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PROPOSED METHODOLOGY FOR AEOLIAN ENERGY  
DEVELOPMENT IN LATIN AMERICA

ABBREVIATIONS USED IN THIS WORK

AGAE	ADVISER GROUP OF AEOLIAN ENERGY
CNIE	NATIONAL COMMISSION OF SPACE INVESTIGATIONS - ARGENTINA
IIE	INSTITUTE OF ELECTRICAL INVESTIGATIONS - MEXICO
ELETRORBRAS	BRAZILIAN ELECTRICAL COMPANY - BRAZIL
ITINTEC	INSTITUTE FOR TECHNOLOGICAL RESEARCH FOR INDUSTRY AND TECHNICAL STANDARDS - PERU
CEPAL	UNITED NATIONS ECONOMIC COMMISSION FOR LATIN AMERICA (UNECLA)

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## AEOLIAN ENERGY

### 1. INTRODUCTION

Technological evolution, outbursting during this century, has not contributed to substantial improvement of human population living conditions, since the industrial society, from which it was originated and consolidated, came to being provider of goods destined to minorities, without solve problems such as the satisfaction of essential needs, subocupation, disguised or open unemployment, it did, on the other hand, assist to its worsening in several regional countries.

The so-called "modern stratum" of the farming sector was not kept out of the foresaid evolutive process. Its principal activity, vegetable production, received such impact, transforming itself into an eager energy consumer and a clear expeller of animate energy, substituting it by inanimate energy. This impact, similar to the urban sector, the principal receiver of carried human population from farming sector, was and is one of the principal causes of environmental impairment which begins to alarm mankind.

It is unquestionable that the engine of this process is the availability of energy at reasonable prices with enough reserves to secure continuity in time. The oil crisis of the 70's proved the importance of investing on alternative energy sources of renewable kind and of wider scope in relation to users, with the purpose of guaranteeing the maintenance of the evolutive process.

It is well-known the example of the rich countries for its oil resources with populations that, for the lack of suitable infrastructure, have not access to the utilization of energy as means to improve the "habitat" or to make the working methods more efficient.

It is also clear that this eagerness of energy consumption has had a depredating effect in the ecosystem, and worst yet, the availability of hydrocarbons has been burnt in inadequate uses, up to a point that we are conscient that by the end of this century we will be facing another energy crisis, unless new and different energy sources are obtained.

Facing the fact, it stands to reason that the challenge consists, apart from the reorganization for preservational purposes towards rational use of existing resources, in the attempt of obtaining low cost energy sources with perpetual production, which contributing to the foresaid reorganization, allows the unlimited expansion of the number of beneficiaries of progress.

Consequently, the equation consists of two similar important terms: to avail energy sources for perpetual use and ensure a minimum distribution of them to the majority of human population.

In the Region's particular case, the solution of this equation seems to be found in the rational development of energy generated by the use of renewable natural resources, mainly the SUN.

Actually, researchers have centered efforts in taking advantage of the SUN, directly as heat source, photoelectricity, evaporation capability, etc., or indirectly using wind energy originated by atmosphere heating.

### 1.1 The Wind as an Energy Source

Winds are originated fundamentally by unequal heating of the Sun over the earth's surface. It is known that the air that lays during the day over large water extensions, stays relatively cold, since caloric energy is inverted by evaporation or is absorbed by the water.

On the contrary, the earth is heated more rapidly originating an increase of the temperature of the air mass deposited on it, losing density and raising itself. The relative vacuum is rapidly filled in by the cold and dense air from the sea, and a maritime breeze appears over the continent.

The faster cooling of earth during the night, produces the contrary process, this is an earth breeze that blows towards the sea.

We can find a similar explanation for the mountain breezes produced by the unequal heating of the slopes in regards to the deep part of the valleys. These local winds are added to the general circulation of the atmosphere motivated in the amount of heat that the Equatorial air mass receive which provokes a thermal disparity with the polar mass and which produce displacements from the poles towards the Equator in the earth surface, completed with the movement of hot air from the Equator towards the poles by the high zones of the atmosphere.

We also have to add to this effect the earth rotation which gives as a consequence the rotation towards the West of the cold air mass in their way towards the Equator, and, that in the high atmosphere, the hot winds that go towards the poles have a rotation on the East direction.

