCATION
1976	A.T.D.O.	Gadani Masjid
1977	A.T.D.O.	Gadani
1977	S.D.O., Cholistan	Buttan
1977	Peoples District Council	Imam Bux Goth
1978	Mr. Ashraf Abbasi	Super Highway
1980	Mr.Taj Hidayatallah	Mirpur Sakro
1981	Mr.Ashiq Ali Bhutto	Thatta
1981	Baluchistan Development Authority, Quetta	Chagai
1981	D.F.O. Mirpurkhas	Malle-Jo-Tar
1981	D.F.O. Kotri	Uth Plan
1983	Brigadier Hayat	Thatta
1984	Habibullah Mines Ltd.	Lakhra
1983	Sandoz (Pak) Ltd.	Jamshoro
1981	Church World Services	Rattanabad
1984	Greener Karachi Society	Karachi
1984	Bilal Farms	Super Highway
1984	Yousuf farms	Super Highway
1985	Anwar Farms	Super Highway
1984	U.A.C. London U.K.	for Nigeria
1986	A.T.D.O.	Karachi
1987	UNATRAC	for Nigeria
1987	Energy Resources Cell	Faiz Mohd. Goth
1987	Energy Resources Cell	Baz Kando
1987	Christ the King Seminary	Karachi
1987	District Council Karachi	Safar Goth
1987	District Council Karachi	Rodhin Baluch Goth
1988	SAZDA	Okraro Chanio (Thar)
1988	SAZDA	Dhaklo
1988	SAZDA	Kharore Nara Region
1990	D.F.O. Baluchistan	Hub Dam



PAKISTAN: ADMINISTRATIVE DIVISIONS 19

ATTACHMENT H

WIND ENERGY ACTIVITIES IN TURKEY

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GENERAL DIRECTORATE OF ELECTRICAL POWER RESOURCES SURVEY AND DEVELOPMENT ADMINISTRATION

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I. WIND ENERGY ACTIVITIES OF ELECTRICAL POWER RESOURCES SURVEY AND DEVELOPMENT ADMINISTRATION (EİE)

EİE, of the Ministry of Energy and Natural Resources, possesing a state economic enterprise character, was established in 1935, with the purpose of generating electrical power from surface and subsurface resources of Turkey and its utilization throughout the country.

The activities of EİE are conducted through the operation of 4 main technical departments hydrological survey, geology and drilling design and energy resources surveys, and 5 other supporting departments, and advisory legal and inspection/control units.

EİE undertakes all the necessary reconnaissance and feasibility studies to develop the national resources for generation of electrical power, and accordingly completes planning and final design studies towards the realization of this purpose.

During last few years new tasks were assigned to the Administration for the rational utilisation of energy resources, planning and development of new and renewable energy sources particularly in the field of solar and wind power and energy conservation studies.

Our present activities in wind energy are as follows:

1- Wind Energy Potential

Until recently the wind energy potential of Turkey was not determined in detail. Thus a study was initiated by EİE. First step consisted of identification of favourable locations for wind energy, based on measurements taken by the state Meteorological Organization at 114 stations.

The studies aimed to identify the temporal and natural distrubution of wind energy potential of the country were performed in last few years. The results reveals an annual average wind speed of 2.5 m/s and annual wind power density of 24 W/m^2 for Turkey. Slide 1. (wind Energy Potential Annual Distrubution)

Establishment of an outdoor wind park, for the execution of the research generation of electricity and mechanical energy for windpump system from wind energy, has been completed within the Administration Complex. Slide 2(General wiew of Energy Park)

2- EIE Wind Turbine-Generator System

In cooperation with Middle East Technical University, EIE initiated a project to investigate manufacturing and operating problems of a wind energy conversion system in 1983.

The purpose of this project is to develope a wind turbine-genarator system to generate electricity in rural regions in Turkey. The installed system has a rated capacity of 1.1.kw and was installed at New Energy Resources Park of EIE.

The system consists of 17 m high cage type steel tower, Darrieus type three-bladed vertical axised aeroturbine, a 1.1. kW syncranous generator, an electronic control unit with a microproscessor and a set of storage batteries with 250 Ah, 48 V capacity. Slide; 3,4,5,6,7.

Only the aeroturbine part of the system had been imported. The other parts of the system was manufactured locally. The WTG System has been erected in the test field . Slide:6

3- Bandirma WTGS

A project to investigate the establishment and operating problems, long-term production and efficiency, and the possibilities of meeting a small amount of energy demand with the wind energy has been initiated by EIE in 1987.

The system has been established in a farm in Bandirma where there is considerable wind energy potential.

The system had been imported from abroad and consists of 18 m high, guywired tubular steel tower, horizontal axis, downwind, 12 m diameter two reinforced polyester fiberglass blades,20 kW capacity synceronous generator

The system is used for meeting the lighting and water pumping demand of the farm. The system has been supplied with a stationer type 48 V, 250 Ah battery group and a 1 kW inverter to assure the necessary load of the farm. Slide 11,12,13,14,15,16,17,18,19,

4- Water Pumping System by the Wind Energy

A water pumping system had been imported from abroad and it had been established to investigate the pumping capacity and operational problems and possibilities of meeting the water demand of small farms with this kind of wind energy using mechanical water pumps.

The mechanical energy, produced by 6 bladed wind turbine, placed on top of a 6 m high guy wired steel pipe, is used to pump the water by a suction-pression pump from maximum 7 m depth to 5 m height. The System can start pumpin at the wind speed of 3 m/s and it has been installed in the New Energy Resources Park of EIE. Slide 20,21,22,23,

II- WIND ENERGY STUDIES OF OTHER ORGANIZATIONS

1- İSTANBUL TECHNICAL UNIVERSITY

-Research of Wind Energy Potential in Aegean Coasts

-Wind Turbines With Horizontal Axis. The aim is to search the possibility of using wind energy for electricity in remote islands. The study is performed on 1.5 kW Darrieus type wind turbine generator.

-The Design of Low and Medium Powered Wind Turbines:
To install wind farms in some regions of Turkey. Some of the turbines will only be used for mechanical energy, such as mills, pumping.

2- TURKISH SCIENTIFIC AND TECHNICAL RESEARCH INSTITUTE (TÜBİTAK)

-Wind Map of Turkey .

-Research For Wind Energy Conversion Technologies .

3- PRIVATE SECTOR

-In 1984 a system capable of producing 55 kW at 12.5 m/s wind speed , has been installed in Altınyunus facilites by importing the system from Vestas, Denmark with the aims of producing electrical energy from wind energy. Tower with a height of 22.6 m, was manufactured by a local firm. The system,starting producing energy at a wind speed of 4-5 m/s, reaches rated power at a wind speed of 12.5 m/s . The system does not contain a battery therefore energy produced is directly being consumed.
Slide: 24

-In western provinces of Turkey, some small firms manufacture and operate water pumping systems which utilise wind energy.
Such systems are coarge since they are manufactured by small firms.
Slide: 25,26,27,28,29,30,31,

- In western shores of Turkey there are windmills used in ancient times. Slide: 32,33,34,35,36