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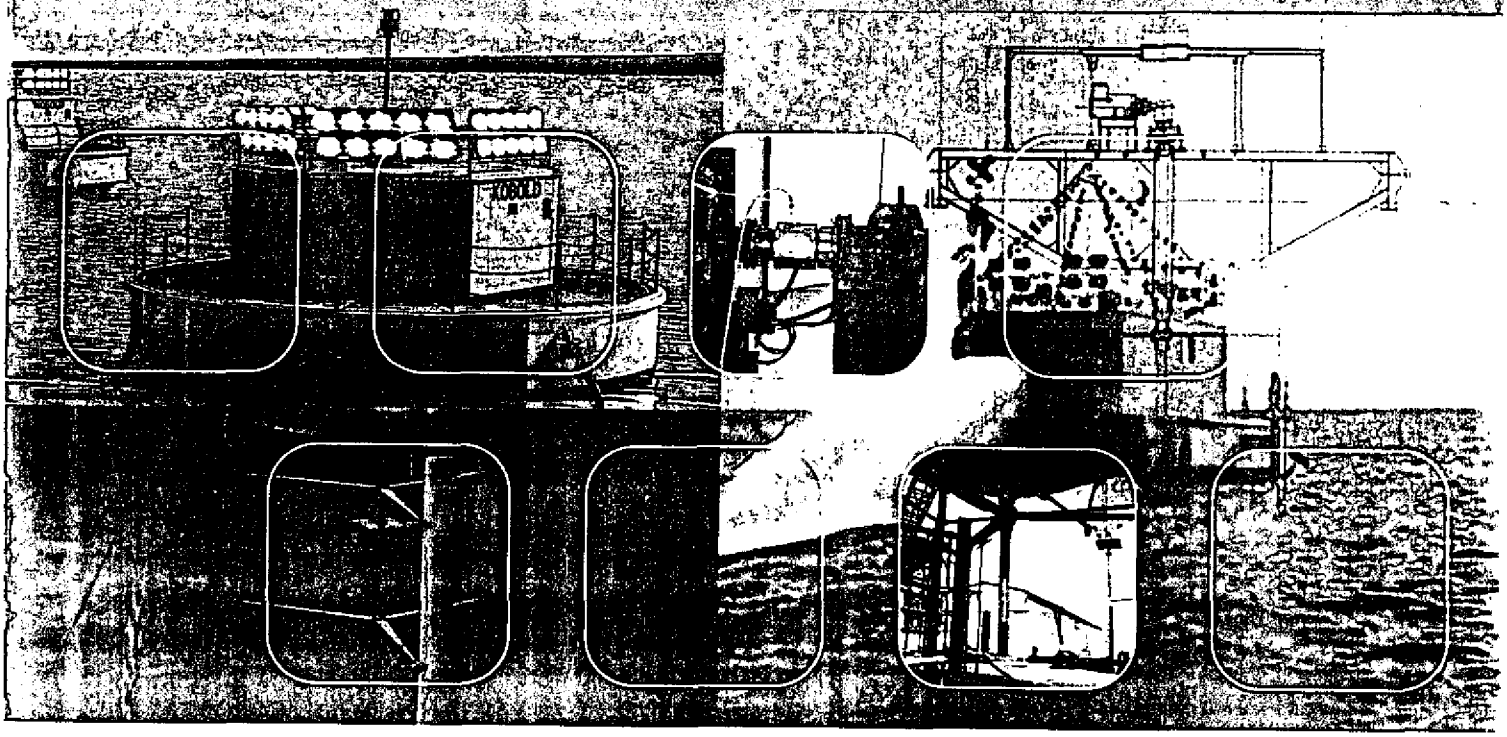
Messina Conference

15-16 September 2005



Kobold technology promotion and transfer

for marine current exploitation in South East Asia

Papers and presentations

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2005

This document has not been formally edited.

The timley compilation of this doccument was thanks to the dedicated and hard work of Ritin Koria, intern at UNIDO, Vienna

Contents

SECTION I - Conference Background

Summary of UNIDO Programme on Marine Current Exploitation in South East Asia

BRIEF DESCRIPTION

Renewable energy is becoming more and more a vital contribution in support of economic development and everyday life especially in rural and out-of-grid areas. It is also becoming an important integral component in supporting some productive activity. Renewable energies by definition are derived from those sources that can be tapped without depleting their reserves, namely biomass, hydro, geothermal, wind, waves and marine current energy. Useful energy can be generated from marine currents using completely submerged turbines comprising of rotor blades and a generator. Water turbines work on the same principle as wind turbines by using the kinetic energy of moving fluid and transferring it into useful rotational and electrical energy. The velocities of the currents are lower than those of the wind, however owing to the higher density of water (835 times that of air) water turbines are smaller than their wind counterparts for the same installed capacity.

There are many benefits to utilising marine current energy, including:

- The resource has four times the energy density of a good wind site, so the diameter of water turbines can be less than half that of a wind turbine for the same energy output;
- The water velocities and therefore power outputs are completely predictable, once accurate site measurements have been taken;
- Water turbines will not need to be designed for extreme atmospheric fluctuations as required with wind turbines, meaning that the design can be better cost-optimised;
- With increased conflicts over land use, water turbines offer a solution that will not occupy land and has minimal or zero visual impact;
- The greatest resource is in close proximity to coastlines and many areas with high population densities;
- The technology is potentially modular and avoids the need for large civil engineering works.

In Philippines as is the case in Indonesia a large number of small villages and communities along the costs in the numerous islands of the archipelagos are without any source of electric energy. And in view of the relevant costs for bringing to these

remote or isolated places the grid there are no scheduled programmed intervention for any immediate solution for the short medium term. To address this important social, economical, developmental issue the utilization of cost effective, stand alone, independent marine current energy system could provide a suitable, feasible and immediate answer and solution.

For the purpose to make available into the local national market in the identified region a technology that could provide a promising answer to the energy needs and demand of a substantial part of the local population, the introduction of the exploitation of marine currents is herewith proposed.

The project will be implemented mainly to formalise institutional support and secure the needed commitment for setting in place three pilot plants, one in each country participating to the project. To this aim bilateral meeting will be organised to provide the local counterparts with full information of the services that a MCET can deliver and the benefits that this technology could provide for the development of out-of-grid and remote rural areas. It is also foreseen to organise a study tour in order to bring to Europe selected decision makers to visit the operational pilot plant already in place in Sicily, Italy. During this negotiating and awareness building phase will be identified at country level the operational partners that will be involved in the manufacturing, assembling and erecting the pilot plant in the three selected Asian countries.

In order to further promote the MCET technology and facilitate further its commercialisation it has been foreseen within the context of the present project document to collect all relevant institutional, technical, operational information and start to package a dedicated GEF project in which attention will be focused on the farming approach of MCET application. Here again broad synergies and involvement of all national and regional decision makers will be sought in order to ensure full support and national ownership for a bigger follow up phase for MCET application in the whole South East Asia region.

Along the above strategy the key objectives of this initiative are:

- To promote and establish an operational partnership with the Department of Energy in the Philippines, the Chinese Ministry of S&T, the China International Center for Economic and Technical Exchanges (CICETE), the Ministry of S&T in Indonesia and the University of Naples and the Centre for National Research of Messina, Italy in order to transfer, adapt and apply the Kobold turbine for the energy needs of the coastal population in the region.
- To start to prepare a full fledged project for launching the use and application of the Kobold turbine in large scale through the support of GEF and other potential international donors.

The estimated costs for the full implementation of the project are 200,000 and the time frame for its execution will be 12 months from its inception.

New perspectives for Renewable Energy

On the eve of the third millennium energy still bypasses roughly two billion people, mainly individuals economically and socially weak, living in rural areas, burdened with poor quality of life, poverty, malnutrition and at the edge of development. Furthermore energy is available on random and inefficient supply to another two billion people, which cannot rely on basic services. The majority of this unfortunate part of humanity has to rely for his daily need of energy on biomass, quickly depleting existing natural resources. The non-renewable sources of

energy, like petrol and coal, are becoming more and more a commodity for the richest part of the national societies rather than an investment for equitable development also for the frailer part of the local society. While the richest 20% of mankind consume some 60% of the world's produced energy, the poorest fifth uses less than 4%.

Whereas fossil fuels currently account for some 75% of world energy use, and nuclear power for 6%, the world seems to be in the early stages of a major global energy transition, one that is likely to accelerate during the next coming year. Since fossil fuels consumption increases faster than the discovery of new reserves, the fuels prices will grow in the next decades. The increasing awareness of the global environmental effects of energy generation is another important issue that also developing countries have to take into consideration. The use of fossil fuels, by releasing carbon dioxide to atmosphere, creates the problems of greenhouse gas emission. Carbon dioxide is the major greenhouse gas that contributes to world global warming. There is therefore a need to use better and in a more sustainable way the traditional fossil energy sources while at the same time exploiting in a more effective way renewable energies.

Renewable energy is becoming more and more a vital contribution in support of economic development and everyday life especially in rural and out-of-grid areas. It is also becoming an important integral component in supporting some productive activity. Renewable energies by definition are derived from those sources that can be tapped without depleting their reserves, namely biomass, hydro, geothermal, wind, waves and marine current energy. Each of these resources can be utilised through specific technological solution to produce an array of energy related products including electricity, solar cells, gaseous fuels and others.

Renewable energies are becoming a subject of priority attention and interest for many countries due to the increased awareness of the environmental issue. Major constraints for a wide use and application of RE are population growth, social values, indigenous lifestyles, lack of policy, little political support and very importantly, technological development and capability.

OVERVIEW OF MARINE CURRENT ENERGY (MCE)

The global marine current energy resource is mostly driven by the tides and to a lesser extent by thermal and density effects. The tides cause water to flow inwards twice each day (flood tide) and seawards twice each day (ebb tide) with a period of approximately 12 hours and 24 minutes (a semi-diurnal tide), or once both inwards and seawards in approximately 24 hours and 48 minutes (a diurnal tide). In most locations the tides are a combination of the semi-diurnal and diurnal effects, with the tide being named after the most dominant type.

Generally the marine current resource follows a sinusoidal curve with the largest currents generated during the mid-tide. The ebb tide often has slightly larger currents than the flood tide. At the turn of the tide (slack tide) the marine currents stop and change direction by approximately 180°. The strength of the marine currents generated by the tide vary, depending on the position of a site on the earth, the shape of the coastline and the bathymetry (shape of the sea bed). Along straight coastlines and in the middle of deep oceans, the tidal range and marine currents are typically low. Generally, but not always, the strength of the currents

is directly related to the tidal height of the location. However, in land-locked seas such as the Mediterranean, where the tidal range is small, some sizeable marine currents exist.

There are some locations where the water flows continuously in one direction only, and the strength is largely independent of the moon's phase. These currents are dependent on large thermal movements and run generally from the equator to cooler areas. The most obvious example is the Gulf Stream, which moves approximately 80 million cubic metres of water per second (Gorlov, 1997). Another example is the Strait of Gibraltar where in the upper layer, a constant flow of water passes into the Mediterranean basin from the Atlantic (and a constant outflow in the lower layer).

Areas that typically experience high marine current flows are in narrow straits, between islands and around headlands. Entrances to lochs, bays and large harbours often also have high marine current flows (EECA, 1996). Generally the resource is largest where the water depth is relatively shallow and a good tidal range exists. In particular, large marine current flows exist where there is a significant phase difference between the tides that flow on either side of large islands.

There are many sites worldwide with velocities of 5 knots (2.5 m/s) and greater. Countries with an exceptionally high resource include the UK (E&PDC, 1993), Ireland, Italy, the Philippines, Japan and parts of the United States and in some extend also South China and Indonesia. Few studies have been carried out to determine the total global marine current resource, although it is estimated to exceed 450 GW (Blue Energy, 2000).

Status of the Technology for MCE

Useful energy can be generated from marine currents using completely submerged turbines comprising of rotor blades and a generator. Water turbines work on the same principle as wind turbines by using the kinetic energy of moving fluid and transferring it into useful rotational and electrical energy. The velocities of the currents are lower than those of the wind, however owing to the higher density of water (835 times that of air) water turbines
are smaller than their wind counterparts for the same installed capacity.

The power that is able to be extracted from the currents is dependent on the velocity of the water flow and the area and efficiency of the water turbine, and can be calculated as follows: $P=\frac{1}{2}\rho Sv^3Cp$
where: ρ is the density of sea water (1025 kg/m^3)
S is the area of the rotor blades (m^2)
v is the marine current velocity (m/s)
Cp is the power coefficient, a measure of the efficiency of the turbine

Marine current energy is at an early stage of development, with only a small number of prototypes and demonstration units having been tested to date. There are no commercial grid-connected turbines currently operating. A number of configurations have been tested on a small scale that are essentially marinised wind turbines. Generally speaking, turbines are either horizontal axis or vertical axis turbines. Variants of these two types have been investigated, including turbines using concentrators or shrouds, and tidal fences. Horizontal axis turbines (axial flow turbine). This is similar in concept to the widespread horizontal axis wind turbine. Prototype turbines of up to 10 kW have been built and tested using this concept. There

are currently plans to install a demonstration machine of 300 kW off the south coast of the United Kingdom (MCT, 2000).

Concentrators (or shrouds) may be used around the blades to increase the flow and power the turbine. This concept has been tested on a small scale in a number of countries, including New Zealand (Rudkin, 2001).

Vertical axis turbines (cross flow turbine). Both drag and lift turbines have been investigated, although the lift devices offer more potential. The best-known example is the Darrieus and the Kobold turbines with three or four thin blades of aerofoil cross-section. Some stand-alone prototypes have been tested, including a 5 kW Darrieus turbine in the Kurushima Straits, Japan and a kW Kobold turbine in Messina Strait in Sicily, Italy (see details further below in this document). The concept of installing a number of vertical axis turbines in a tidal fence is being pursued in Canada, with plans to install a 30 MW demonstration system in the Philippines (Blue Energy, 2000).

In order for marine current energy to be utilized, a number of potential problems will need to be addressed, including:
o Avoidance of cavitation by reducing top speeds to approximately 8 m/s. This suggests a turbine with a higher solidity than a wind turbine;
o Prevention of marine growth building up on the blades or ingress of debris;
o Proven reliability, as operation and maintenance costs are potentially high;
o Corrosion resistance, bearing systems and sealing.

Turbines may be suspended from a floating structure or fixed to the seabed. In large areas with high currents, it will be possible to install water turbines in groups or clusters to make up a marine current farm, with a predicted density of up to 37 turbines per square km. This is to avoid wake-interaction effects between the turbines and to allow for access by maintenance vessels (DTI, 1999).

As there are currently no commercial turbines in operation, it is difficult to assess the cost of energy and competitiveness with other energy sources. Initial studies suggest that for economic exploitation, velocities of at least 2 m/s (4 knots) will be required, although it is possible to generate energy from velocities as low as 1 m/s. As the technology matures and economies of scale are reached, it is likely that the costs will be then reduced substantially.

PERSPECTIVES FOR THE MCE

Compared with other renewable technologies, there has been little research into utilising marine current energy for power generation. However, in principle marine current energy is technically straightforward and may be exploited using systems based on proven engineering components (FMP, 1999). In particular, knowledge gained from the oil and gas industry, the existing hydro industry and the emerging wind energy industry can be used to overcome many of the hurdles facing marine current energy.

The global marine current energy resource is very large, and it has a number of advantages over other renewables. The above table shows a comparison of the marine current energy resource with other renewables and conventional energy sources. It is clear that there are many benefits to utilising marine current energy, including:
o The resource has four times the energy density of a good wind site, so the diameter of water turbines can be less than half that of a wind turbine for the same energy output;

	Renewable resources	Low capital cost	Low running cost	Minimal environmental impact	Predictable	Minimal visual impact	Modular
Fossil	✓	●	✓	✓	●	✓	✓
Nuclear	✓	●	✓	✓	●	✓	✓
Wind	●	✓	●	●	✓	✓	●
Solar	●	✓	●	●	✓	✓	●
Hydro	●		●	✓	●	✓	✓
Wave	●	✓	●	●	✓	●	●
Marine Current	●	✓	●	●	●	●	●

o The water velocities and therefore power outputs are completely predictable, once accurate site measurements have been taken;

o Water turbines will not need to be designed for extreme atmospheric fluctuations as required with wind turbines, meaning that the design can be better cost-optimised;

o With increased conflicts over land use, water turbines offer a solution that will not occupy land and has minimal or zero visual impact;

o The greatest resource is in close proximity to coastlines and many areas with high population densities;

o The technology is potentially modular and avoids the need for large civil engineering works.

The above table shows that marine current energy is one of the most promising new renewable energy sources, and is deserving of further investment. Furthermore, the know-how is now available to combine existing technologies to utilise marine current energy for power generation.

The environmental impact resulting from marine current energy use is likely to be minimal. Project planning will need to be cognisant of species protection including fish and marine mammals, although since the blade velocities and pressure gradients are low this is unlikely to cause any serious problems (Fraenkel, 1999). In siting turbines, consideration of shipping routes and present recreational uses such as fishing and diving will be required. It may be necessary to establish fishery exclusion zones.

It is likely that water turbines will initially be deployed in island or coastal communities with strong marine currents and which are isolated from national grid systems, where they are most likely to offer a cost-effective alternative. However, marine currents have the potential to supply significant quantities of energy into the grid systems of many countries. As interest grows, marine current energy is likely to play an increasing role in complementing other energy technologies

and contributing to the future global energy supply mix.

Tidal energy potential has been investigated by a number of countries, notably France where a 240 MW demonstration plant was built on the Rance estuary during the 1960's and has now completed 30 years of successful operation. The Russians have built a small 400 kW device near Murmansk, which was later followed, by a 17.4 MW experimental device, built by the Canadians at Annapolis on a small inlet off the Bay of Fundy. A series of small plants have been installed in China. None of these countries have progressed to further development. In the UK a series of industrial consortia in collaboration with Government have investigated the prospects for tidal energy on the Severn, Mersey and a number of smaller estuaries.

The ENERMAR/Ponte di Archimede project
In 2002 the pilot phase of the ENERMAR project, developed and implements by a consortium in which were involved the University of Naples and the company "Ponte di Archimede nello Stretto di Messina S.p.A.", was successfully completed in Italy.

The purpose of the ENERMAR project was to demonstrate that the exploitation of marine currents, by means of an innovative turbine called Kobold, is a cost effective and convenient approach when compared to other renewable energy sources exploitation. A pilot plant was set in place in the Strait of Messina, close to the Sicilian shore, in front of the Ganzirri village, close to the homonymous lake (see Appendix Figures 1 and 2).
This plant has been used to test and demonstrate the performances of the system and its components as well as its limited environmental impact. At the chosen site the measured current speed is 2 m/s (4 knots), the sea depth is 20 meters and the plant was moored at 150 meters offshore. (see Appendix Figure 3). The current is alternating; its period of inversion is equal to 6 hrs and 12 minutes, while the period of amplitude is equal to 14 days.

The aims of this project were the following:
o To test the first pilot plant in the world, comprehensive of a support floating structure, a turbine and the necessary equipment to produce and manage the electric energy generated;
o To optimize the whole system and its single components;
o To promote wide application and commercialization of the ENERMAR technology, on the basis of the benefits and advantages achieved exploiting marine currents face other sources of alternative energy.