This fast summary leads us to the fact that we are in front of a marvellous energy source, practically unexhaustable and available to struggle in the search for its adequate utilization.

To confirm these considerations, we only need to see that the estimation on the renewable available potential of the winds around the whole planet should be  $10^6$  MW, this is, ten times the hydric available potential of the earth.

In Latin America the predominance of the ocean surfaces over the continents in the South Hemisphere, makes the general circulation to become closer to the mentioned theoretical system. Nevertheless, the knowledge is only general and therefore, it is necessary to classify the winds and their variations, to be aware of the geomorphological influence that in the practice provokes a more or less acute displacement from the theoretical scheme.

## 1.2 OLADE's Action

Taking the foresaid into account, during the First Extraordinary Meeting of OLADE Ministers, carried out in San Jose, Costa Rica on July 6th. and 7th., 1979 it was emphatically explained "the importance of achieving a joint action of the Latin American region face to the union of nations and without detriment of each government sovereignty, OLADE is consolidated as the principal instrument in charge of promoting energy cooperation and coordination among its Member States and sub-regional organizations."

In observance of this express commission prescribed by said Ministers, because of the need to find alternative solutions to the energy crisis, among other determinations, OLADE decided to establish a Work Program for the massive utilization on Wind resource in the Region.

## 2. OBJECTIVE

Taking into account the importance of aeolian energy as alternative source to those actually in use, mainly due to the facility of obtaining and considering its non-predatory characteristic to the ecosystem, an evaluation of this resource is proposed for Latin America, in the certainty that its benefits may be applied with priority particularly to rural populations of less resources, and to an ample sector of human population in general. This evaluation implies the full utilization of technical power existing in the Region, under an adequate coordination tending to minimize economic resources applied in the research. Therefore, as a consequence of attending the rural sector, the migration of population to the cities will be avoided, and the productive activity of this sector will be kept and better living conditions could be possible to attain.

An important point in the surveying of the aeolian resource in the Region, is that such could serve as reference for studies as the effect of wind over energy transmission lines, the impact on structures located at windy areas, among others.

The initial applications foreseen will be directed to the productive activities, mainly through the use of wind mills for water pumping, electricity aerogenerators and grain mills. Even more, aeolian energy could be considered in integrated systems of alternative sources of energy, which seems to be the most reasonable and efficient solution at the time being. An illustrative and simple example could be found in the solar heaters where a pump moved by the wind may be used in the transference of heated water.

Large scale applications for the future will also be considered with the development of aerogenerators of 100 KVA or more, to be used as loading terminals in the rural communities.



## 2.1 Features of the Work

Naturally, all efforts to be carried out in the Region so as to attain benefits from aeolian energy must be based on the knowledge of this resource, to determine by means of a compared resource-evolution research of the demand, in which cases that development is an acceptable solution to satisfy needs of potential users. In addition, it must take into account the achievement of balanced relationships between the country and city.

Nevertheless, it must be emphasized that in spite of financial efforts carried out by regional countries for industrial growth, their economy still depends on agricultural and mining activities in large scale. This implies the existence of scattered groups of people, which impedes the endowing of essential services such as energy distribution. The lack of basic services is part of the motivation which carries the population to scatter disorderly towards communities with large human agglomerates, increasing costs of services, in particular, and damaging the ecological system in general.

Supplying conventional energy for population that is scattered or concentrated in small groups has been obstructed hitherto, due to service rentability viewpoints.

As can be deduced, one of this work's premises assumes that one of the possible variables to maintain rural population in its own environment is allowing their sharing the benefits of technical development, providing possible access to a superior quality of living compared to the present.

Finally, considered of vital importance for the Region, is the overcoming of radial diagrams, that means the union of each Latin American Country to various developed centers located outside it, replacing this by a plan that implies union within the Region.

The foresaid radial diagram leads to the unawareness of regional countries' own capacity, and costly if not frustrating efforts duplication.

### 3. ACTION PLAN FOR LATIN AMERICA

The proposed action plan is divided in six (6) chronological consecutive stages of which contents are described in the following items.

#### 3.1 Stage I

Definition of parameters to accomplish the Applicability of Aeolian Energy Study in Latin America.