From idea to reality. A scaled model of the turbine was built and tested in the water tank of the Department of Naval Architecture at the University of Naples. The blades were designed to oscillate without restraint with respect to the radial direction up to 90 degrees and the torque was generated mainly by blades drag. A picture of the first small turbine model is shown in figure 4.
In a second phase a mathematical modeling, "ad hoc" developed by the Department of Aeronautical Engineering of the University of Naples, was utilized to predict the turbine behavior and its power output. The mathematical modeling was coupled with extensive experimental activities of a bigger model of the Kobold turbine in the wind tunnel.
After this initial test a second model of turbine was built and again tested in the wind tunnel (see figure 5); the lifting on the blades generated this time the torque. This model was built to be tested with different number

of blades and to optimize the blade articulation angles. The model had a diameter of 2.2 meters, blades height was of .8 meters and blades chord was 0.17 meters. It was tested with 2, 3, 4 and 6 blades.

Optimization of blade articulation angle was then performed to solve the problem of negative power in the low rotation range. The turbine has been tested several times, modifying its characteristics according to the numerical and experimental test results. All the investigations led to an accurate definition of the turbine kinematical characteristics. The theoretical evaluation has taken into account various mathematical models, suitable to describe and foresee the Kobold turbine behavior from the dynamic and kinematical point of view.

The Kobold turbine prototype. The core of the ENERMAR plant is the patented Kobold turbine, which is a Vertical Axis Hydro Turbine suitable to transform marine currents kinetic energy into mechanical energy. The Kobold turbine has been designed to comply, to the best possible, with minimum environmental impact, maximum efficiency as well as with low construction and maintenance costs.
The main characteristics of the Kobold turbine are the following:
o blades rotation direction independent from marine current direction;
o very high starting torque, that makes the turbine able to start spontaneously, also in loaded conditions, without the need of any starting devices.
The ENERMAR plant is usually mounted on a floating platform (buoy). The turbine consists of a transmission shaft, built with special steel, and three couples of radial arms, each of them holding a blade. From the mechanical point of view, the Kobold turbine has been designed according to simple and effective principles, entailing during its whole life cycle limited maintenance interventions.

The pilot case. The ENERMAR pilot plant has been installed in a suitable place in the Strait of Messina, Sicily, Italy. The average sea tidal current speed at the installation site is around 2 m/s. The first set of tests resulted in a systematic data collection of the mechanical behavior of the turbine. Even with low speed current (1.2 m/s is the cut-in speed), the rotor start rotating very fast, without any external assistance. The global efficiency of the system has been measured as ratio between the produced electrical power and the theoretical power available in the current relative to the intercepted area:
$Cp=2Pe\rho/Pv^3S$
where S= diameter x blade-height (S=30 m^2 in case of Kobold turbine),
ρ is the water density (1025 Kg/m^3) and
v is the current speed in m/s.

The global efficiency of the Kobold system records 23%, which is comparable to the efficiency of wind turbine already on the market since quite some time. This first result can be considered excellent because on-going and future improvements in the mechanical transmission system will certainly further enhance the global efficiency of the system.

JUSTIFICATION

ENERGY NEEDS IN THE SOUTH EAST ASIA REGION

All renewable forms of renewable energy, wind, photovoltaic, biomass and marine current are becoming for a large number of communities in developing countries an important source of energy. Rapid growth of population, increases demand for energy, need for better quality of life especially in

rural areas are putting a lot of attention and interest on renewable energy resources.

A large part of the population in China, Philippines and Indonesia are still left out from any kind of supply of electricity and electric power. The local authorities in most cases do not have the financial resources to invest in power plant and the extension of the existing grids. Therefore there are no immediate and quick answers for providing the population outside the existing grid, especially in the rural areas, with electricity supply.

In Philippines as is the case in Indonesia a large number of small villages and communities along the costs in the numerous islands of the archipelagos are without any source of electric energy. And in view of the relevant costs for bringing to these remote or isolated places the grid there are no scheduled programmed intervention for any immediate solution for the short medium term.

To address this important social, economical, developmental issue the utilization of cost effective, stand alone, independent marine current energy system could provide a suitable, feasible and immediate answer and solution.

For the purpose to make available into the local national market in the identified region a technology that could provide a promising answer to the energy needs and demand of a substantial part of the local population, the introduction of the exploitation of marine currents is herewith proposed.

To harvest the potential energy plentiful available in the South East Asia marine region, the acquisition, transfer and adoption of a Kobold technology could be of enormous contribution to the development and poverty alleviation of many coastal areas of the countries taking part in this project.

The power produced by suitable dimensioned Kobold turbine could easily respond to diversified needs, bringing a number of advantages in technological capability, job creation, services rendered, improved quality of life not excluding environmental benefits.

To promote the adoption and transfer of the proposed Kobold technology a number of barriers have to be addressed, namely:

o Availability of information: The large potential of marine currents in the South East Asia region, coupled with preliminary operational experience in Italy and further ad-hoc investigations in the region, suggest that the availability of information is unlikely to be a significant barrier to future Chinese, Philippine and Indonesian schemes;
o Risk
o Financial
o Market Characteristics
o Regulations
o Strategic Issues

END OF PROJECT SITUATION

At project completion the following achievements will then have been accomplished:
Institutional and operational counterparts will be identified and properly acquainted with the new prototype of MCE.

A comprehensive assessment and overview reporting of the most promising locations and sites in the three countries where the Kobold technology could be used with advantageous return in energy production.

A follow-up project proposal, aiming at

securing GEF co-funding, that will address the issue to further support promotion and diffusion in the whole South East Asia of the manufacturing and the application of Kobold solutions will be initiated.

TARGET BENEFICIARIES

The target beneficiaries of this project can be identified at different level. The ultimate beneficiaries of this initiative are those communities leaving in coastal areas where no electricity is available. The pilot plants will produce quite a substantial output of energy that will enable entire small communities to take advantage of the benefits of a regular supply of electricity. From this aspect the project is addressing at its core poverty alleviation and will improve tremendously the quality of life of many families.

It should be considered also the benefit that national decision makers can draw from the possibility to consider on their planning and developmental decision making of a new, abundant, cost-effective and locally available resource of energy.

PROJECT STRATEGY

The project will be implemented mainly to formalise institutional support and secure the needed commitment for setting in place three pilot plants, one in each country participating to the project. To this aim bilateral meeting will be organised to provide the local counterparts with full information of the services that a MCET can deliver and the benefits that this technology could provide for the development of out-of-grid and remote rural areas. It is also foreseen to organise a study tour in order to bring to Europe selected decision makers to visit the operational pilot plant already in place in Sicily, Italy. During this negotiating and awareness building phase will be identified at country level the operational partners that will be involved in the manufacturing, assembling and erecting the pilot plant in the three selected Asian countries.

In order to further promote the MCET technology and facilitate further its commercialisation it has been foreseen within the context of the present project document to collect all relevant institutional, technical, operational information and start to package a dedicated GEF project in which attention will be focused on the farming approach of MCET application. Here again broad synergies and involvement of all national and regional decision makers will be sought in order to ensure full support and national ownership for a bigger follow up phase for MCET application in the whole South East Asia region.

REASONS FOR ASSISTANCE FROM UNIDO

Herewith the main reasons for resorting to UNIDO assistance for the definition, preparation, implementation and management of the present project proposal:

o Availability of data and international sources related to energy and RE;
o Management and implementation skill in handling regional initiatives;
o Proven record of international partnerships promotion and establishment;
o Extensive experience on Technology Promotion and Transfer related issues;
o Fund raising activities with international institutions and donors;
o Honest broker role.

SPECIAL CONSIDERATIONS

Special consideration should be given to the active involvement from the beginning of this exercise of all key players in the energy sector at national level.

Special attention should be also given to the

funding of the whole activities proposed in the project in order to secure effective and feasible results.

CO-ORDINATION ARRANGEMENTS

The overall co-ordination of the project will be under the direct responsibility of UNIDO with field involvement and support of the concerned national authorities and associations involved will take care of all local inputs, arrangement and organisation.

Minutes of the Expert Group Meetings
Marrine Current Energy Exploitation

Jakarta, 23-25th Feb 2005

MINUTES OF EXPERT GROUP MEETING
MARINE CURRENT ENERGY
JAKARTA, 23 – 25 FEBRUARY, 2005

Potential and Synergies for Exploitation of Marine Currents in South East Asia

UNIDO with the support of the Ministry of Research and Technology of the Republic of Indonesia and the Italian Embassy in Jakarta, has organized an Expert Group Meeting in Jakarta on 23-25 February 2005 on the project of 'Exploitation of Marine Current in Asia and South East Asia". The objective of the meeting was to advance the UNIDO project for the exploitation of marine current for the production of energy in the People's Republic of China, the Philippines and Indonesia, with utilization of the technology of Ponte di Archimede SpA. This technology can provide a very relevant contribution to the clean energy needs in Asia and South East Asia.

The meeting was attended by high officials from the UNIDO Headquarters, Vienna, the representative of the Ministry of Science and Technology and the Ministry of Commerce of the People Republic of China, the representative of the Ministry of Research and Technology and various related institutions of Indonesia, the representative from the Philippines through the Philippine National Oil Company and the President of the Italian company Ponte di Archimede. (List of participants attached.)

The meeting was opened by the UNIDO Director for Investment and Technology Promotion Branch, Ms. Liang Dan and by the President of the company Ponte di Archimede, Dr. Elio Matacena. The welcome message from the Indonesian Government was delivered by Ms. Utari Budiharjo, to which followed the speech of the Italian Ambassador to Indonesia, H. E. Mr. Francesco M. Greco.

The project presentation, highlighting objectives and expected achievements, was done by Mr. E. Vento, UNIDO project manager. Ing. A. Moroso, Ponte di Archimede and Prof. You Yage, Guangzhou Institute of Energy Conversion, who since several years have been collaborating in research activities bound to the development of the Kobold turbine, presented two technical relations relevant to the Kobold turbine technology.

Mr. Li Baoshan from the China delegation, Mr. V. Bala, as a representative of Philippines and Dr. Agus Supangat representative of the Indonesian Ministry of Marine and Fisheries, provided very interesting presentations of national initiatives related to use and application of Renewable Energy (RE) in their home countries with special consideration to marine energy.

On the second day of the meeting Dr. Ashwin Sasongko, Secretary to the Minister of R&T of Indonesia, brought to the meeting the welcome and best wishes of his Minister expressing full support and appreciation for the UNIDO initiative,

highlighting the potential of the utilization of marine current for energy production in a vast regions of the Indonesia archipelago.

Mr. Pekka Skytta, EC Co-director of the EC-ASEAN Energy Facility (EAEF), presented a comprehensive picture of the EC-ASEAN activities in the field of energy, with specific information on the modalities and guidelines for participating to the EAEF calls. Dr. Andi Eka Sakya presented, in his turn, the ASEAN project submitted by the Indonesian government with participation of PNOC, UNIDO and Ponte di Archimede in November 2004. Dr. L. Fulci, Vice President of the Ponte di Archimede, presented the Company strategy concerning international cooperation for the promotion of the kobold turbine and power plants in the Asian region. Mr. R. Phillips, Global Environment Facility (GEF) project expert, provided a comprehensive outline of the mechanisms and procedures for formulating and submitting a GEF proposal.

The technicians and experts present made contributions and comments during the various sessions of the EGM. This interaction has provided the occasion for an open discussion of the relevance of the kobold turbine, the importance of securing additional funding to the UNIDO initiatives, and the necessity to seek additional synergies for further development and application of the technology proposed.

As major outcome of the meeting the participants came to a common understanding on the following points:

a) As evidenced by the natural power of the tragic December 2004 Tsunami, the power of the sea is potentially substantial local resource to be positively utilized in order to derive clean and renewable energy in the region;

b) The Kobold turbine technology is a very innovative technology that can provide cost effective and efficient results in exploitation of marine currents and the promotion of renewable energy in the region;

c) In depth assessment of the most promising sites in the three participating countries should be carried as soon as possible in order to identify the optimal locations for setting up pilot plants and test cases farms of Kobold turbines;

d) Funding possibilities should be explored with all potential multilateral and institutional donors and financial institutions;

e) The concerned stakeholders should take part in the call to be launched in the near future by the ASEAN and the EC;

f) All three countries will support the formulation of a GEF proposal to be submitted for funding;

g) Support for application and adoption of RE, in particular marine current energy, will be advocated with the competent national authorities and sectorial decision makers;

h) As follow up to the Jakarta meeting, subsequent awareness building meetings will be held in the Philippines and the People's Republic of China. The conclusion of the awareness building phase will entail a conference on marine currents in Messina, Italy where the Kobold prototype of Ponte di Archimede is operating.

All participants expressed appreciation for the professional coordinating work carried out by UNIDO and the Indonesian Ministry of Research and Technology, especially to session chairs Mr. Masayoshi Matsushita and Mr. Ardito M. Kodijat.

Signed in Jakarta, 25 of February, 2005

Representative of MoRT, Indonesia

(Ardito M. Kodijat)

Representative of PNOC, The Philippines

(Victorino S. Bala)

Representative of MoST,
People's Republic of China

(Li Baoshan)

Representative of Ponte di Archimede, Italy

(Elio Matacena)

Representative of UNIDO HQ Vienna

(Liang Dan)

Representative of UNIDO Jakarta

(Masayoshi Matsushita)

Final Report of the Round Table on Marine Current Exploitation in South East Asia

Manilla, 28-29th April 2005

FINAL REPORT OF THE ROUND TABLE ON
MARINE CURRENT EXPLOITATION IN SOUTH EAST ASIA
MANILA, 28-29 APRIL, 2005

Round Table on Manufacturing and Application of Kobold Turbine Systems for Energy Production

UNIDO with the support of the Philippine Council for Industry and Energy Research and Development (PCIERD) of the Department of Science and Technology of Philippines and the participation of the Italian Embassy in Manila, has organized a Round Table Meeting in Manila 28-29 April 2005 on the project of "Exploitation of Marine Currents in China and South East Asia".

The Meeting was attended by UNIDO representatives from Vienna and the Indonesia Office, the representatives of the Department of Science and Technology and the Department of Energy of Philippines as well as representatives of the Ministry of Research and Technology of Indonesia. At the meeting, contribution has been made also by representatives of the Asian Development Bank, the Development Bank of Philippines, Philippine National Oil Company and the National Mapping and Resource Information Authority.

A number of dedicated presentations were made in order to update all the participants on the recent development on marine current technology, information related to the ASEAN call and specific data on potential Philippines and Indonesian sites suitable for MCE and the past and future activities of the UNIDO promotional project.

As major outcome of the meeting the participants come to a common understanding on the following points:

- Under the coordination of UNIDO a proposal will be submitted to ASEAN Centre for Energy (ACE) under the European-ASEAN Energy Facility (EAEF) for the *Facility 3 of the call due in June 2005*. Indonesia and Philippines will contribute with in kind contribution of € 50,000 each, Ponte di Archimede with € 50,000 in cash and UNIDO with € 100,000 with the ongoing project resources dealing with the Promotion of MCE in South East Asia, for a total amount of € 250,000 representing 50% of the whole proposal to be submitted to EAEF. The feasibility studies which will be emphasized on the Facility 3 will take into consideration all aspects dealt with under the Kyoto Protocol.

- Full support of the regional UNIDO project which aims at setting in place 3 Kobold Turbine Prototypes one in each participating country (Philippines, Indonesia and People's Republic of China). The Philippine prototype will be put up after the feasibility study will be completed.

- Philippines and Indonesia call on UNIDO to ensure the necessary fund raising with institutional and the private donor in order to finance the three prototypes, one in each Country. The needed contributions for the prototype project will be as follows:

UNIDO	€ 500,000
Ponte di Archimede	€ 300,000
People's Republic of China	€ 200,000

- Philippines and Indonesia representatives took note of the UNIDO follow up activity for a visit of the Ponte di Archimede prototype in Messina in July 2005.
- The Participants agreed to explore all possibilities for additional funding to promote use and application of MCE with dedicated project proposals with institutional multilateral donors, such as World Bank, Global Environmental Facility, Asian Development Bank and others as appropriate.

Signed in Manila on 29 April 2005

Representative of DoS&T, Philippines

Raul C. Sabularse

Representative of MoR&T, Indonesia

Andi E. Sakya

Representative of Ponte di Archimede

Elio Matacena

Representative of UNIDO

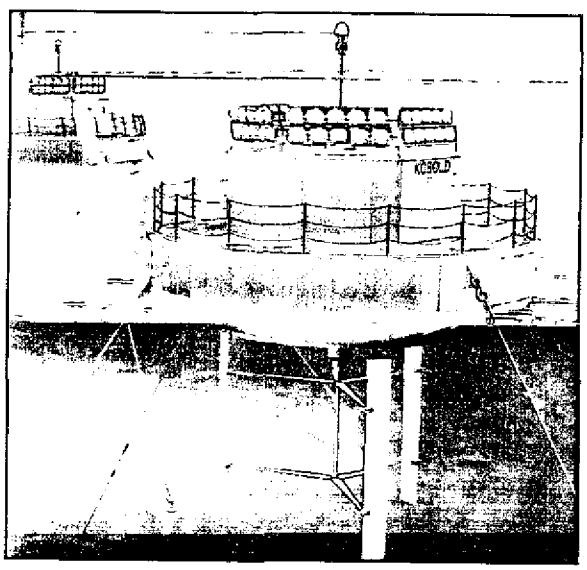
Emilio Vento

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

AIDE-MEMOIRE

Conference on Exploitation of Marine Currents for Energy Production

Messina, Italy
15-16 September 2005



Organized by UNIDO
in cooperation with
Horcynus Orca Technology Park,
National Research Council, and
University of Messina, Italy

United Nations Industrial Development Orgaization

Aide-Memiore

BACKGROUND

All renewable resources of energy, such as wind, photovoltaic, biomass and marine current are becoming for a large number of communities in developing countries an important source of energy. Rapid growth of population, increases demand for energy, need for better quality of life especially in rural areas are putting a lot of attention and interest on renewable energy resources.
A large part of the population in many developing countries is still left out from any kind of supply of electricity and electric power. The local authorities in most cases do not have the financial resources to invest in power plant and/or the extension of the existing grids. Therefore there are no immediate and quick answers for providing the population outside the existing grid, especially in the rural areas, with electricity supply. As is often the case a large number of small villages and communities along the coasts in the numerous islands and along coastal areas are without any source of electric energy. And in view of the relevant costs for bringing to these remote or isolated places the grid there are no scheduled programmed intervention for any immediate solution for the short medium term.

To address this important social, economical, developmental issue the utilization of cost effective, stand alone, independent marine current energy system could provide a suitable, feasible and immediate answer and solution. For the purpose to make available into the local national market in the identified region a technology that could provide a promising answer to the energy needs and demand of a substantial part of the local population, the use and exploitation of marine currents is therefore proposed.
In close cooperation with Ponte di Archimede, an Italian company which has been developing the very innovative technology ENERMAR for the purpose to exploit marine currents, and thanks to the financial support of the Italian authorities, it was possible in 2004 to finalize a project aiming at promoting and disseminating in selected developing countries the use and application of the Kobold turbine. Within the programmed activities of this project, as a start up activity to build awareness and consensus among decision makers and technology experts dealing with the energy issue and RE application, it was decided to organize a conference where updated information on MCE technologies could be shared and disseminated among the intervening partici-

pants and at the same time trying to attract additional synergies into a broad programme for application of MCE especially in developing countries.

OBJECTIVES

Along the outline and objectives of the UNIDO project US/RAS/04/069, the purpose of the Conference convened in Messina will aim to:

o Secure political and operational support and commitment from decision makers for promotion and application of MCE, the Kobold turbine technology, as a viable and effective contribution to energy supply in many coastal areas;

o Build broad awareness of the potential of the MCE for production of energy among decision makers from selected developing countries and institutional donors supporting development activities in developing countries;

o Provide wide coverage and information on the innovative Kobold solution for MCE developed by the Italian company Ponte di Archimede Spa;
o Disseminate information on the UNIDO/Italian Ministry of Foreign Affairs Initiative for promotion and technology transfer support for the kobold turbine system in favour of selected developing countries, starting from the South East Asia region and China.

EXPECTED OUTPUTS

In line with the above objectives, it can be anticipated that at the end of the two days of the Messina Conference:

o All participants will have a full understanding of the potential of the Kobold turbine application from the technological point of view (manufacturing), the benefits (provision of energy/electricity), and the social impact (rural communities development, poverty alleviation and productive uses);
o Wide dissemination of the ENERMAR and the Kobold turbine application achieved through involvement of key information players;
o Broad recognition of the efficiency and effectiveness of specific MCE solutions for the benefits of coastal areas applications for energy production;
o Operational support secured both from the potential donors institutions and beneficiary countries authorities for further promotion and application of the proposed technology.

PARTICIPATION

The participants attending the conference will be national representatives of competent Ministries from Indonesia, China and Philippines, the respective countries' Ambassadors in Rome and also sector-related EC's authorities in Bruxelles.

Due invitations will be extended also to the Italian authorities who have generously financed the project as well as to selected academic and diplomatic representatives that could make substantial contribution to the success of the proposed Conference.

DOCUMENTATION

o Aide-Memoir of the Conference
o Conference Programme
o List of Participants
o Project UNIDO US/RAS/04/069
o Project ASEAN
o Summary Report of Jakarta EGM, February 2005
o Recommendations Manila Meeting, April 2005

LANGUAGE

The working language of the Conference will be English.

TIME AND VENUE

The Conference will be held from 15 to 16 September 2005 at:
University of Messina, Italy
National Research Council, and
Horcynus Orca Technology Park

The Politecnico di Milano role in the research "Current for current"

Alfredo Cigada, Alberto Zasso

INTRODUCTION

There is no doubt that the interest towards renewable energies is going to grow in future years: the continuously growing trend in the petroleum value will make this process faster and faster. Of course, according to each country particular situation, this interest is addressed towards different techniques: under this point of view Italy, surrounded by seas, shares with many other countries the aim to try exploiting this potential richness to its full extent.

This has been one of the primary reasons for Politecnico di Milano to pick up this new challenge and start working in the topic of marine current energy. The decision is rather recent and the research on the subject area is still at its infancy, with no commercial products existing at present, hence the moment has been considered to be extremely favorable to start.

Due to the aforementioned facts, the literature primarily deals with general evaluations concerning the economic convenience for the operation of "water mill" plants; the objective being to obtain the highest possible power levels, best efficiency, to make comparisons against other energy sources and to locate optimum sites for the positioning of new plants. Some sceptical perceptions were encountered but similar impressions arose when the consideration of wind farms for power generation was an issue throughout Europe. It's an important occasion for both research and technology growth and it can't be missed. Lagging behind at this stage may mean not to be able to bridge the gap at a later stage.

In spite of all these reasons the national and international funding for research programs puts special emphasis on the renewable energy systems, confirming the general interest on the topic. According to the preliminary documents the European Union Framework VII Program has a special budget devoted to this topic, and also the National Research Program has recently opened a new call on the same theme. National interest in the subject can also be noted through the part organization of a conference by the Italian Association for Wind Engineering, in which wind turbines and water turbines are a part of the consideration in the work program. In 2004 the UK's Department of Trade and Industry announced an investment into wave and tidal technologies of 75 million euro. At the funding launch the UK Secretary of State for Trade and Industry, Patricia Hewitt said: "The UK's wave and tidal flows are the

greatest in Europe and I want to ensure we harness these immense natural resources to generate power for the UK. Renewable energy - through wind, wave and other sources - plays a vital part in our fight against climate change, and we are committed to further developing renewable energy to play an increasing role in the UK's energy mix. This announcement reflects that vision and puts us firmly on the path to becoming the world leader in renewable energy" she added. "The same statements can be applied to Italy, or more generally speaking, to all Europe".
Politecnico di Milano finds through its collaboration on various international projects and agreements with institutions has offered the chance to be a part of a network with research groups from several countries, whom have expressed a strong interest in the exploitation of marine current technology. These countries include China, the Philippines, Indonesia each having special sites with strong tidal currents and in some cases, like Indonesia, where the country is formed of a number of small islands. For these situations marine current energy extraction looks very attractive having a few or negligible competitors, as power has to be given to small communities (at affordable rates) in places where cables for power transmission are hard to be brought. Such countries have the ability to become involved in marine current research, thanks to institutions like UNIDO or the network linking ASEAN and Europe providing assistance and support.
Another point that is worthwhile being mentioned is the co-operation between Politecnico and Ponte di Archimede, as both have shared common research interests in the past and that is still present, these being water and water exploitation. Visualizing the concept of marine current harvesting, a patented device from Ponte di Archimede, the Kobold turbine, has been taken by UNIDO as a priority project to be brought to countries within the Far East. Its improvement is the object of the present research carried out by Politecnico di Milano

This short summary traces the framework within which Politecnico di Milano's research was carried out during its initial stages.

As mentioned earlier, while literature concerning a general economic evaluation on this new energy source is rather rich, the number of papers concerning both research and technological aspects is still poor, partly due to the fact that the science is still at its infant stages, and due to an attempt to preserve the intellectual property ownership on results.

At this stage research by Politecnico di Milano has just started, so this presentation is more a project plan, rather than a summary of results. This plan has been organized at two levels:
- Blade optimization, aimed at considering the Kobold prototype turbine, designed and built by Ponte di Archimede, already in operation in the Messina Straits. Assuming this solution as state of the art, any possible improvement under the fluid dynamic point of view is sought after for the improvement of efficiency for power generation.
- A more general perspective, which is dependant on the availability of a reasonable budget for research, and the problems that marine current energy will face relating to skills for development.

At this stage the fluid dynamic optimization will be considered at a back-to-basic level; reconsideration of the vertical against horizontal axis solution; the optimal action to be exerted on the vanes; as well as issues of drag or lift. Other aspects to be re-considered include; power conversion and transmission, the layout of the plan, as well as maintenance problems and the identification of suitable sites for exploitation. The issue of full-scale tests on the prototype could be planned to elucidate any potential problems.

As the second stage is far away, the adopted strategy is to focus on the first phase. Entering softly into the problem, limiting risks and becoming familiar with the project.

Efficiency improvement through proper turbine design can make use of expertise gained from the research group working for decades on the fluid elasticity, and utilizing technologies such as the wind tunnel at Politecnico di Milano. The use of a wind tunnel for a water turbine optimization could be considered rather odd at a first glance, however the past experience of the research group has proven that once the main simil-

itude scaling is accounted for, then the first stage improvements are performed with ease in air rather than in water, as instrumentation works in an easier and cleaner environment. This experience has already given good results in testing flood effects on bridge decks and to improve hull performances. Only the final stage means going to the water channel, working with an already roughly optimized model. It is worthwhile writing a few lines on this facility and the group working in it.

POLITECNICO DI MILANO WIND TUNNEL

Through the supporting a world-renowned state-of-the-art facility the excellence of Politecnico di Milano in research can be noted. The areas in which it excels are the field of Long-Span Bridge Wind Engineering and general aerodynamics. The decision to design and build a new large Wind Tunnel, having a broad application spectrum, and very high and a number of testing facilities added to this.

The Wind Tunnel at Politecnico di Milano is the most significant facilities available in Europe for Wind Engineering applications as well as for flow-structure interaction. The facility has been working at full capability since September 2001 and in the four years of operations it has been fully booked for applications both in the fields of wind engineering and aerospace applications. In addition to this several aerospace applications have been dealt with including helicopter aerodynamics (Agusta), air intake aerodynamics, flying model aeroelasticity etc. Figure 1 shows an overview of the wind tunnel, it can be described as a closed circuit facility in vertical arrangement, having two test sections, a 4x4m high speed low turbulence and a 14x4m low speed boundary layer test section. The overall wind tunnel characteristics are summarized in Table 1. The vertical arrangement and flow circuit are sketched in the vertical section of figure 2 and figure 3. The presence of two test sections offering different characteristics is peculiar to this facility, a very wide spectrum of flow conditions from very low turbulence and high speed in the contracted 4x4m section (Iu<0.15% - VMax=55 m/s) to the earth boundary layer simulation in the large wind engineering test section. Focusing on the boundary layer test section. Its overall size is 36m length, 14m width and 4m height allowing for very large scale wind engineering simulations, as well as for setting up scale models of very large structures including wide portions of the surrounding landscape. The relevant height of the test section and its very large total area (4m, 56m2) allows for very low blockage effects even if large topographic models are included.

The flow quality in with smooth flow shows a 1.5% along wind turbulence and 3% mean speed fluctuations in the measuring section. A very large 13m-diameter turntable lifted by air-film technology allows for fully automatic rotation of very large and heavy model fitted over it (max load 100.000 N). The device is specifically suited for very quick and easy change, for wind exposure of very long span bridge aeroelastic models, and avoids all the problems concerned with the repetitive assembly and disassembly of those complex models (see figure 4).

The wind tunnel has a floating floor, allowing for a very clean model set-up, leaving all the instrumentation cable connections out of the flow. A very long upwind chamber was designed in order to develop a stable boundary layer and keep the flow conditions stable, even when parameters like temperature are considered. There is the presence of a heat exchanger linked to the general control loop of the facility. The wind tunnel is operated through an array of 14 axial fans organized in two stacks of seven 2x2m independent cells. 14 independent inverters drive the fans allowing for a continuous and independent control of the rotation speed of each fan. This fully computer controlled facility can help in easily obtaining, combined with traditional spires & roughness techniques, a very large range of wind profiles simulating very different flow conditions and very different geometrical scales. The wind tunnel process is fully controlled by a PLC and a computer network (ABB control system) monitoring through more than 100 transducers all the most important flow parameters in terms of wind speeds, pressures, temperatures, humidity, vibrations of the fans and of the structure, door opening etc, allowing for feedback control on the flow temperature and speed. Flow conditions were found to be very stable and a confir-

Politecnico di Milano Wind Tunnel

Tunnel Overall Dimensions 50×15×15 [m]

Maximum Power (Fans only) 1.5 [MW]

Test Section	Size [m]	Max Speed [m/s]	$\Delta U/U$ %	Turb. Int. I_u %
Boundary Layer	14×4	16	$<\pm 3$	<1.5
Low Turbulence	4×4	55	$<\pm 0.2$	<0.15

mation of this fact is the very low turbulence level in smooth flow. All the various typical sets of spires have been developed in order to simulate the different wind profiles and an original facility has been recently installed allowing for active turbulence control in the low frequency range.
Concerning the low-turbulence high-speed section, positioned in the lower arm of the circuit, the large dimensions (4x4m) and the quite high wind speed (55 m/s) enable to reach Reynolds numbers in the order of Re = 4.5 E6, allowing reliable assessment of the bridge deck aerodynamics in section model tests. The very low levels of turbulence reached in this section (0.15%), allow for wide spectrum of possible applications. A number of transducers, instrumentation and data acquisition systems are available, allowing for all the typical boundary layer wind tunnel measuring applications in the field of wind engineering.

WIND ACTION ON STRUCTURES.

The research activity in the area of wind-structure interaction has primarily been focused on the dynamics of overhead power lines vibrating under the effect vortex shedding, then to aeroelasticity in long span bridges that is still now one of the core subjects of the research. The large expertise gained in both the experimental approach as well as in the numerical has resulted in the availability of reliable simulation models for the flow-structure interaction for application in different fields. The most prestigious research concerns the long-span bridges using aeroelasticity, the research group being responsible for the aerodynamic design and the flow-structure interaction of the Messina Bridge. The wind tunnel facility enabled the set up measurement techniques methodologies and correlated numerical simulation models among the most innovative and advanced in the international contest. Figure 5 shows the Messina Bridge section model being tested in the Wind Tunnel. The Research Group is responsible for international benchmarking focused on the comparison of the methodologies proposed by the a worldwide network, made up of the most active and renowned research groups in the area of numerical simulation of long span bridge dynamics in response to turbulent wind.
Ongoing research into train dynamics has been recently extended to the new experimental data offered by the wind tunnel facility, allowing for a greater understanding of the vehicle's aerodynamics, particularly the

effects of crosswinds. This subject is of crucial importance for very high-speed trains, taking advantage of the large sized low-speed section. Experimental campaigns on large, scale models have been set-up with correct reproduction of different boundary conditions related to the various arrangements of the rail tracks both in fixed and moving train configurations. The experience gained in aerodynamic aspects, allowed, as a consequence, to enhance the Politecnico di Milano expertise in the railway field resulting in a more comprehensive and refined implementation of the numerical models simulating the train dynamics. Figure 6 shows an example of the instrumented and traveling train model in the wind tunnel.

A subject deeply integrated between base research and application concerns is about the dynamics of cylinders in the flow stream. Tensioned cables for varying applications, from overhead power lines to the strands of suspended bridges, and submerged oil risers, are just some possible examples. Figure 7 shows two tensioned cylinders in tandem arrangement in the wind tunnel. The measure set up has been developed for vortex shedding vibrations insight. Another relevant research subject showing the high international relevance of Politecnico di Milano is concerned with sailing yachts. Taking advantage of innovative measure methodologies recently set up in the wind tunnel a further improvement has been gained in numerical codes simulating yacht performance. Figure 8 shows a scale model of an America's Cup boat fully instrumented with 6 components force balance and 4 channels sails remote control. Another field of is related to high-rise buildings and large flexible roofs. Figure 9 shows a scale model of a high rise building fixed on a 6 components balance and instrumented with 150 pressure taps allowing an understanding of the forces and pressure distribution due to wind action. Figure 12 and Figure 13, on the other hand show examples of very large and flexible roofs models reproduced by aeroelastic scale models allowing the study of the response of the structures to turbulent wind.
Experimentation needs computational support to scale up from the model to the behavior of the full-scale prototype. The full-scale check of the simulation model predictions is finally the fundamental tool in order to validate the whole experimental-numerical methodology. Figure 10 and 11 show two relevant examples of full scale campaigns managed by Politecnico di Milano, the first on the free standing Store-Baelt tower is at the construction stage, the longest Europe suspension bridge measuring the vortex shedding excitation, the second on the Humber Bridge (at that time the world longest suspension bridge), measuring the response due to the turbulent wind. A CFD approach to fully understand the over mentioned subjects is now an available tool, thanks to the increasing performances of computational resources. Figure 14 and Fig. 15 show results of simulations performed on bridges and trains. Experimental data are fundamental for the validation of the very promising CFD techniques, considering future developments of numerical methods and computer science. All the aforementioned skills and competencies are going to be applied to the new project of the Kobold turbine.