The achievement of this research requires the fulfilment of three immediate goals:

- a) Preliminary evaluation of the aeolian energy resource in the Region.
- b) Determination of actual technological capabilities to make use of aeolian energy in the Region countries.
- c) Preliminary estimation of countries that could be potential users.

Preliminary evaluation must begin from available geological and climatic information. According to experiences regarding availability, reliability and structure of information, it is necessary to define a minimum of information to be obtained and a regular methodology for its processing and analysis.

To fulfil the foresaid goals, the following actions must be carried out:

- a) To make an inventory of available regional technology for the use of aeolian energy. It implies technological exchange and consequently the establishment of a formal mechanism for its accomplishment.
- b) To define the minimum necessary geological and climatic parameters, which must be requested from each country for its processing and analysis.
- c) To define a standardized methodology for information release, use and analysis.

To attend these goals, the creation of an Adviser Group of Aeolian Energy (AGAE) is proposed, being formed by regional technicians in whose first meeting those actions would be analyzed.

As an approach to the work this Group should achieve, following are several outlines in relation to this stage goals.

### 3.1.1 Inventory of Available Technology in the Region

The quality of the experience acquired in research, development and demonstration of systems destined to make use of aeolian energy in most of the regional countries, will serve as base for the establishment of improved projects in relation to each zone's specific needs.

This inventory will allow to show the advantages and disadvantages of each technology, and consequently will discover the most adequate solutions, as well as possible combinations between conventional and new technologies.

The following technologies to be inventoried are outstanding:

- a) Methods of exploration and location of areas of interest for their aeolian energy potential.
- b) Quantification and characterization of aeolian energy potential in areas of interest.
- c) The actual state of research, development and demonstration of aeolian energy converter systems and energy storage systems.
- d) Latin American experience on studies over environmental and socioeconomic conditions of the areas to be attended by non conventional systems of energy sources.

### 3.1.2 Definition of minimum necessary geological and climatic parameters

It is necessary to define the minimum essential parameters for the raising of the necessary geological and climatic conditions, which attainment will be in charge of each country.

Basically, the available data from different national institutions would be utilized, related to studies and geoclimatic surveys.

In case there is lack or non-trustful information in regards to wind behaviour or geological data, guidelines or recommendations should be suggested for the installation of measuring systems through specific programs of technical-scientific cooperation. This cooperation shall be developed preferentially among the Members States of OLADE.

Among the most important parameters to be preliminary considered are the following:

- a) Average velocities of winds measured during an statistically reasonable period; daily, monthly and yearly.
- b) Event frequency
- c) Wind direction
- d) Geo-topographic and hydrogeological maps
- e) Maps of potential utilization of soils
- f) Maximum velocities of winds
- g) Suspension particles carried by the wind

### 3.1.3 Standardized methodology for analysis and processing of information

Information must be processed according to a methodology that will allow a common language to all the working groups and will permit the attainment of comparative results. This activity will be in charge of AGAE that will define this methodology based on the accumulated knowledge of the study of the wind, already performed by the existing meteorological networks, with present available geological works, together with the mathematical models already developed by each country.

Standards established for analysis, should take into account the following aspects:

- a) Geographical distribution of stations and networks.
- b) Evaluation of areas selected for measurements and limitation on the use or summarized data, to select priority areas.
- c) Adequation of winds information in relation to instrumental quality, its maintenance, presentation and data calculation for priority area selection.

### 3.2 Stage II

Analysis of information obtained in Stage I

Preliminary studies of the resource, based on historic and geographic information of the respective national institutions of meteorology and geography, will permit an approach to its knowledge, on a standardized basis. This will allow the detection of interest areas for the development of the resource from the energy point of view, as well as foreseeing a socio-economic impact.

Consequently this stage will permit the definition of areas in which physical and meteorological aspects must be studied in depth, as well as other socio-economic research to be developed.

During this stage, the physical and meteorological studies will be performed based on available information, considering the high installation and operation costs of new meteorological networks, which magnitude will be the minimum necessary for sample operations of statistical studies that will allow to maximize the utilization of this network and its information. This is possible since for the energy utilization of the wind, it is necessary

to be basically aware of the following: seasonable fluctuations, average seasonable velocities, dominant directions, daily pattern and turbulence. Based on this information the wind can be characterized by zones, and the potential and usable energy could be statistically inferred.