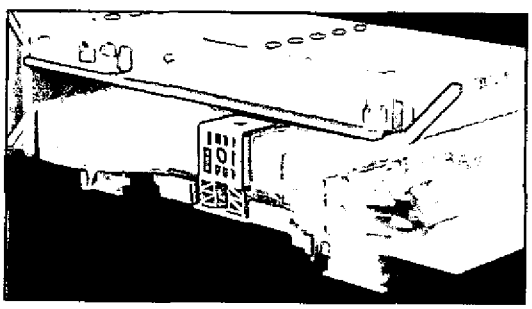


Fig. 1: Politecnico di Milano Wind Tunnel

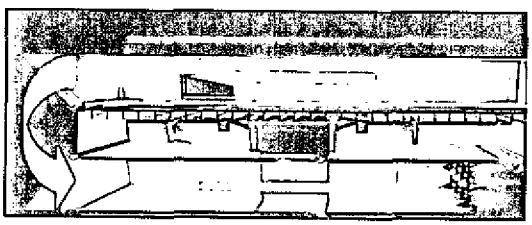


Fig. 2: Wind Tunnel section

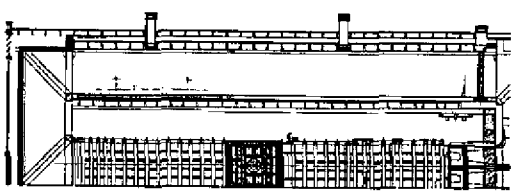


Fig. 3: Wind Tunnel section

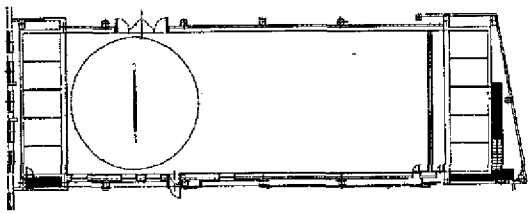


Fig. 4: Wind Tunnel top view

Fig. 5: Messina-Bridge model

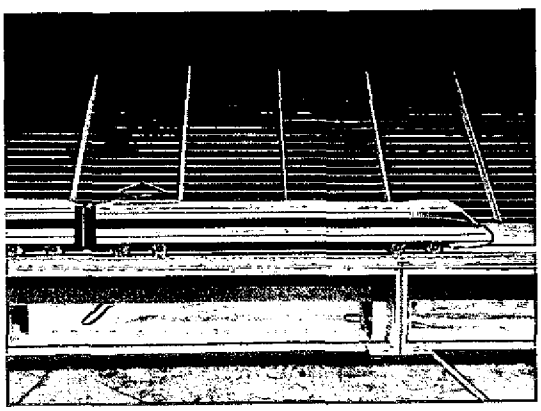


Fig. 6: Railway vehicle ETR-480

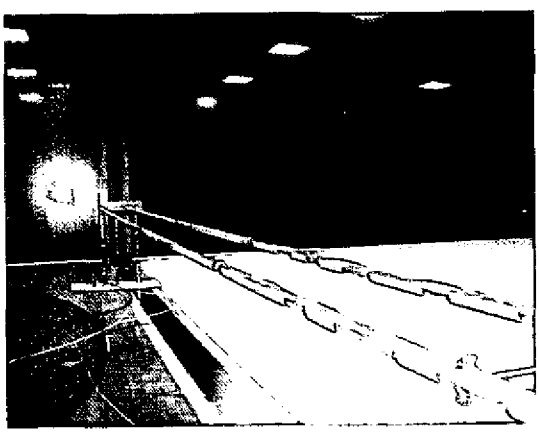


Fig. 7: Tensioned twin cylinders

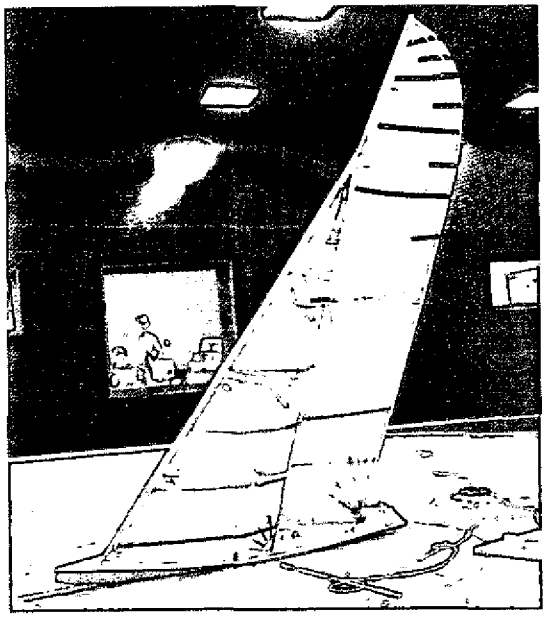


Fig. 8: America's cup yacht

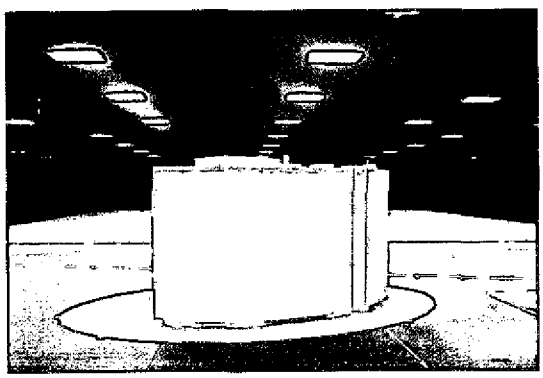


Fig. 9: High rise building

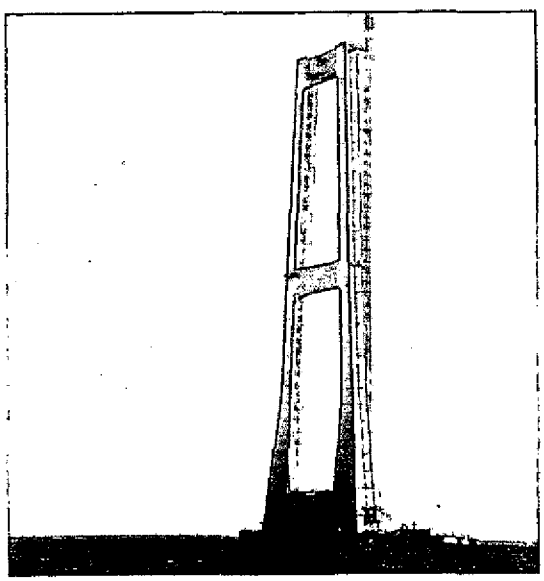


Fig. 10: Store-Baelt full scale monitoring

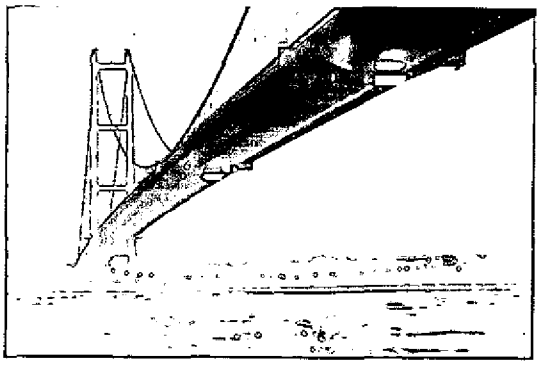


Fig. 11: Humber Bridge full scale monitoring

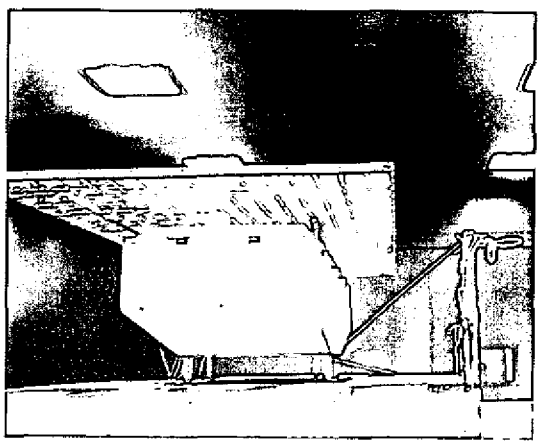


Fig. 12: Flexible roof aeroelastic model

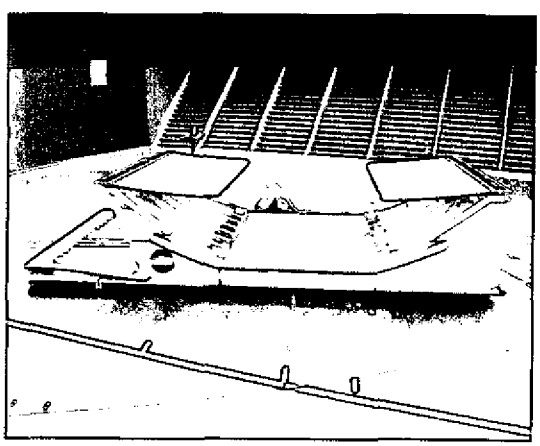


Fig. 13: Stadium roof aeroelastic model

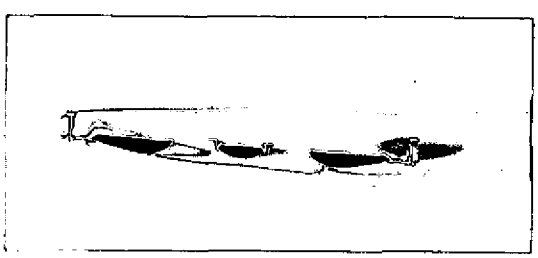


Fig. 14: Multiple-box girder CFD simulation

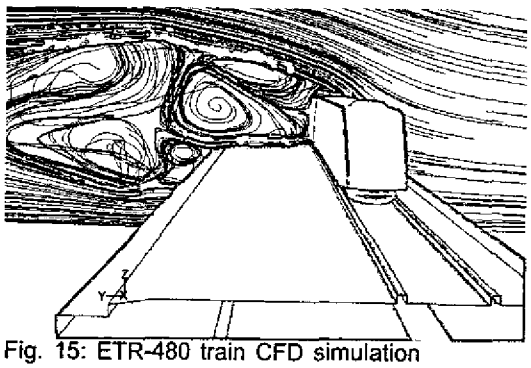


Fig. 15: ETR-480 train CFD simulation

THE KOBOLD VANE

Prior to starting a wide range activity, a research plan has to be outlined. As already stated, the leading idea is to start with the existing Kobold turbine. The overall processes that could lead to the optimal adaptation of the technology at local conditions can be foreseen and planned in different phases. These could be:

- o Assessment of the present technological development;
- o Mathematical modeling
- o Experimental tests on the complete turbine
- o Optimization

The first phase, that is the evaluation of the existing situation, may be split into different tasks

- o Setting up of a single vane model to be tested in the wind tunnel
- o Setting up of a suitable load cell to measure forces
- o Wind tunnel measurements
- o Data analysis

The aim of the initial phase is to deal with the wind tunnel tests on a single vane. The key activities will involve an in depth evaluation of the turbine wing profile in the wind tunnel, measuring both the flow field in the surrounding a vane and the global forces given by the stream. This will enable the ability to derive the aerostatic coefficients. Of course the leading role of such a large wind tunnel will be that of working with a rather high scale prototype (it is planned to reach 2/3 of the real profile).

To achieve these measurements it will be necessary to develop a dynamometric model of the turbine blade and run the necessary tests in the wind tunnel, prior to arriving at the final elaboration of the collected

data and the overall evaluation of equipment efficiency. To expand on this, the first phase needs to set up a vane model for the wind tunnel testing operation. This being an important step for the evaluation as in accordance with the usual procedures adopted, the wind tunnel features should match those needed for the specific test to be performed. The vane model will have to be designed to be as light as possible in order to limit the dynamic effects on the recorded measurements and at the same time it must have sufficient rigidity in order to reduce any wind-structure dynamic interaction. This operation requires particular skills in the model construction. Special care will have to be devoted to similitude scaling as the real structure will have to operate under water, which implies a very high Reynolds numbers. Testing will have to be organized at the highest possible Reynolds numbers (high speed and large models).

With reference to the following symbols

ρ V and μ the fluid density, velocity and viscosity, B the vane chord, having indicated with the suffix P and M the quantities related to Prototype and Model, with reference to the standard I.S. values $\mu_{Air} = 1.83 \cdot 10^{-5}$, $\mu_{Water} = 1.0 \cdot 10^{-3}$, $\rho_{Air} = 1.23$, $\rho_{Water} = 1.0 \cdot 10^{3}$, the ratio between Prototype and scale model Reynolds Number can be represented as follows:

$$Re = \frac{\rho V B}{\mu} \qquad \frac{Re_P}{Re_M} = \frac{\rho_{Water}}{\rho_{Air}} \frac{\mu_{Air}}{\mu_{Water}} \frac{V_{Water}}{V_{Air}} \frac{B_P}{B_M}$$

$$\frac{Re_P}{Re_M} = 14.87 \frac{V_{Water}}{V_{Air}} \frac{B_P}{B_M}$$

Having selected a scale ratio of the model in the order of 2/3 or in other words $B_P/B_M = 3/2$, the Reynolds Number ratio prototype to model is in the order of $Re_P/Re_M = 22.3 \cdot V_{Water}/V_{Air}$.

Being the typical current speed in the order of $V_{Water} \cong 1 \div 2\ m/s$, and being the tests performed at a wind speed $V_{Air} \cong 16\ m/s$ the typical Re ratio will be in the order of $Re_P/Re_M \cong 2$.

In other words the wind tunnel tests will be very closely representative of the full scale Reynolds Number. Special care will be taken in doing tests with different roughness of the vane surface, being an increase of roughness representative of higher equivalent Reynolds Number conditions.

The next step will consist of setting up a special wind tunnel balance to get the aerostatic vane coefficients. According to the model scaling. Internal or external load cells will have to be adopted, although some solutions already exist for both kinds adjustments to fit the actual model will have to be provided and subsequent calibration will have to be performed to match the target uncertainty. It is then expected that testing will be carried out for at least three wind speeds, for a whole 360° rotation, a complete screening will get data for the whole 360° turn as the vane is expected to work at whichever relative angle between the incoming flow and the vane axis. Forces on the vane will have to be directly measured together with the flow speed in order to get the aerostatic coefficients for the chosen vane profile. Eventually some tests will have to be repeated under turbulent flow to obtain the static coefficient variation under these conditions.

A final part will consist of data analysis, in order to produce a final report that should provide the needed inputs for the next steps.

The overall research plan has wide perspectives, once the described preliminary steps have been run and results have been achieved some further aspects are to be investigated. To fully understand the real aim of the global work an outline is given of the various phases or tasks within each of the previously mentioned research phases:

Mathematical modeling will be split into
- o Model creation
- o Parameter sensitivity analysis
- o Simulation of the complete turbine

Experimental tests on the complete turbine will consist of the following tasks:
- o Experimental set-up: complete turbine
- o Wind tunnel tests
- o Comparison between numerical simulation and experimental measurements

Optimization is going to be the final part, relying on the results of the previous phases.

The data given by wind tunnel test will constitute a proper basis for the next step, which will be a preliminary simple numerical model of the turbine.

Figure 1: Politecnico di Milano Wind Tunnel 3D transparent rendering; the 14 2m diameter axial fans array is recognizable on the right lower side

Figure 2: Longitudinal section showing the flow circuit; on the upper side is the boundary layer test section - on the lower side cen-

tre is the high speed low-turbulence test section - on the lower side at right is the 14 axial fans array

Figure 3: Wind Tunnel horiz. section of the upper boundary layer test section (overall size 36x14m) - on the left side is the 13m-diameter air film supported turntable

Figure 4: Aeronautical application in the 4x4m low turbulence test section. A portion of the fans array is visible on the back

Figure 5: View of the boundary layer test section (14x4m) showing the 1:250 scale aeroelastic model of Messina bridge on the 13m diameter turn-table

THE ENERMAR SYSTEM

Alberto Moroso
Ponte di Archimede

INTRODUCTION

Marine currents represent large renewable energy resources and have the potential to give a significant contribution to fulfill the worldwide energy demand.

The president of Ponte di Archimede S.p.A., Elio Matacena, came up with the idea of utilizing a vertical axis turbine to extract energy from the marine current in the 80's. He had then been inspired by how his ships, ro-ro ferries from Caronte S.p.A., moved in the Strait of Messina, site famous since ancient times for its very strong currents, by the means of Voith Schneider vertical axis propellers, very particular devices - completely different from the normal screw propellers - used for those ships requiring a high manuvrability such as tugs and bidirectional ferries.
The main advantages of the vertical axis turbines, compared to horizontal axis ones, are the designinig and building simplicity and that the turbine, no matter where the flow comes from, will always rotate in the same direction.

The ENERMAR system - with its core, the patented Kobold turbine - was succesfully operating in the Strait of Messina since June 2001,
In January 2005 it was drydocked for maintenance, the generator and the inverter have been changed to comply with the requirements for the Italian electricity grid. In late July 2005 the Kobold prototype has been connected to the grid. This is the first marine current turbine in the world to be producing electricity to a local electricity grid, see figure 1, below.

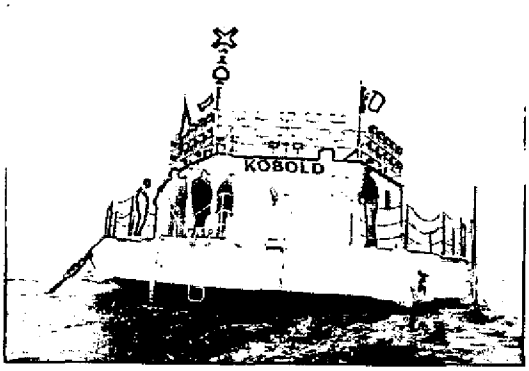


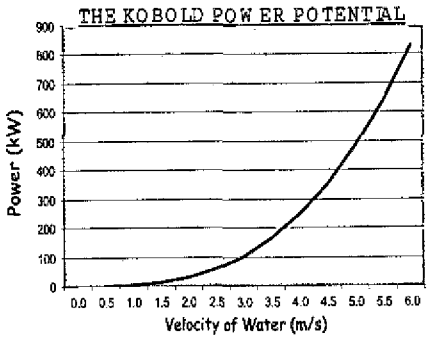
Fig. 1. - The Kobold turbine in the Strait of Messina

The theoretical power of any fluid flow (air, water, etc.) is given by the following formula:

$$P = 1/2\ \rho\ S\ V^3$$

in which S is the projected area of the turbine, ρ is the fluid density and V is the current velocity. Not all this power is extractable from the flow, but only about the 60% due a phisical low well known as "Betz's Limit". In the teoretical power formula the velocity is present at the third power, so if the velocity doubles the power gets 8 times bigger; to double the power is enough to increase the current velocity of the 25%, and so on. Another basic pointof the formula is represented by the fluid density: the water density is about 850 times bigger than the air, thus having plants of the same size, at the some velocity the water plant will produce 850 times the power of a wind plant; or also to have the same power of a water turbine in a current of 8 knots velocity (about 4 m/s) the wind turbine will have to work in a wind of about 136 km/h (38 m/s). By this comparisons it is evident that, at the same power output, the water plants are smaller than the the wind ones, implying minor building costs, smaller payback times and cheaper maintenance.

As seen below, the produced electrical power is the product of the global efficiency, the turbine diameter, the blade height (S=30 m^2 in case of Kobold turbine), the water density (r) and the current speed (V). The actual efficiency of the Kobold turbine is about 25%. This efficiency will be increased further with an optimized mechanical and electrical system. For example the bearing of the turbine shaft was changed during the maintenance and this increased the efficiency of the system of about 3%. Furthermore note that already at this stage the Kobold turbine has efficiency comparable to the long-time developed wind turbines.



THE DEVELOPMENT HISTORY - FROM AN IDEA TO THE KOBOLD PROTOYPE IN THE STRAIT OF MESSINA

The very early tests of a current device commisioned by Ponte di Archimede Co. were carried out in the hydroynamic tunnel of the Voith, in Germany, in 1986, when several models were tested. All those prototypes derived from the Voith Schneider vertical axis marine propeller.
In the Voith Schneider propellers any blade rotates cyclically of a certain angle around its vertical axis. By changing this angle it is possible to change the thrust direction in all the 360°. The Voith turbine worked exactly in the same way, having the blades moving cyclically during the revolution.
The tests gave good results, showed the real possibility of Marine Current Energy, although the Voith turbine showed some points to improve: the efficiency was not very high (around 15%), the turbines in some conditions were not self starting and the Voith propellers (and therefore the turbines) are devices with complicated mechanisms and moving parts to allow the blades motion, thus delicate and expensive.

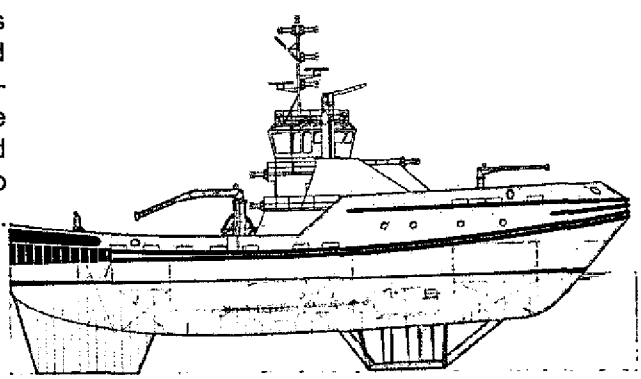
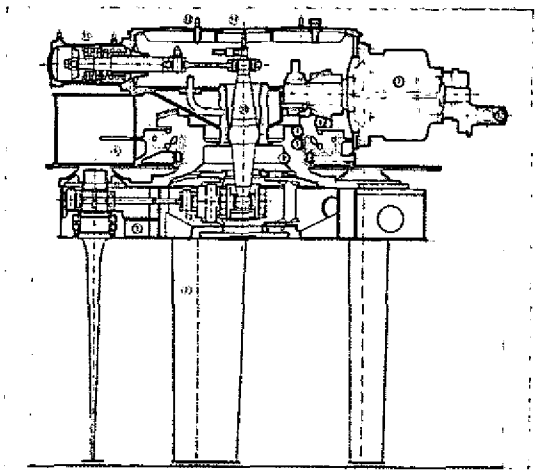
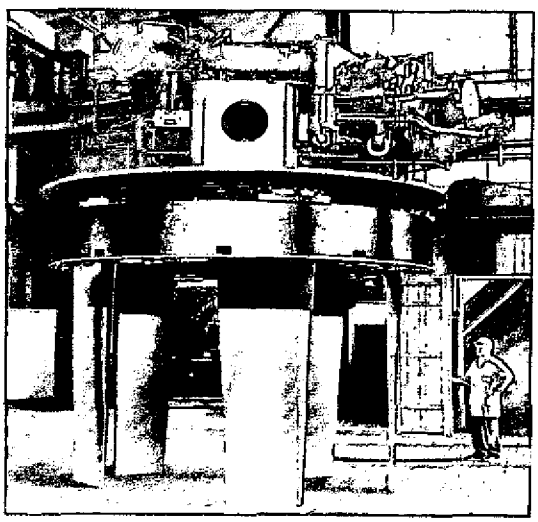


Fig.3 - Voith Schneider marine propeller





The Voith tests led Ponte di Archimede Co. to start in 1995 the development of a new concept turbine which had to be as simple as possible, without moving parts and, above all, self-starting in any condition.
The result of these studies was the concept of a new hydraulic turbine, the Kobold Turbine, having self-moving blades, thus without any mechanism to control the blade orientation, and having a high starting torque under any condition. Like any vertical axis mill, the Kobold turbine rotates in the same direction no matter the current direction.
The concept of a simple, cheap and reliable machine having characteristics of sturdiness and high efficiency was the target of the study of Ponte di Archimede Co. which, in 1998 patented the Kobold Turbine

The first model of a Kobold turbine was built and tested in the towing tank of Naval Engineering Dept. of University of Naples "Federico II" at the end of 1996 The blades were free to oscillate up to 90 degrees (with respect to the radial direction) and the torque was generated mainly by the drag of the blades.
Two different models were tested in the towing tank, a first with 3 blades and a second with 5 blades. For both of them the blade profile was a flat plate having a chord of 90 mm and a height of 230 mm. The turbine diameter was 800 mm and the two models were tested at the velocities of 1.0, 1.5 and 2.0 m/s.

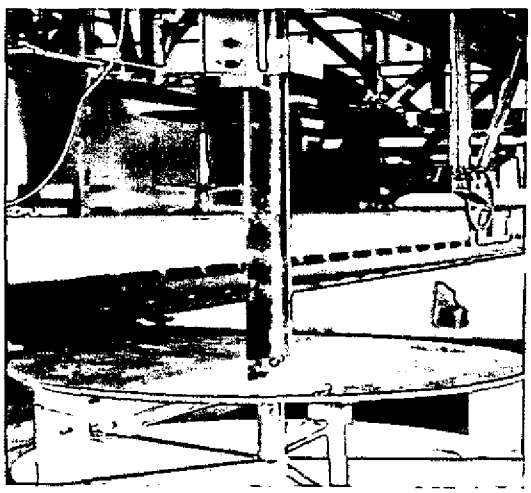


Fig. 4 - Kobold turbine model (5 blades) tests in the towing tank of Dept. of Naval Engineering of University of Naples

The towing tank tests fully confirmed the theoretical calculations of the first mathematical model of the turbine behavior.

Further improvements led the Kobold turbine to the actual configuration. A numerical code "ad hoc" developed at Dept. of Aeronautical Engineering of University of Naples

"Federico II" was used to predict the turbine behaviour and output power, taking into account the interference between the blades, the passive resistance of other turbine components (for instance the arms) and other major aerodynamic parameters. The optimization of the turbine led to change some parameters in the working point of the turbine, so this time the torque was mainly generated by the lift of the blades.

To validate the correctness of this new and more sophisticated mathematical model, the numerical activity was coupled with extensive experimental activities consisting in wind-tunnel tests of a larger model of Kobold turbine. In fact a new model was built and tested in the wind tunnel of Dept. of Aeronautical Engineering, University of Naples (see figure 5).

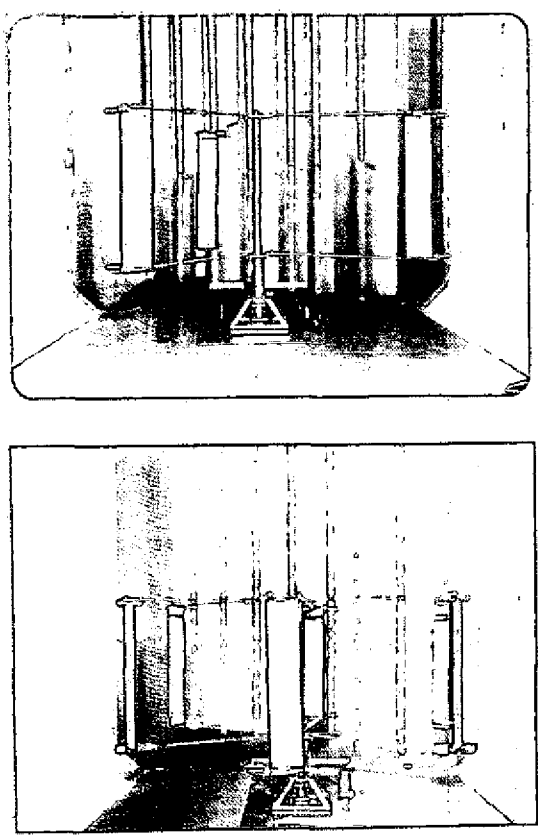


Fig. 5 - Model of Kobold turbine in the wind-tunnel of the Department of Aeronautical Engineering of University of Naples (3 blades, left; 6 blades, right)

This model was designed to work in the wind tunnel, thus working at completely different current (in this case wind) speed and rotational speed and was built in such a way to change as many parameters as possible in the turbine configuration.
The model had a diameter of 2.2 meters, blades height was of 0.8 meters and the blades chord was of 0.17 meters. It was tested with 2, 3, 4 and 6 blades. The blade airfoil was a NACA 0018 standard profile and due to the high number of possible parameters variation, hundreds of tests were performed. A particular care was given to the possibility to change the angle of blade oscillation. The first Kobold turbine model tested had the blade oscillating like the ones tested in the towing tank. To optimize the angles and to avoid the influence of inertial forces on the blade oscillation, on the blade was positioned a counterweight in order to have the blades fully balanced. The angle was controlled trough two adjustable blocks (see figure 6).

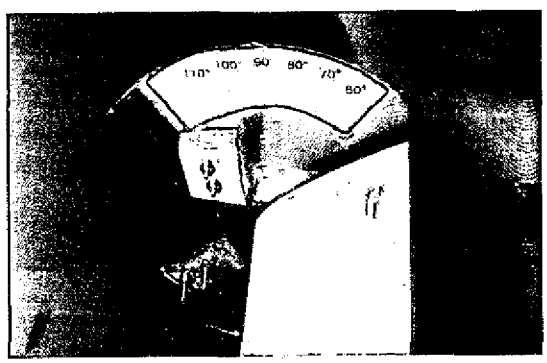
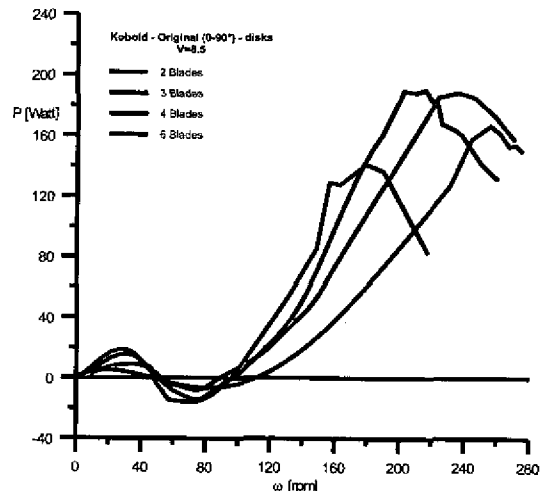


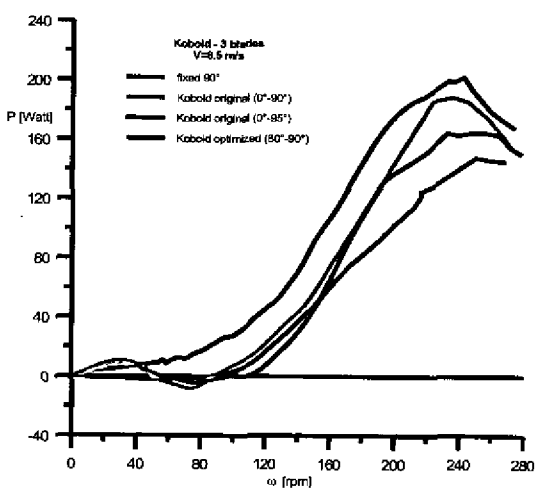
Fig. 6 - Details of the blade tip with counterweight. Arrangements to optimize blade pitch angle

In graph 1. below it can also be seen the effect of blades number on produced rotor gross power. This graph clearly shows why a 3-blade configuration was chosen for the real prototype (in fact the maximum rotor gross power is the same of 4 blade arrangement, but with obvious less losses due to blade sustaining arms and minor construction costs).

Optimization of blade oscillation angle was then performed to solve the problem of negative power in the low rpm range. In graph 2. the gross rotor power for different blade oscillation angle setting is shown.



Graph 1 - Original Kobold turbine (blade articulation 0-90°). Gross rotor power for different blade number configuration (wind-tunnel tests)



Graph 2. - Kobold turbine optimization. Gross rotor power for different blade articulation settings (wind-tunnel tests)

The turbine was tested several times, modifying its characteristics according to the numerical and experimental test results. All the investigations led to the improvement both of the mathematical model and of the turbine characteristics, deeper investigating the kinematical and the dynamic behavior of the tested device.
The final result of these theoretical evaluations and model tests was the Kobold prototype in the Strait of Messina, see figure 7.

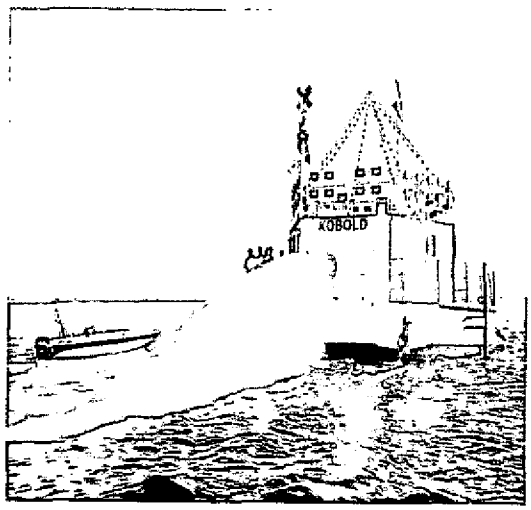


Fig. 7 - The Kobold turbine in the Strait of Messina

THE KOBOLD PLANT IN THE STRAIT OF MESSINA - THE ENERMAR SYSTEM

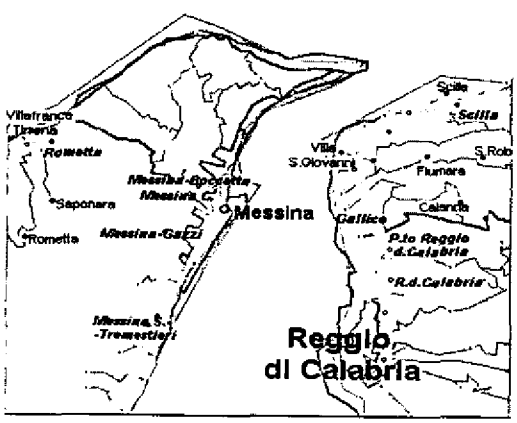


Fig. 8 - The location of the Kobold prototype

The Kobold turbine has been designed to satisfy, at the highest possible level, the environment safeguard and efficiency needs, as well as the necessities of low construction and maintenance costs. The ENERMAR system has been designed so that minor causes cannot result in disproportionately heavy damage. The design has taken into account the practicability of carrying out inspections of relevant components.

The characteristics of the Kobold turbine are the following:

o direction of rotation independent of marine current direction.
o a very high starting torque, that makes the turbine able to start spontaneously, also in loaded conditions, without the necessity of any starting devices.

The airfoil used for the turbine blades is a new concept unsymmetrical profile, so called HILIFT 18, designed for this purpose by the Department. of Aeronautical Engineering of the University of Naples, taking into account both the maximization of the turbine performances and the risk of the cavitation which would quickly damage the blades.
The blades structure, mainly for the hydrodynamic loads and for the weight, was studied using advanced FEM programs and was realized in carbon fiber and epoxy resin.

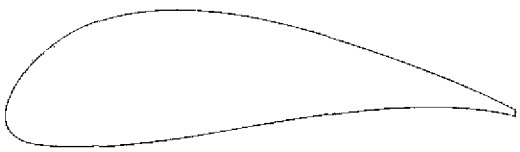


Fig. 9 - HILIFT 18 profile.

From the mechanical point of view, the Kobold turbine has been designed following simple and effective principles, so as to need for its whole useful life very limited maintenance interventions. The design has taken into account the practicability of carrying out inspections of relevant components.

The main turbine dimensions are the following:

Diameter	6 meters
Blade Span	5 meters
Chord	0.4 meters
N° of Blades	3

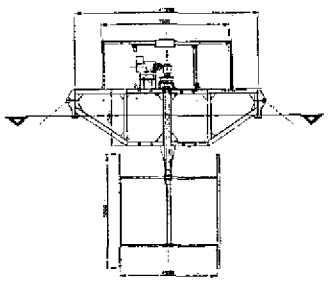


Fig. 10. The ENERMAR system

The 3-blades turbine rotor is mounted under a round shaped buoy of 10 m diameter.
The buoy was built in steel according to the Italia Shipping Register (RINA) regulations for the steel ships and certified by RINA.
The main characteristics of the floating platform are the following:

Diameter	10.0 m
Depth	2.5 m
Design Draft	1.4 m
Displacement	35.0 t
Steel weight	25.0 t
Metacentric height	5.0 m

This last parameter indicates the stability characteristics of the floating platform: the bigger is the metacentric height the higher is the platform stability. If compared to a standard ship with the same displacement, the platform stability is about 6 times bigger.
Since the turbine, when working, produces a thrust having approximately the current direction, this thrust (which is around 10 - 15 t) generates with the mooring reaction a moment inclining the whole plant.
For reasons of both global plant efficiency and safety on board, it is important that this trimming angle is as small as possible.

Actually, in normal working conditions, the trimming angle is around 5 degrees.

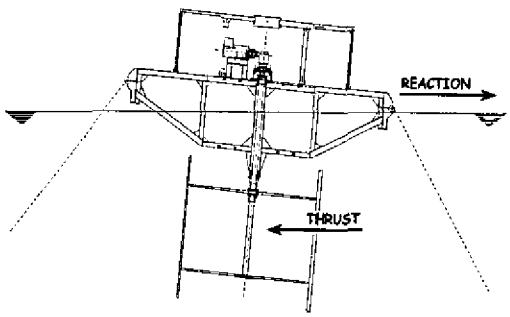


Fig. 11 - Trimming moment in working conditions

The platform is moored to the seabed by means of four mooring lines composed each of a chain (27 m) at the sea bottom and of a textile rope going up to the platform. The anchoring devices are 4 mooring blocks made of concrete having the weight of 35 t each.
The site where the plant is positioned is very closed to Ganzirri, in the Strait of Messina, by the Sicilian coast, distant from the shore about 150 - 200 m.
The depth goes from 15 to 35 m and the maximum current speed is around 2.0 m/s although there are places, in the Strait of Messina, where the current speed can be more than 3.0 m/s.

The mechanical energy produced by the turbine is turned into electrical by means of a synchronous brushless 380 V three-phase electric generator.
Since the turbine rotates very slow (18 - 20 r.p.m.) while the generator, to have an output at 380 V and 50 hz, needs to rotate at 1500 r.p.m., the turbine is connected to the electric generator through an epicycloidal gearbox with ratio 90:1 increasing thus the rotational speed at the generator shaft.

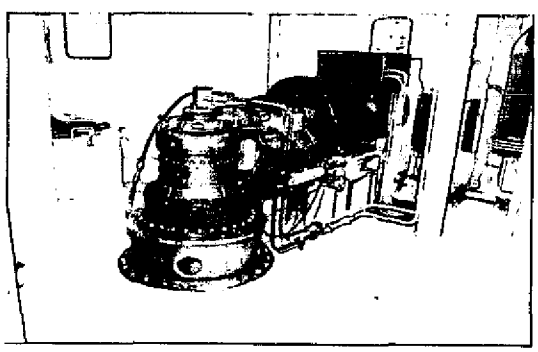


Fig. 12 - Machinery room - Generator and gearbox

The global efficiency of the system is defined as the ratio between the produced electrical power and the theoretical power available in the current relative to the intercepted area:

$$\text{ç} = \frac{\text{Pelectrical}}{.5\ \tilde{n}\ V^3\ S}$$

where S = Diameter* Blade Height (S=30 m^2 in case of Kobold turbine) ρ, r is water density and V is the current speed. The measured global efficiency was (before 2005) around 23%, which is comparable to the long time well developed wind turbines and so this first results can be considered excellent even because on-going improvements in the mechanical transmission system will certainly rise the global efficiency very soon. Although the plant design power is about 80 kW, the maximum power output was around 25 kW due to the site, which is not the best for this purpose in the Strait of Messina.

Up until January 2005 the electricity produced by the turbine was used on board by turning on 20 floodlights each of them absorbing 1 kW of power (total produced power 20 kW) with a current speed of about 1.8 m/s and driving the electro pump (25 kW) with a current speed of about 2.0 m/s.

As reported in the introduction, the plant has just been permanently connected to the Italian electric grid. It is the first marine current energy plant to be connected to a national grid.
Since the turbine rotates at any speed, depending only on the current velocity, the electricity is produced at any frequency and tension. This gives no problems when the electric power is used on board for experimental purposes, but when giving electricity to the national grid, the requirements are very strict in terms of frequency, tension and phase.

To meet the grid requirements a static rec-

tifier-inverter was installed on board in order to have, no matter the turbine speed, always the same electrical output in terms of tension and frequency, and always in phase with the national grid.

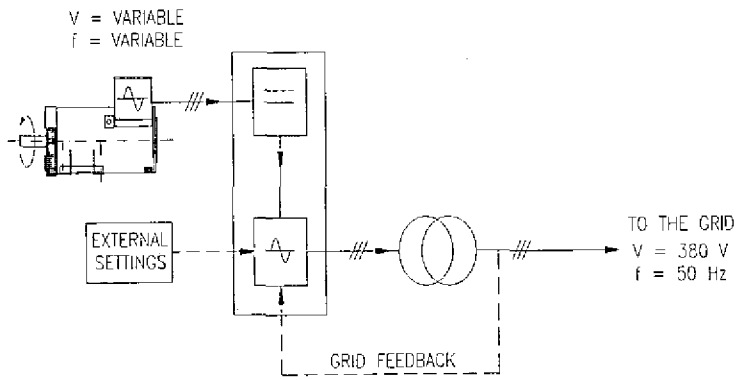


Fig 13 - Main scheme of the electric part

THE ENVIRONMENT

The environmental impact of the Kobold turbine has been evaluated particularly from the point of view of the compatibility with the sea, flora and fauna. The environmental impact and compatibility study, carried out by the University of Messina (ITALY), has reached the following conclusions:

o the environmental impact is negligible.
o the Kobold units are compatible with the Italian rules for the installation and removal of sea structures.

The visual impact of the plant is very low and, in case of plant removal, the works for the site reclamation are of a small amount: there are no permanent structures on the seabed and the bigger components, the mooring blocks, are easily removable using a normal crane.

RESEARCH

With the experience from a full scaled system in the water for 4 years of time Ponte di Archimede S.p.A has all the necessary information to develop an optimized mechanical system and is further on developing a design tool together with INSEAN in Rome and Politecnico di Milano
Since the transfer air - water is not so immediate, the contribution of INSEAN, with its experience in naval architecture, both numerical and experimental (INSEAN has one of the biggest towing tanks in the world), and of Politecnico di Milano, with its experience in aerodynamics and wind tunnel tests, will be precious to fully understand the differences in the turbine behavior in air and water.
This comparison will be very important to decide which studies can be carried out in the wind tunnel - wind tunnel tests are cheaper and easier to manage in case of multiple configuration models - and which ones have to be necessarily done in the towing tank or in the hydrodynamic tunnels.
Furthermore, using the most advanced techniques in computational fluodynamics (CFD), a new sophisticated mathematical model is being prepared in order to have a more powerful tool to estimate different design conditions without carrying out model testing. This will be very helpful for future projects where the turbine will have to be optimized for specific site conditions. The computer model and the optimized mechanical and electrical system are to be finished in 2005.

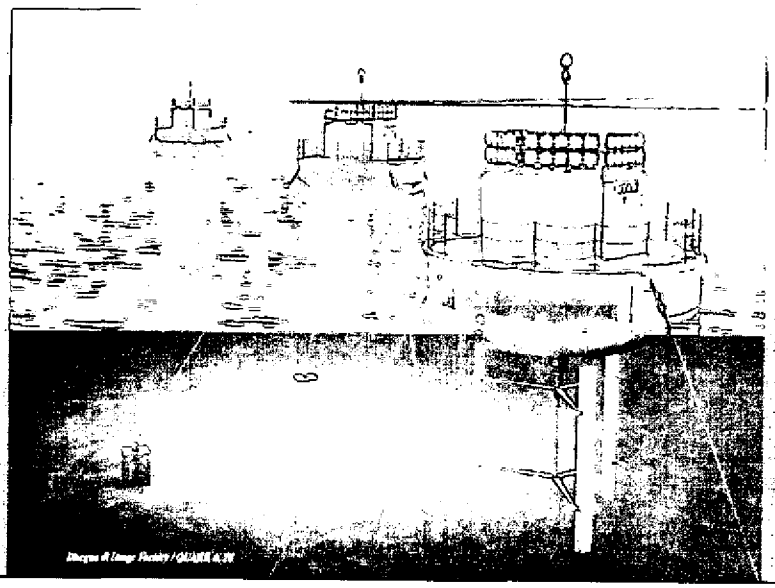
THE FUTURE

The next step is to provide renewable energy to remote islands in the People's Republic of China, the Philippines and Indonesia. This will be done by installing turbine farms of the patented ENERMAR system - the Kobold. This is an ongoing project together with UNIDO and the governments of the three countries.