### 3.2.1 Tasks to accomplish

The fulfilment of this stage consists of two simultaneous and two subsequent consecutive sections. These are:

- a) Elaboration of a computing analysis model.
- b) Recompilation of information explained in Stage I.
- c) and d) Recompilation and standardization of the format in which information must be recorded for processing. These last two activities will be coordinated by OLADE, as well as the similar steps corresponding to development of other Programs related to Non Conventional Sources of Energy.

The Adviser Group of Aeolian Energy will carry out the analysis of the information, and will diagnose in order to define Stage III.

The final objective of this stage is the attainment of a Latin American Atlas, of preliminary characteristic, in which the levels of the aeolian energy potential will be indicated by zones. This Atlas will serve for the elaboration of a detailed working plan by the AGAE, for the second step of sample operation and data obtaining, concentrated in the areas of interest.

### 3.3 Stage III

Regional meteorological and socioeconomic studies in areas of interest.

This is the most significant stage, from both technical and budget points of view, for the Program's outcome.

Participation and cooperation from all institutions involved with the matter, regional or extra-regional, will be required, because their results of resource evaluation and feasibility determinations are substantial for its application.

#### 3.3.1 Goals of this Stage

Mainly two, namely:

- a) Determine in detail the aeolian energy resource in areas of interest.
- b) Diagnose of socioeconomic conditions, desirable applications, social and technical restrictions and impact by the introduction or extension of this technology.

#### 3.3.2 Tasks to fulfil

Based on **program planning** during the Adviser Group's second meeting, a group of meteorological work will be established which will be responsible for the coordination and/or development of sampling in areas of interest. Its tasks will be:



- a) Define working methodology.
- b) Determine measurement equipment and data obtaining systems.
- c) Determination of statistic processes, simulation of theoretical distribution of wind speed probabilities.
- d) Purchase of complementary meteorological equipment.
- e) Equipment installment and operation in areas of interest.
- f) Recompilation, processing and evaluation of information.

Simultaneously to the measurements works and characterization of winds in the interest areas detailed socioeconomic analysis and studies will be carried out in the same areas, in relation with possible applications of water pumping, mechanical propelling and electric generation. These studies will be related to the following:

- a) Underground water distribution, depths, qualities, etc.
- b) Chief crops, their water supply and demand.
- c) Geological and topographical characteristics.
- d) Soil potential use capability.
- e) Governmental programs.
- f) Density of population, incidence according to sex and age.
- g) Other economic activities.
- h) Energy demand, demand by sectors.
- i) Existing energy supply (electricity, natural gas, kerosenes, diesel, gasolines, firewood and charcoal)

### 3.4 Stage IV

#### Determination of Potential Markets

Having determined areas of interest according to wind intensity and availability, estimates of present and future demand in each of these areas must be brought out, in order to choose project areas.

Each specific project of an interest area, implies the selection of one aeolian energy conversion system with a determined power, the most adequate in each case. Addition of all conversion systems elected, will allow knowing the number of necessary equipment, total power and technology required. Besides, the foresaid will permit cost estimation to establish a priority order regarding project performance.

### 3.5 Stage V

#### Orientation of Action to meet Potential Markets

To meet these markets, based on the existing technological capability in the Region, classification of potential zones is anticipated, as well as equipment listing, so as to permit range establishment with particular specifications and quantifications of the demand in each one.

When determining specifications, electrical power for voltage and frequency settling will be taken into account, specially for average equipment for interconnected systems. Consumption of small equipment will be destined to productive activities as well as domestic appliances such as: radios, televisions, refrigerators, etc.

The results of this stage will permit carrying out demonstrative programs with existing technology and the development of new systems according to the reality and needs of Region countries.

The analysis of capability of Latin America towards the use to be given to energy and production of equipment among various countries, has a purpose that should be taken into account in project selection. During the design, local industry participation, element exchange and rational use of production lines will be considered.

Summarizing this stage, with previous considerations, recommendations to attain development of existing capabilities will be determined, to cover Potential Markets needs.