Presentation - Ponti di Archimede

The KOBOLD Turbine

An Innovative Technology For The Exploitation Of Marine Currents

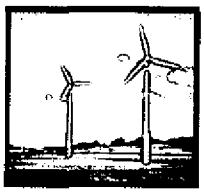


WHY ENERGY FROM MARINE CURRENTS ?

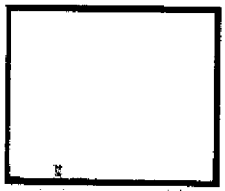
The Marine Current Energy is a clean, renewable source of energy.

Very similar to the wind, has a first big advantage of being completely predictable, since it is generated by the lunar phases.

For both wind and marine currents the theoretical power of a fluid current is given by:



$$P = \frac{1}{2}\rho S V^3$$



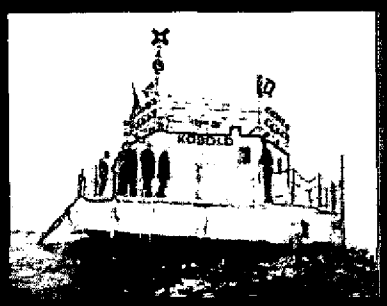
The term ρ in the above formula is the fluid density
Sea water density is about 840 times higher than air:

The energy contents of marine current is much higher than wind.

For example, a marine current at 8 kn (4 m/s) speed, has the same energy content as a wind at 136 km/h (38 m/s).

ADVANTAGES OF MARINE CURRENT ENERGY

- Predictable
- Smaller plants, if compared with other renewables of the same power output, thus:
- Lower building costs
- Lower running costs
- Shorter amortization time



DISADVANTAGES OF MARINE CURRENTS ENERGY

Obviously there also are some minor problems connected to the Marine Current Energy.

They are mainly related to the marine environment, but the marine industry has to deal with them everyday:

- Cavitation risk
- Sea weed and barnacles
- Risk for weather injuries
- Maintenance difficulties

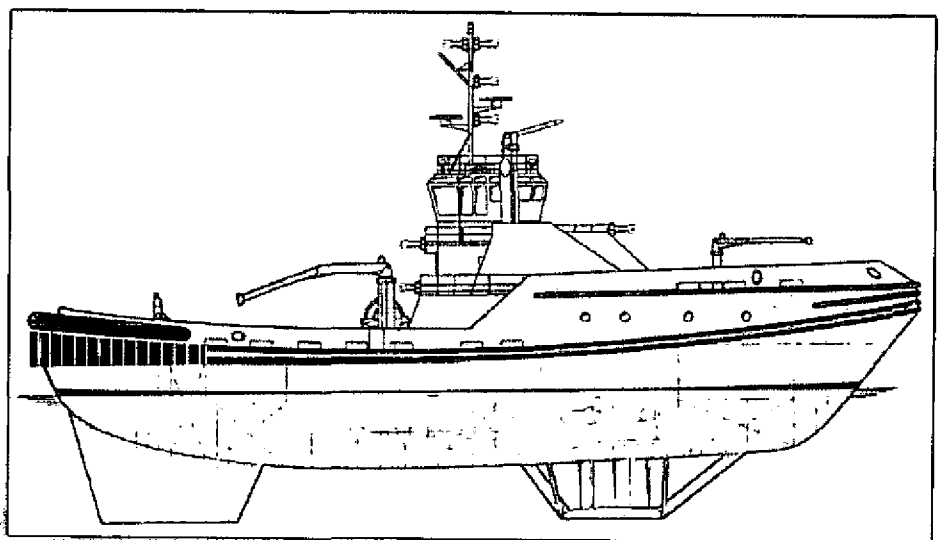
THE KOBOLD TURBINE

The *Kobold* is a hydraulic vertical axis turbine with free oscillating blades, patented in 1998 by Ponte di Archimede S.p.A.

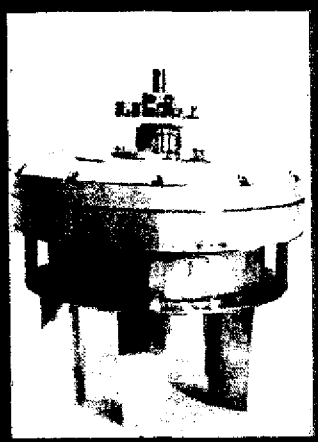
Its main characteristics are:

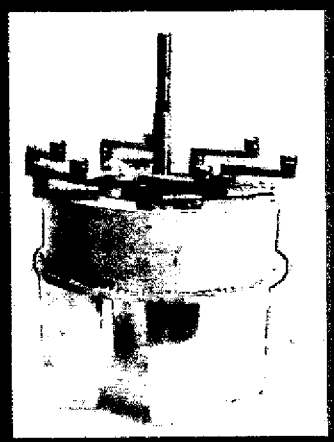
- ✓ Rotation direction independent of current direction.
- ✓ High starting torque.
- ✓ High efficiency.
- ✓ Reliable, sturdy and simple.
- ✓ Self adjusting blades.
- ✓ No moving mechanisms.

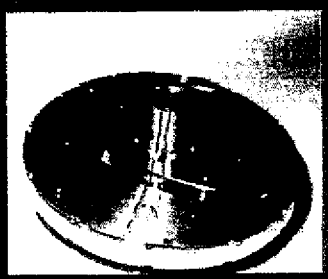
The architecture of the *Kobold* turbine was inspired by the Voith-Schneider marine propellers, often used on particular type of ships such as tugs and bidirectional ferries instead of the classical screw propellers.



Already in 1985 tests were carried out in the towing tank of Voith GmbH (Germany) on a small turbine derived from a Voith-Schneider ship propeller.







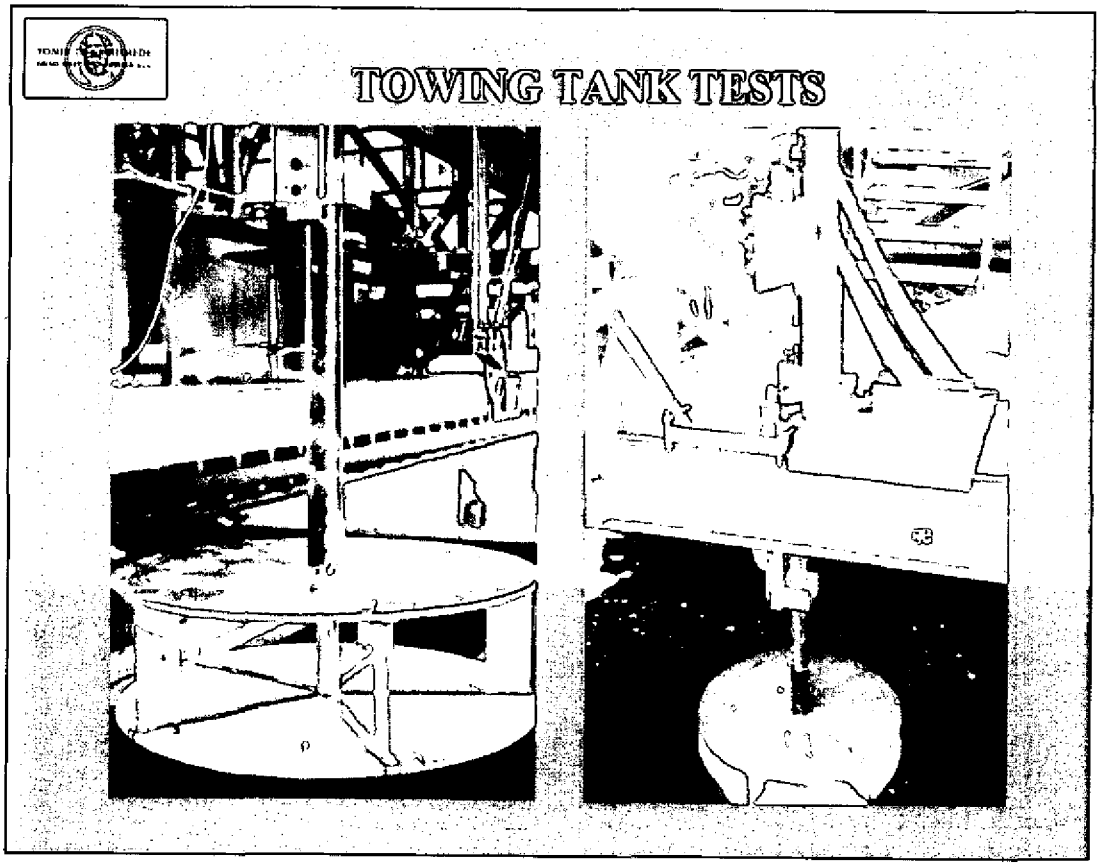
Note the mechanism for blades oscillation

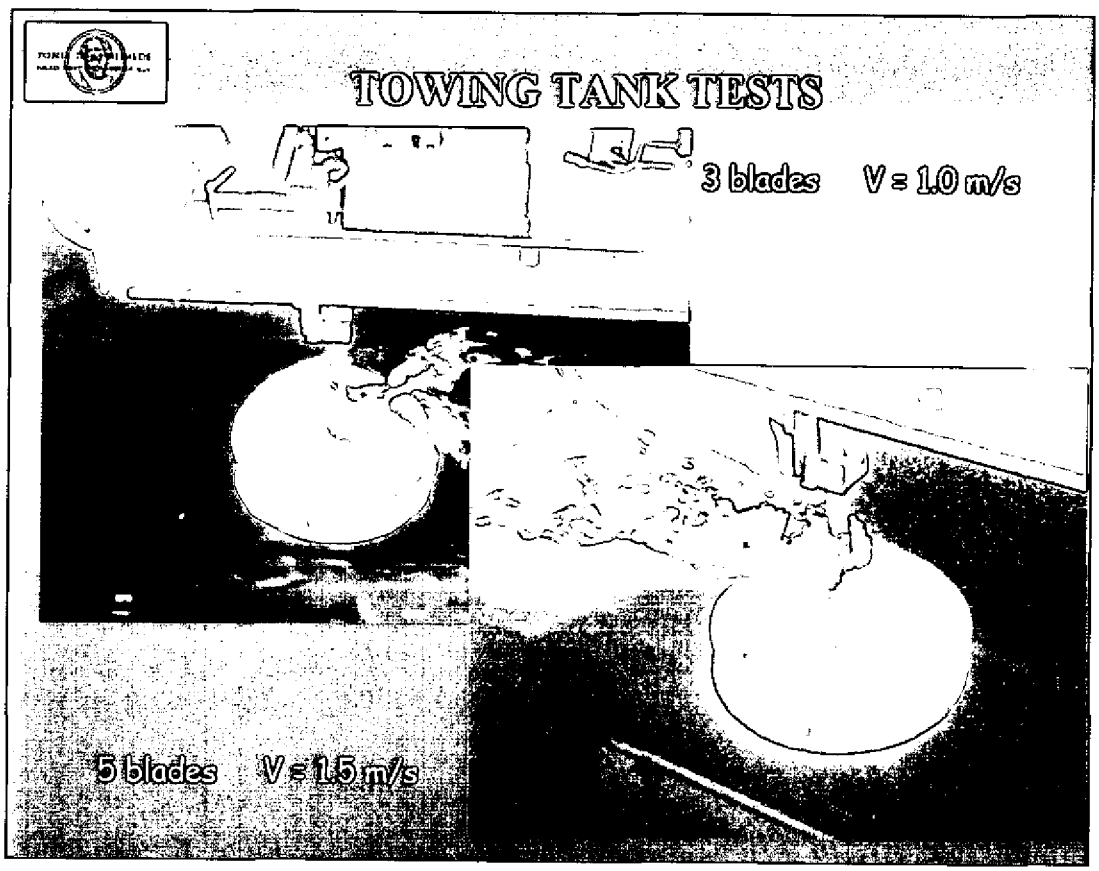
In 1995 PdA begun the study of a new prototype, the actual *Kobold* turbine which had to be simple, reliable, economic and, above all, had to be characterized by a high efficiency.

At this aim, an intense experimental phase begun, with two series of model tests carried out at University of Napoli "Federico II".

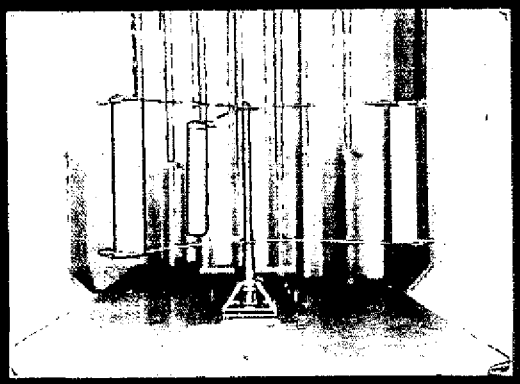
The first series of tests was held in the towing tank, with two different models.

The second series of test, to improve the results achieved in the water, took place in the wind tunnel, testing several different configurations.

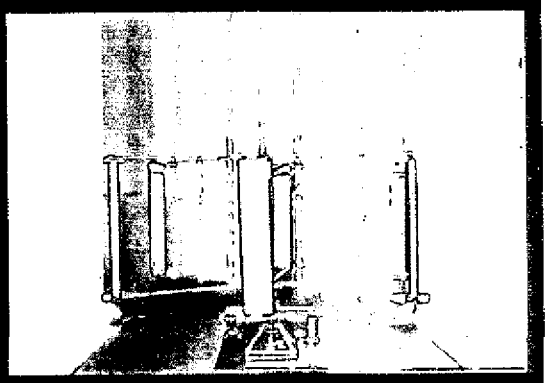

TOWING TANK TESTS


TOWING TANK TESTS
3 blades V = 1.0 m/s
5 blades V = 1.5 m/s

WIND TUNNEL TESTS



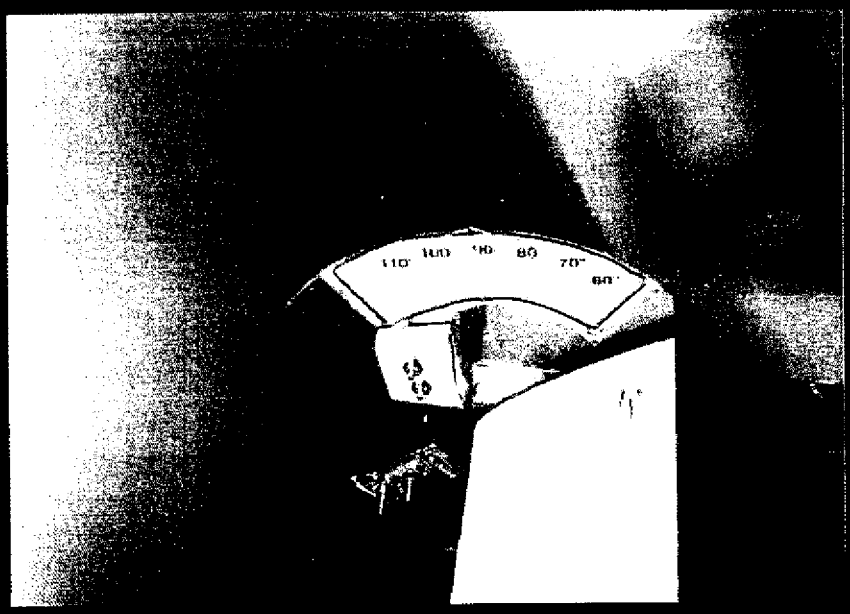
3 blades model



6 blades model

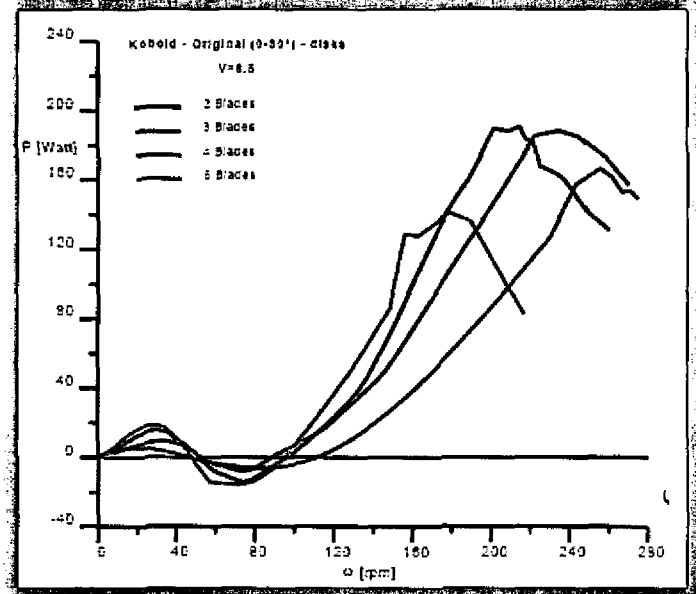
Later, in the wind tunnel, hundreds of tests were performed, changing the main turbine parameters, such as number of blades and blade oscillation angle.

WIND TUNNEL TESTS



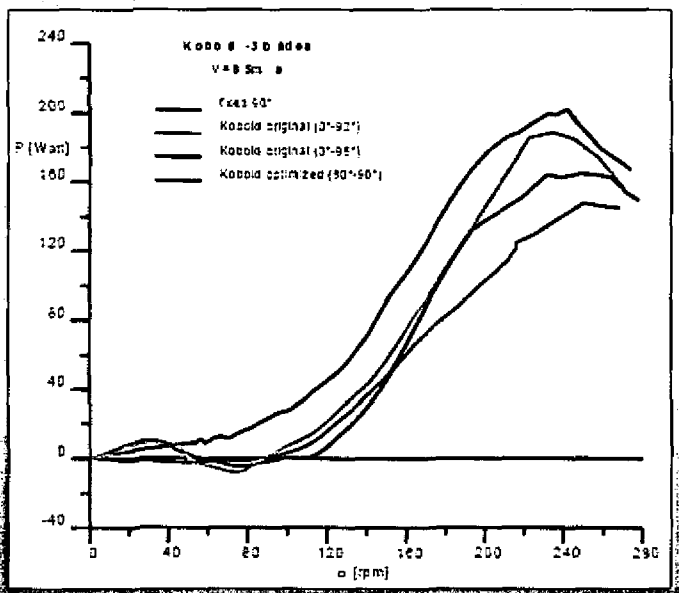
Model arrangement to evaluate the influence of the blade oscillation angle

TESTS RESULTS (blades free oscillation)



- 3 blades model gave the best results. (*red line*)
- In all tests, excellent starting torques were observed.
- All models showed to suffer of lack of acceleration.
- In a small rpm interval a negative power was measured.

OPTIMIZAZION (blades limited oscillation)



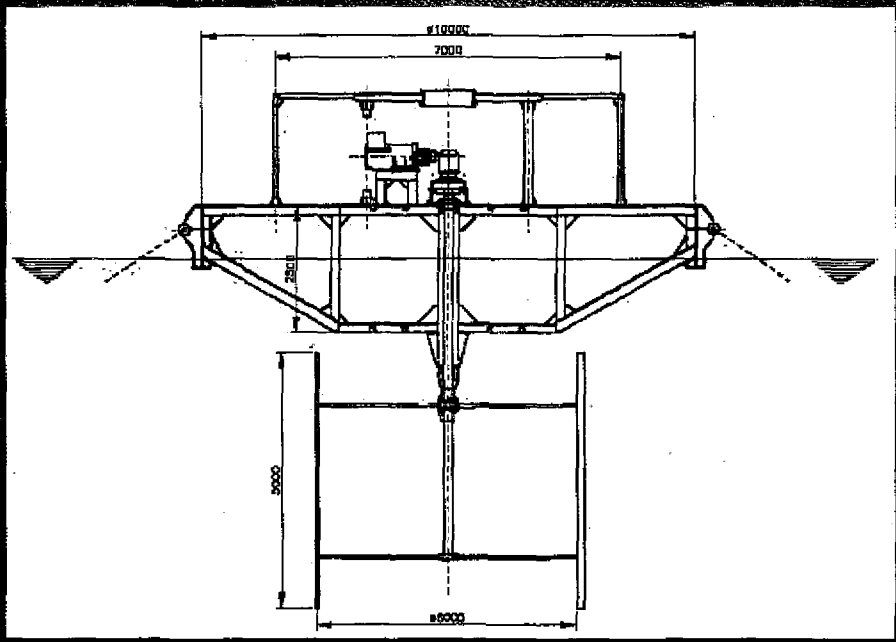
- The blade oscillation was confined in a sector between two angles.
- A further increase of starting torque was reached.
- Turbine characteristic curve is all contained in the positive power zone.
- Turbine power was improved.

THE ENERMAR PILOT PLANT

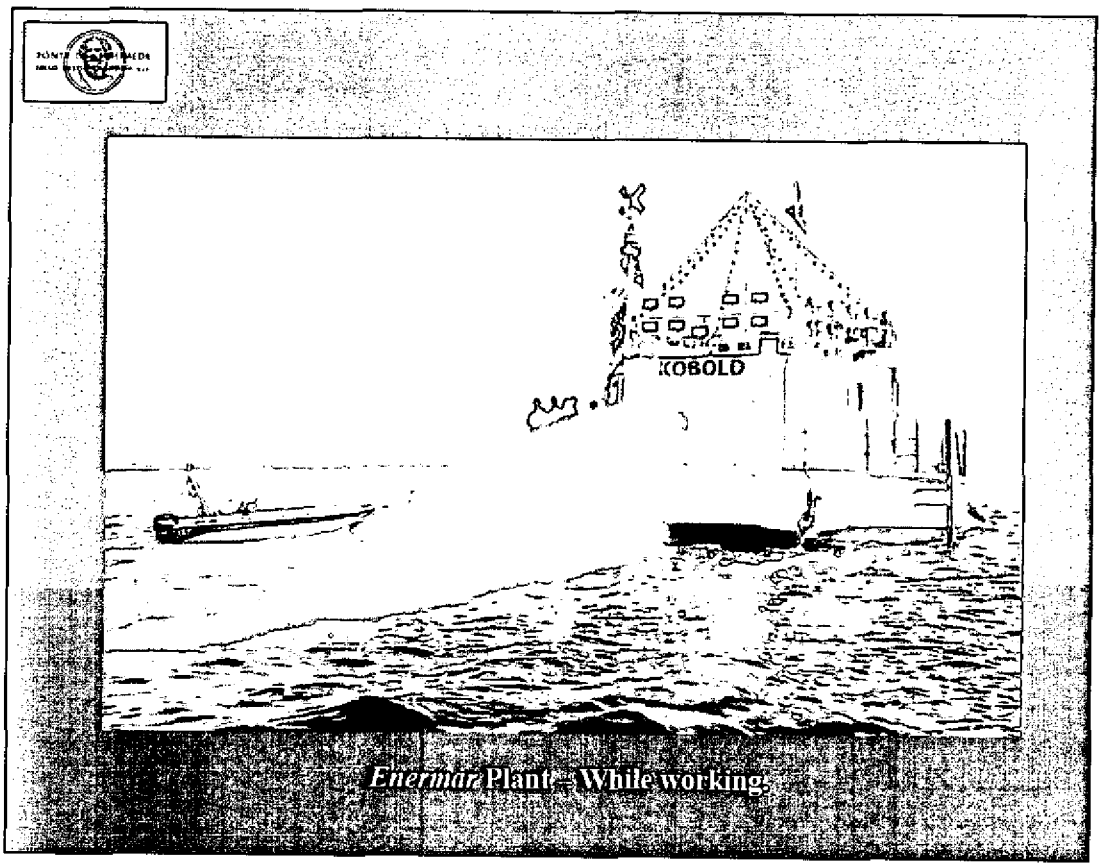
The *Enermar* pilot plant was launched in 2001 in the Strait of Messina, financed by Ponte di Archimede S.p.A., the Regione Siciliana Government and the European Community.

A Kobold turbine is fitted under the bottom of a cylindrical floating platform of 10 m diameter, moored at the sea bed in 4 points.

The turbine is a Kobold 3 bladed type, with limited oscillation angle.

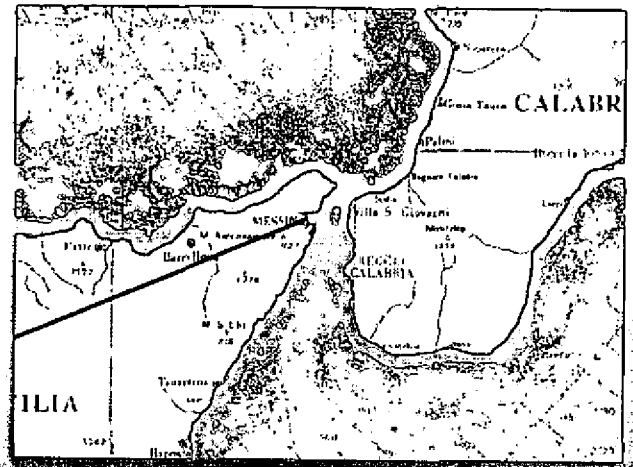


Enermar Plant – General Arrangement



Enermar Plant – While working

The installation site is 150 offshore from Ganzirri, by the Sicilian coast, where the average speed of the tidal current is between about 1.5 e 2 m/s, although there are points, in the Strait of Messina, where the velocity peaks can reach more than 3 m/s .



PLANT CHARACTERISTICS

TURBINE	
Rotor diameter	*6.0 m*
Blade height	*5.0 m*
Chord	*0.4 m*
Blades number	*3*
Blade profile	*Hilift 18*
Blade material	*Carbon Fibre*

FLOATING PLATFORM	
Diameter	*10.0 m*
Depth	*2.5 m*
Displacement	*35 t*
Mooring blocks	*4*
Block material	*concrete*
Block weight	*35 t each*

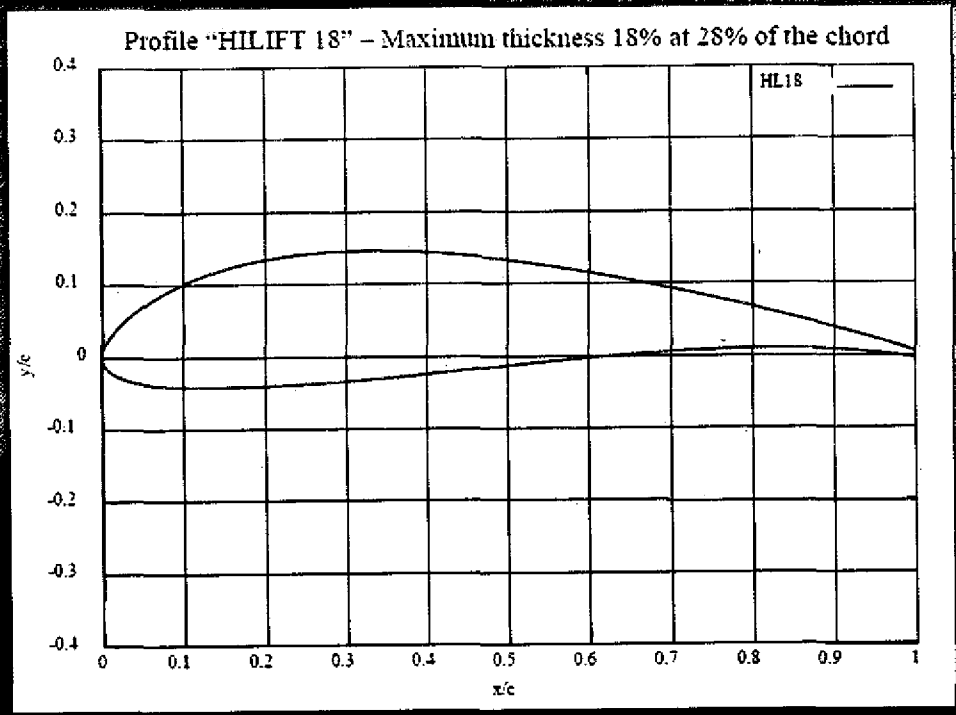
Turbine revolutions — 18 rpm (max)

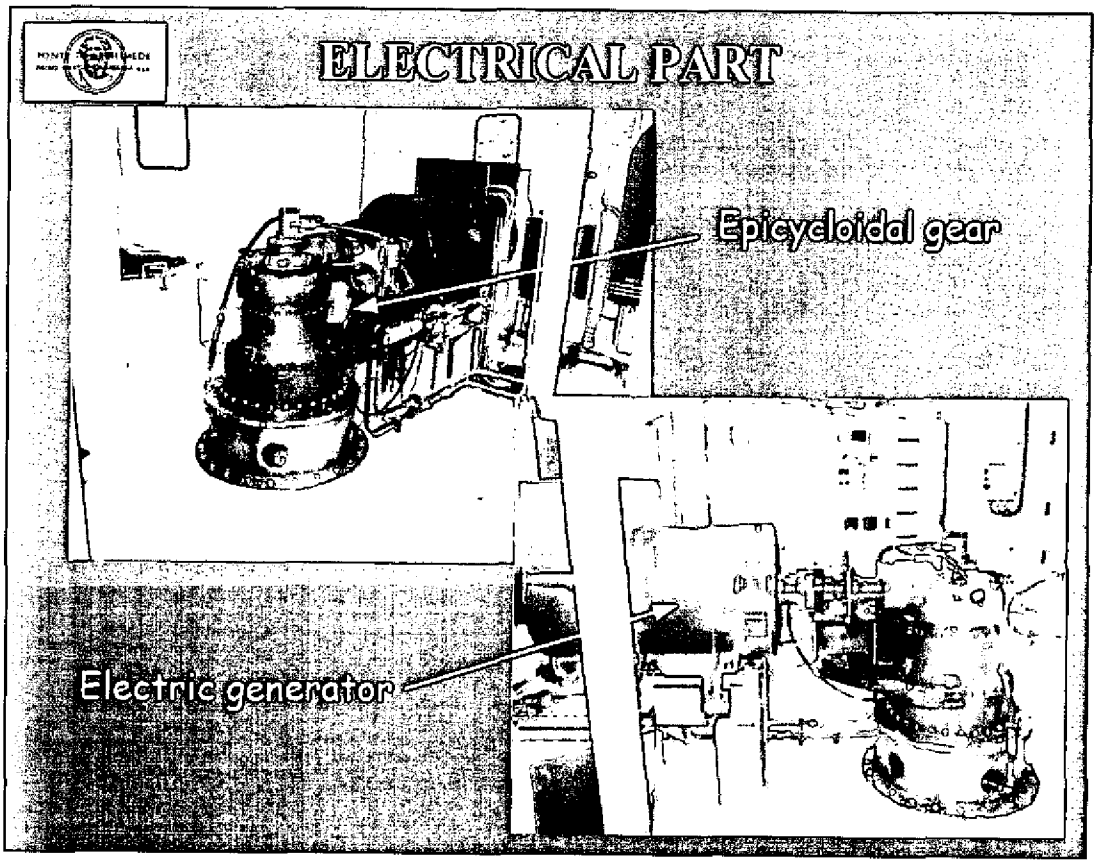
Epicycloidal reduction gear — ratio 90:1

Syncronous generator (brushless 3-phase) — 120 kW at 1500 rpm

Electric load (floodlights, purely ohmic) — 20 lights, 1 kW each

It is also present, as electric load, a 380 V / 30 kW "fire-fighting" water pump.





RESULTS

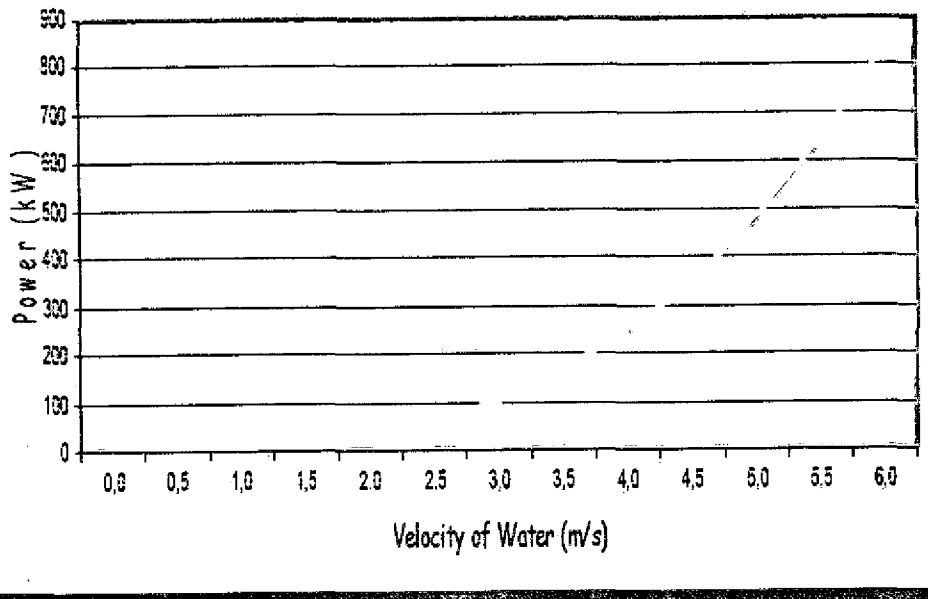
- The tests were carried out in a range of current velocity between 1 and 2 m/s.
- The global net efficiency, defined as :

$$\eta = \frac{\text{Electric Power}}{\frac{1}{2}\rho S V^3}$$

inclusive of electric and mechanical losses, was estimated in roughly 25%.

- At 2 m/s the power produced was about 25 - 30 kW

THE KOBOLD POWER POTENTIAL

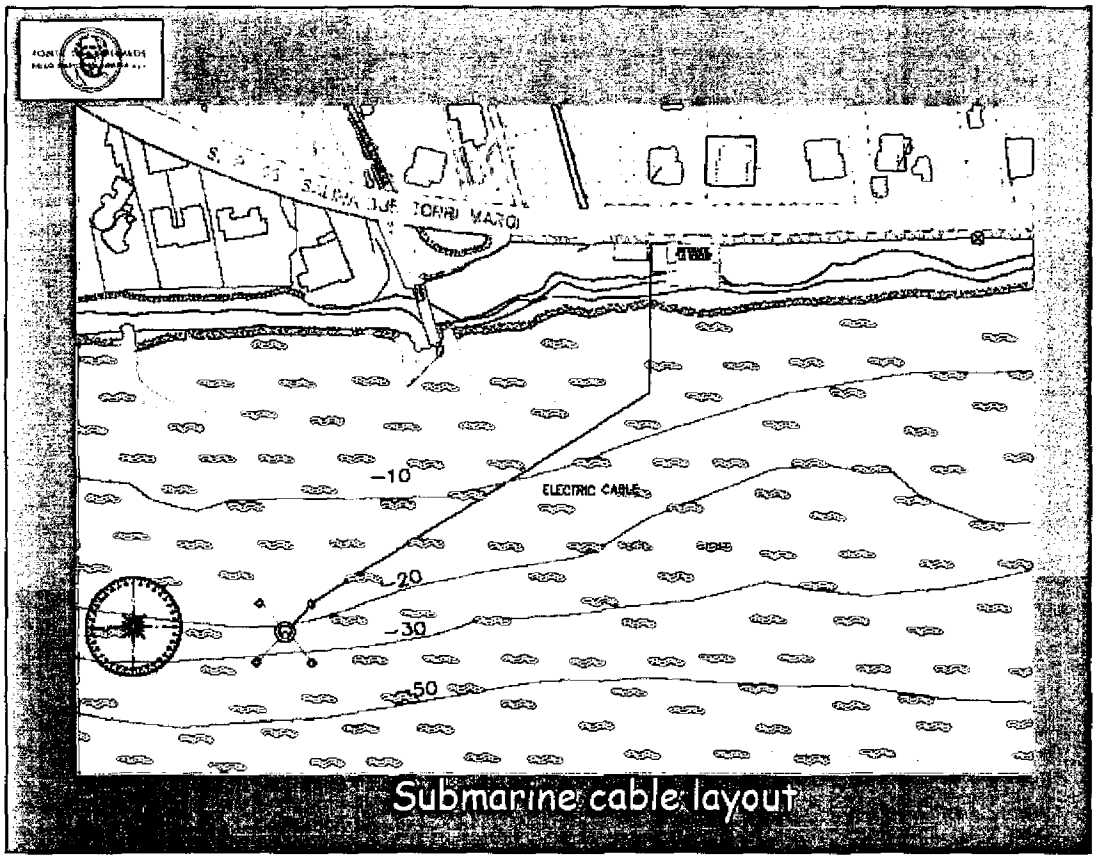


CONNECTION TO THE ELECTRICAL GRID

In the first phase the energy was used on board for experimental purposes, giving power to the floodlights and to the "fire-fighting" pump.

The latest works on the turbine consisted in connecting the plant to the electric grid by means of a submarine cable, and in adapting the electrical plant in order to meet the grid requirements.

The KOBOLD turbine is the 1st marine current turbine to be connected to a national electricity grid.