This task is of great importance and difficult to carry out due to the difficulty implies in coordinating institutions and industries located in different countries and with different regimes. On the other hand, beginning any activity means retrieving investments on long terms, for which industries will be reluctant to show interest at first.

Because of this, the Adviser Group of Aeolian Energy will have to undertake few projects useful to attain a supranational cooperation methodology, that having a didactic effect will show the possibility of its achieving, and serve later as recommendations, technical publications, etc., that will be sent to Member States for consideration and use.

Besides, this limitation makes the Organization's backing feasible with available resources, and does not mean an interest in legislating over national governments.

### 3.6 Stage VI

#### Development of programs and projects

In this stage, concrete achievements will modify the original plan, serving not only for equalizing levels in Latin America, but also as an effective demonstration of the helpfulness of technological cooperation among Member States.

Here we emphasize again that a plan which does not offer few and definite objectives, runs the risk of not being feasible for development, because of the difficulties to attain the union of different industries and institutes in different countries; with different levels of industrial and scientific promotion, to execute ambitious programs that if satisfy certain conditions, run the risk of causing painful and deceiving disappointments.

Regarding this, if the purpose of the program is to satisfy needs of experimental areas complemented with demonstrations of equipment developed in the Region, an excellent starting point for a new and more substantial action program will have been achieved, enriched with the experience and methodology obtained.

In view of this, the stage has three objectives:

1. Demonstration Programs.

With capability displayed and information exchange up to this moment, we will be able to select equipment developed in the more advanced regional countries, to serve as demonstration in places where interest in using aeolian energy has been showed.

## 2. Development of Specific Projects.

This is the point of convergence of all studies, works, displays, etc., carried out in the antecedent stages of socioeconomic needs analysis in the different areas which were recognized for their available resources. It has been fixed priorities considering community benefits as well as complementary technology limitation.

From this analysis, comes the selection of certain projects which are likely to be carried out in a reasonable period due to available means and financial availability of OLADE.

In all cases, the host country will be the project's counterpart, with active participation not only in the execution, but also in administrative and technical management. In this way, all programs will be a way of qualification and preparation for the countries own programs.

## 3. Technology Exchange.

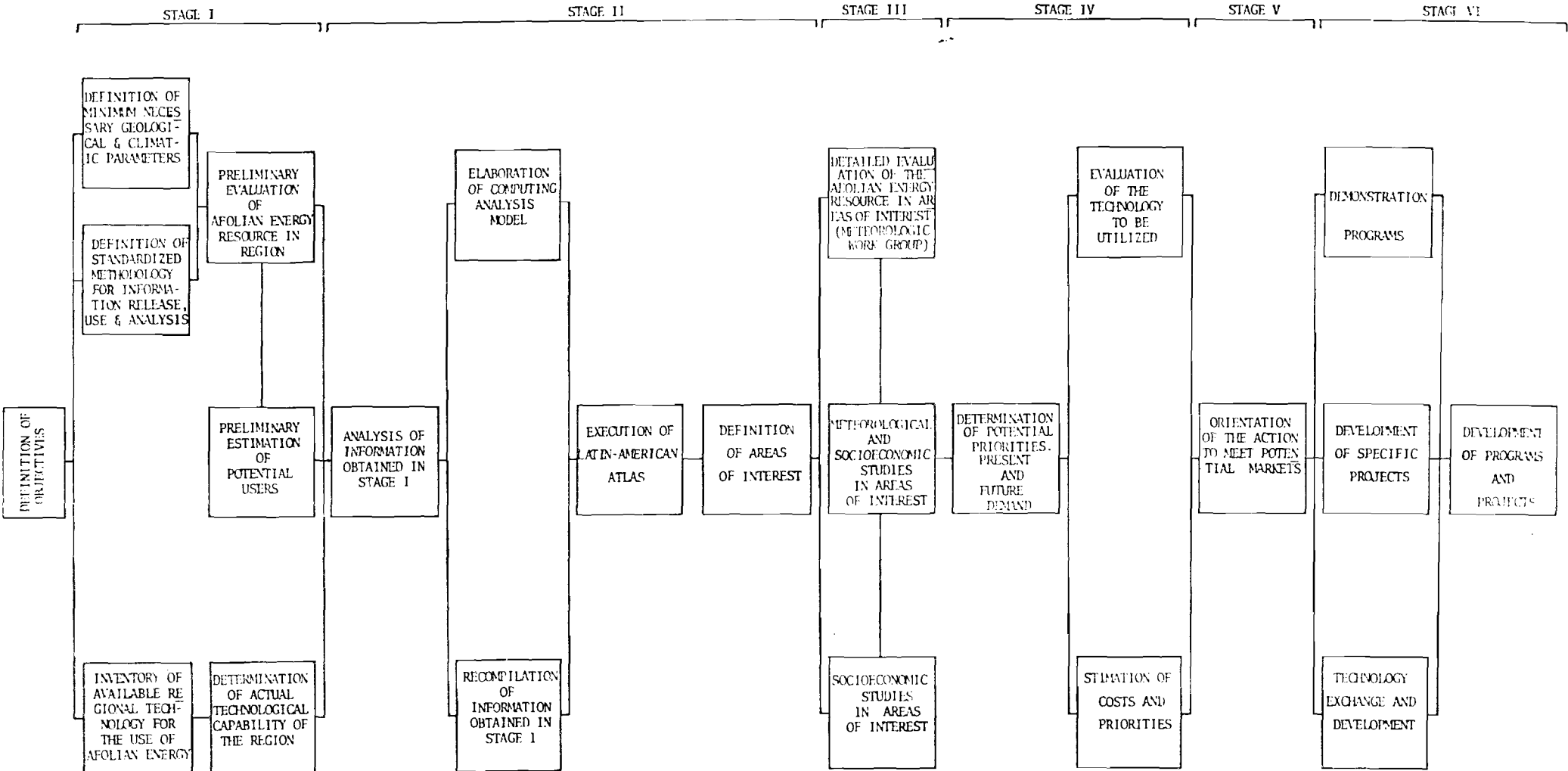
The way to expedite technological exchange will be:

- a) Carrying out capacitation courses and scholarship awarding to integrate work terms in the more developed countries of the Region.
- b) Participation in Demonstration Programs. When it will be selected an equipment developed in a country, for its demonstration use, before and during the demonstration, technicians of the host country will be invited to participate in the preparation and execution, to become them the center of the group destined to apply the use of the technics that are being promoted.

- c) Development of Specific Projects. Apart from the technicians qualified for the task, courses for different stages and subjects involved in the project can be organized, to give out information according to needs and weak items in each country.

Invitations to participate in courses and scholarship awarding will be given mainly to responsible institutions, to secure in this way that projects will be endorsed by national interest. It also prevents that, for personal reasons, the subject is diluted and guarantees the achievement of the multiplier effect, which is only carried out institutionally.

APPENDIX 1 - BLOCK DIAGRAM







APPENDIX 3 - COORDINATION

STAGE	EVENT	PLACE & DATE	RESPONSIBLE
I	DEFINITION OF MINIMUM NECESSARY GEOLOGICAL AND CLIMATIC PARAMETERS	MEMBER COUNTRIES	OLADE/AGAE
	DEFINITION OF STANDARDIZED METHODOLOGY FOR INFORMATION RELEASE, USE AND ANALYSIS	MEMBER COUNTRIES	OLADE/AGAE
	INVENTORY OF AVAILABLE REGIONAL TECHNOLOGY FOR THE USE OF AEOLIAN ENERGY	MEMBER COUNTRIES	OLADE/AGAE
	PRELIMINARY EVALUATION OF AEOLIAN ENERGY RESOURCES IN THE REGION	UNTIL THE 14 MONTH OF THE PROGRAM	OLADE/MEMBER COUNTRIES
	PRELIMINARY ESTIMATION OF POTENTIAL USERS	UNTIL THE 18 MONTH OF THE PROGRAM	OLADE
	DETERMINATION OF ACTUAL TECHNOLOGICAL CAPABILITY OF THE REGION	UNTIL THE 16 MONTH OF THE PROGRAM	OLADE/MEMBER COUNTRIES
	II WORKING GROUP ON AEOLIAN ENERGY	BUENOS AIRES APRIL 1980	OLADE/CNIE-ARGENTINA
	I LATIN-AMERICAN SEMINAR-COURSE ON PROSPECTING, EVALUATION AND CHARACTERIZATION OF AEOLIAN ENERGY	CUERNAVACA-MEXICO MAY 1980	OLADE/IIIE-MEXICO

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APPENDIX 3 - COORDINATION

STAGE	EVENT	PLACE & DATE	RESPONSIBLE
I	I LATIN-AMERICAN SEMINAR-COURSE FOR TECHNICIANS SPECIALIZED IN AEROGENERATION	SEPTEMBER 1980	OLADE/MIN. MINES ENERGY - BRAZIL
II	ANALYSIS OF THE INFORMATION OBTAINED IN STAGE I	UNTIL THE 10 MONTH OF THE PROGRAM	OLADE/AGAE
	ELABORATION OF COMPUTING ANALYSIS MODEL	UNTIL THE 04 MONTH OF THE PROGRAM	OLADE/AGAE
	RECOMPILATION AND STANDARDIZATION OF INFORMATION FORMAT TO THEIR PROCESSING	UNTIL THE 06 MONTH OF THE PROGRAM	OLADE/AGAE
	EXECUTION OF A LATIN-AMERICAN ATLAS	MEMBER COUNTRIES	OLADE/AGAE
	DEFINITION OF AREAS OF INTEREST	UNTIL THE 18 MONTH OF THE PROGRAM	OLADE/AGAE
	III WORKING GROUP ON AEOLIAN ENERGY TO EVALUATE INFORMATIONS OBTAINED IN STAGE I	TO BE DETERMINED	OLADE/AGAE
	I LATIN-AMERICAN SEMINAR-COURSE ON WIND MILLS	LIMA-PERU DATE TO BE DETERMINED ON THE FIRST SEMESTER/81	OLADE/ITINTEC PERU

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APPENDIX 3 - COORDINATION

STAGE	EVENT	PLACE & DATE	RESPONSIBLE
III	DETAILED EVALUATION OF AEOLIAN ENERGY RESOURCES IN AREAS OF INTEREST (METEOROLOGICAL WORKING GROUP)	UNTIL THE 21 MONTH OF THE PROGRAM	OLADE/AGAE
	METEOROLOGICAL AND SOCIOECONOMIC STUDIES IN AREAS OF INTEREST	STARTING FROM THE 22 MONTH OF THE PROGRAM	OLADE/CEPAL
	SOCIOECONOMIC STUDIES IN AREAS OF INTEREST	UNTIL THE 21 MONTH OF THE PROGRAM	OLADE/CEPAL
	ADVISER GROUP ON AEOLIAN ENERGY MEETING TO ESTABLISH A METEOROLOGY GROUP	TO BE DETERMINED	OLADE/AGAE
IV	DETERMINATION OF POTENTIAL MARKETS AND PRIORITIES	UNTIL THE 24 MONTH OF THE PROGRAM	OLADE/AGAE
	EVALUATION OF THE TECHNOLOGY TO BE UTILIZED	UNTIL THE 26 MONTH OF THE PROGRAM	OLADE/AGAE
	ESTIMATION OF COSTS	UNTIL THE 26 MONTH OF THE PROGRAM	OLADE/AGAE
V	ORIENTATION OF THE ACTION TO MEET POTENTIAL MARKETS	STARTING FROM THE 27 MONTH OF THE PROGRAM	OLADE/AGAE

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APPENDIX 3 - COORDINATION

STAGE	EVENT	PLACE & DATE	RESPONSIBLE
V	WORKING GROUP TO DETERMINE COURSES OF ACTION	BUENOS AIRES JANUARY 1983	OLADE/CNIE-ARGENTINA
VI	DEMONSTRATION PROGRAMS	STARTING FROM THE 29 MONTH OF THE PROGRAM	OLADE/MEMBER COUNTRIES
	DEVELOPMENT OF SPECIFIC PROJECTS	STARTING FROM THE 29 MONTH OF THE PROGRAM	OLADE/MEMBER COUNTRIES
	TECHNOLOGY EXCHANGE AND DEVELOPMENT	STARTING FROM THE 13 MONTH OF THE PROGRAM	OLADE/MEMBER COUNTRIES
	DEVELOPMENT OF PROGRAMS AND PROJECT	STARTING FROM THE 33 MONTH OF THE PROGRAM	OLADE/MEMBER COUNTRIES