Submarine cable layout

FUTURE IMPROVEMENTS

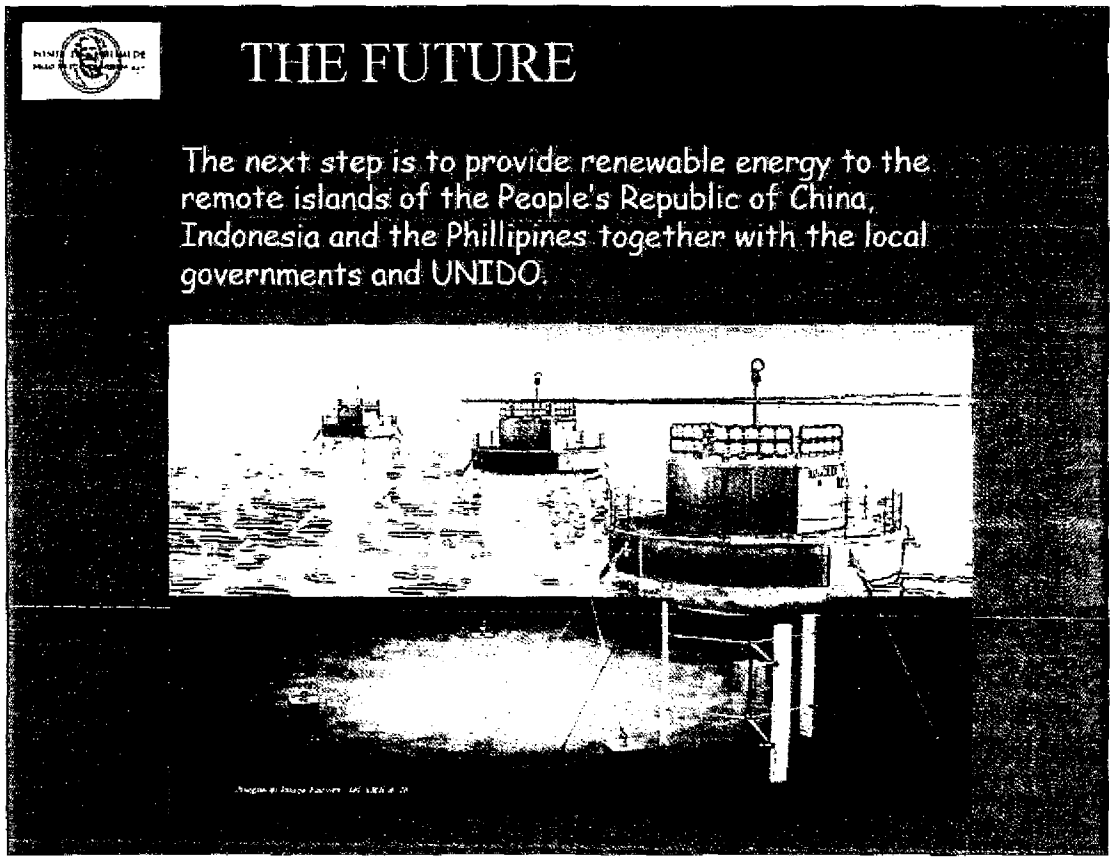
- Improve platform stability

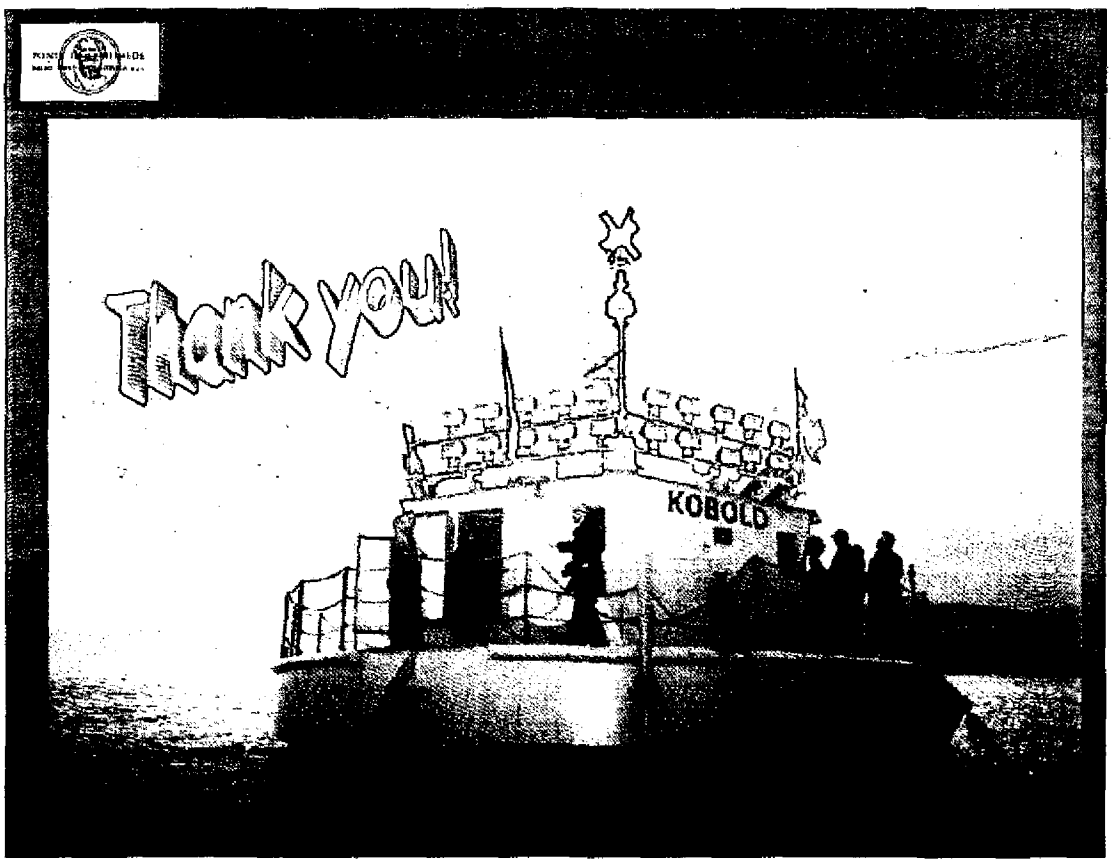
Actually, since the turbine generates a thrust of about 10 t, the platform is working with a trim of 5° - 6° which has negative effects on the global efficiency of the system.

- Numerical and experimental studies of a new configuration of the Kobold turbine with new tests in wind tunnel (Politecnico di Milano), in towing tank (INSEAN, Rome) and in hydrodynamic tunnel (REVMA, Messina).

- Study and installation of a modular *Power Farm*.

- Study of a new kind of direct driven electric generator.


THE FUTURE
The next step is to provide renewable energy to the remote islands of the People's Republic of China, Indonesia and the Phillipines together with the local governments and UNIDO.


Thank you!
KOBOLD

Statement from the Vice President of Ponte di Archimede

In 1994 the Ponte di Archimede Company submitted the first Kobold turbine project to the General Directorate of Research of the European Commission. The Commission financed an initial study to ensure the viability of the turbine. In 1996 the Company participated in a call launched by the Commission for the "Synergy Program" aimed at creating a collaborative effort with the People's Republic of China in the field of renewable energy. Cooperation was started with the Chinese Academy of Sciences through the Institute of Energy Conversion of Guangzhou. In 1997 saw personal participation in the delegation to the Philippines led by the European Commissioner for Energy, who was guest of honour at Conference of the ASEAN Ministers of Energy. 2003 saw the Italian Embassy in Manila present the initiative of the Ponte di Archimede to the local UNIDO office, from where it was brought to the attention of the head office in Vienna.
The present regional project for the Philippines, Indonesia and People's Republic of China was given the go ahead from Vienna and was co-financed by the Italian Foreign Affairs Ministry whilst we patented the turbine.

We then contacted large European electric groups (EdF and ENEL) and, with the promotional support provided by the UNIDO, we consolidated the collaboration between Ministers of Research and Technology and the research institutes of the participating Countries. In the target countries we visited some of the industries that could contribute to the production of the Kobold turbines, operational and research activities therefore being carried out simultaneously.

We have had assurances that by the end of September the Italian Foreign Affairs Ministry will approve the second phase of the UNIDO regional project involving the installation of the Kobold prototypes in the Philippines, Indonesia and People's Republic of China. The first phase was successfully concluded after the three meetings of the participating Countries held in Jakarta (23.2.2005), in Gunagzhou (25.4.2005) and Manila (28.4.2005) respectively. We have been also in contact with the Ministry of Foreign Trade in the People's Republic of China and Italy and with national (SIMEST) and international financial institution (GEF)

for the installation of pilot plants.

There has also been the participation in meetings and talks in Brussels on renewable energies. There is yet to be the approval by the European Commission on important programs relating to the support of marine current projects, with which we are planning to take part in along with our Asian partners.

Scientific and Political Support Towards the ENERMAR Technology in the People s Republic of China

Stefano Zirilli

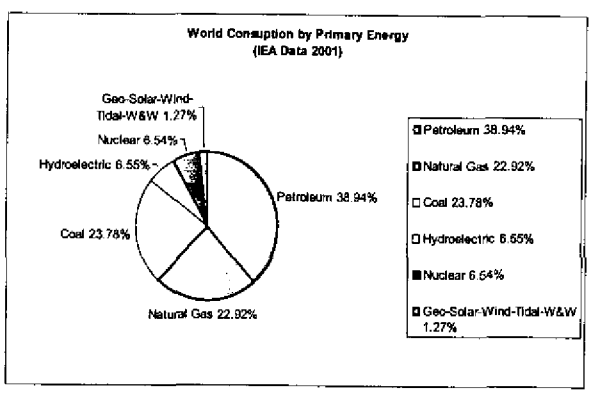
During my duty in China the bilateral project on the Exploitation of Marine Currents for Energy Production was one of the best projects ever applied, both for the innovation content and the potentiality for sustainable social and economic development.

The World Consumption by primary Energy (next graph) clearly shows that the diffusion of the renewable energy is not yet enough. Only 8% was provided by renewable energy in 2001 and despite the overall increase of their use the magnitude of that share remains quite small.

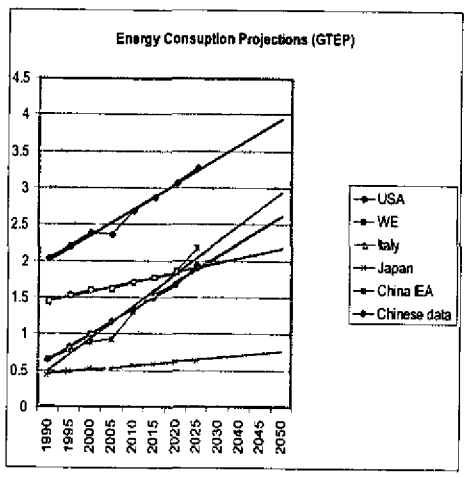
advice that it is of particular importance to promote the adoption of environmentally friend primary energy sources in countries such as China.

In fact its huge economic development (about 10% per year), needs, owing to the still high energy intensity of the economy (in 2002 it was 0.83 OEKg/$ compared to 0.31 of the USA), a huge amount of energy.

The projections show that China will overcome WE consumption in the next 15 years.



The distribution of the World consumption and its increasing tendency (next graphs) For

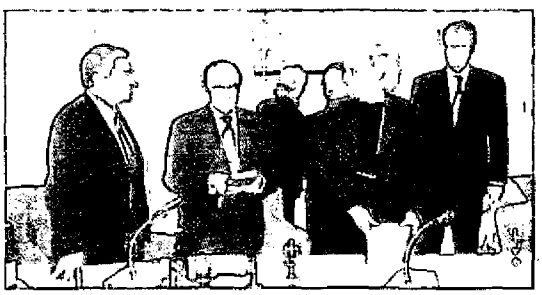


these reasons the spreading in China of the ENERMAR Technology was included in the promotional activities of the S&T Office of the Italian Embassy in Beijing.

The technology was presented to the Chinese Authorities in the Workshop on Sino-Italian Joint Application for the EU Sixth Framework Program. Beijing, 24-25 September 2002 (next picture)

Among the others the Ambassador of Italy HE Paolo Bruni, the Vice- Minister of MOST Liu Yinhua and the President of the Archimedes Bridge Company Mr. Elio Matacena participated to the workshop.

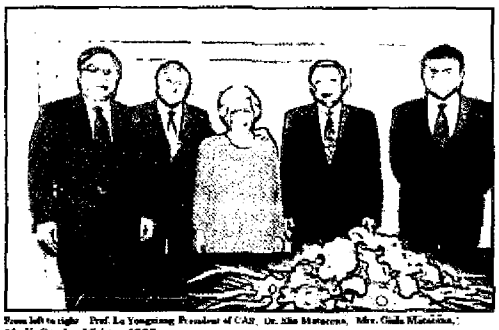
The project was then included in the XI Session of the Sino Italian Protocol for the cooperation on S&T (next picture) as The Study on the Hydrodynamic Characteristics of the Kobold turbine.
Another project on a technology owned by the Archimedes bridge Company on the study of the submerged floating bridge was included in the Protocol too. The



Delegations for the Protocol headed by the Vice Minister of MOFA Margherita Boniver and by the Vice Minister of MOST Ma Songde also underlined the importance of the establishment with the participation of the Chinese Academy of Sciences of the Matacena Foundation with the purpose of promoting bilateral cooperation and exchange in Geosciences.

The entrepreneurial spirit of Dr. Matacena was really appreciated by Chinese Authorities, who decided to confer to him the prestigious 2003 Award for International cooperation (next picture).

The relations between Italy and China received a great benefit from Mr. Matacena's contribution. The picture was taken after a dinner in honor of the Matacenas hosted by Minister of S&T Xu Guanghua, and the President of CAS Lu Yongxiang.



From left to right: Prof. Lu Yongxiang, President of CAS; Dr. Elio Matacena; Mrs. Giulia Matacena; Mr. Xu Guanhua Minister of S&T

I consider a privilege to have had the opportunity to cooperate with him in China and I felt my duty to come here and share with you the review of Mr. Matacena's engagement in China.

SECTION II - Country Inputs

Renewable Energy Programs and Policies in China

By Zhi YU1,[3], Baoshan LI[2] and Dongmei CHEN[3]

1. Sun Yat-sen University, Guangzhou, China
2. Ministry of Science and Technology, Beijing China
3. Expert Group of National Hi-Tech Program, Beijing China

RENEWABLE ENERGY RESOURCES AND DEVELOPMENT IN CHINA

The use of renewable energy resources plays a key strategic role in maintaining balance between energy supply and demand in China, and the Chinese government has therefore consistently promoted renewable energies.

BIOMASS ENERGY

Main biomass resources in China are agricultural wastes, scraps from forestry and forest product industries, and municipal waste. Agricultural wastes are widely distributed. Among them, annual production of crop stalks surpasses 600 million tons and crop stalks suitable to energy production are estimated to represent a potential of 12,000 PJ annually. Wastes from the processing of agricultural products and manure from livestock farms in theory could yield nearly 80 billion cubic meters of biogas. Scraps from forestry and forest product industries represent a resource equivalent to 8,000 PJ per annum.

With the implementation of Chinese Natural Forest Protection Program (which includes logging bans and logging reductions over much of the nation's natural forests) and its Sloping Cropland Conversion Program (which calls for the conversion of much of the nation's sloping cropland to trees and grasses), it is expected that the amount of scraps from forestry and forest product industries used in energy application will increase substantially, with the potential of reaching 12,000 PJ per annum by 2020. Municipal waste in China is expected to reach 210 million tons per annum in 2020, if 60 percent of which is used in landfill methane applications, two to ten billion cubic meters of methane could be produced.

At present, there are more than 12 million household biogas digesters and 1,500 industrial-scale biogas plants in China, which together could produce over five billion cubic meters of biogas annually.

Furthermore, energy crops become a biomass

energy resource with the potential for commercialization. There are many types of energy crops suitable to growing in China, most among are rapeseed and other edible oil plants and some plants growing in the wild, such as sumac, Chinese goldthread, and sweet broomcorn. By 2020, such crops could potentially yield over 50 million tons of liquid fuel annually, including over 28 million tons of ethanol and 24 million tons of bio-diesel. In sum, whether burned directly for electricity production or used as substitute liquid fuel, biomass energy resources have the potential for playing a decisive role in energy supply of China.

In terms of biomass liquefaction technology, China is in an investigative and experimental phase. Currently the main technologies developed and in use are ethanol fuel technology and bio-oil technology.

Io China has already established two large ethanol fuel production bases, one in the north and one in the south, with a total annual production capacity of over one million tons.

o Alcohol production from cellulose, supported by the National High-Tech R&D Program, will be established for demonstration by end of 2005. Interim production line of active char has been constructed. The whole process and technology for alcohol production from cellulose with capacity of 600 tons per year could be developed.

o The National High-Tech R&D Program funded demonstration project of alcohol production from sorgo stalks with capacity of 5000 tons annually has been established and now in the producing stage.

o Bio-oil production has reached about 50,000 tons annually.

Biomass power generation in China, with an installed capacity of almost 2,000 MW, consists mainly of combined heat and power in sugar mills and power generation using rice husks. Other types of biomass power generation, such as biomass gasification for power generation technology supported by National High-tech Research and Development Program, has been promoted to Thailand, Burma and Taiwan, etc., with total capacity of 20MW.

WIND POWER

There are abundant wind resources in large land mass and long coastline are in China. According to estimates of China Meteorology Research Institute, land-based exploitable wind resources represent a potential power generation capacity of 253 GW (at height of ten meters above the ground). The institute has further estimated ocean-based wind resources to represent an exploitable potential of about 750GW, so the total estimated wind power potential in China reach over 1,000GW. Rich wind resources area are located mainly along the southeast coast and nearby islands and northeast, northwest and north of China. Apart from this, there are also rich wind resources in some interior areas. China has large marine areas and ocean-based wind resources are plentiful. With current technology, wind turbines can be installed in the ocean up to 10 kilometers away from the coast and at ocean depths of up to 20 meters.

By the end of 2004, total grid connected installed capacity of wind power in China was 730MW, as showed in table 1. Aside from grid-connected installations, China also has about 200,000 stand-alone small-scale wind turbines with installed capacity of 25MW, which provide electricity to rural household located in remote areas.

China has basically acquired the manufacturing technology of large-scale wind turbines of 750kW or less and is in the process of develop-

ing MW-scale wind turbines, which are expected to be available by the end of 2005.

As it's shown in Table 1, there are 43 wind farms operated in China by the end of 2004, the capability of wind farm operation and management has been improved greatly and the qualified technical personnel in wind power design and construction has been developed as well, which established the sound base for large-scale development of wind power in China.

No.	Name ofW ind Farm	W TG	kW
01	Dabancheng No.2	157	82800
02	Huitengxile	94	68500
03	Nan'ao	130	56690
04	Kelan	65	55250
05	Yuemen	74	52200
06	Dali Chifeng	73	51360
07	Xianrendao Yingkou	47	31660
08	Tongyu	49	30060
09	Dabancheng No.1	58	28000
10	Fuji	27	24300
11	Chengde	40	24000
15	Donggang	38	22450
13	Haiyanghong Dandong	28	21000
14	Kuocangshan	33	19800
15	Shanwei	25	16500
16	Jino	15	16400
17	Hedingshan	26	14350
18	Huilai	22	13200
19	Changdao	20	12300
20	Mulan	20	12000
21	Kangpeng	12	10200
22	Zhangwu	12	10200
23	Zhangbei	24	9850
24	Faku	12	9600
25	Dongfang	19	8755
26	Hengshan	24	7400
27	Zhurihe	32	6900
28	Pingtan	14	6800
29	Dongshan	10	6000
30	Xilin	13	4750
31	Qikia	9	4700
32	Jinzhou	5	3750
33	Shangdu	12	3600
34	Xiaochangshan Dalian	6	3600
35	Dachangshan Dalian	6	3600
36	Fengxian	4	3400
37	ZhangzidaoD Dalian	12	3000
38	Nanhui	1	1500
39	Alataw Shankou	2	1200

Table 1 Cumulative Wind Power Installation in China by the end of 2004

SOLAR ENERGY

China has extremely rich solar energy resources. According to estimates, the total solar radiation hitting China's land area annually is 5*1022J, equivalent to about 170 billion tons of coal equivalent (tce). Based on the distribution of the total radiation hitting China's land surface, it can be seen that Tibet, Qinghai, Xinjiang, the southern part of Inner Mongolia, Shanxi, northern Shaanxi, Hebei, Shandong, Liaoning, western Jilin, the middle and southwest part of Guangdong, the southeastern parts of Fujian, the eastern and western parts of Hainan, and the southwest part of Taiwan all receive a relatively large amount of solar radiation. In particular, areas on the Qinghai-Tibetan Plateau receive the largest amount of solar radiation in China. The distribution of China's solar energy resources is listed in table 2.

Currently, the main use of solar energy in China is the supply of hot water to urban and rural households. The cumulative installed capacity of solar water heaters now surpasses 60 million square meters of collector area. The total installed capacity in 2020 and 2050 could reach 270 million and 500 million square meters respectively with the potential to conserve 81 billion kWh in 2020 and 150 billion kWh in 2050. Potential reductions in peak power loads resulting from these installed capacities would be 110GW in 2020 and 200GW in 2050.

Photovoltaic technology is the main technology used in China for electricity power generation from solar energy. PV modules are used in both industrial and commercial applications and provide electricity to remote rural areas and urban lighting applications. At present, the

Class of Area	Illumination Hours Annually h h	Solar Radiation Annually [MJ/(m².a)]	Distributed Areas
A	3200-3300	6700-8370	west of Ningxia, north of Gansu, southeast of Xinjiang, west of Qinghai and west of Tibet
B	3000-3200	5860-6700	Northwest of Hebei, north of Shanxi, north of Inner Mongolia, south of Ningxia, middle of Gansu, east of Qinghai, southeast of Tibet and south of Xinjiang.
C	2200-3000	5020-5860	Beijing, Tianjin, Shandong, Henan, southeast of Hebei, south of Shanxi, north of Xinjiang, Jilin, Liaonin, Yunnan, north of Shaanxi, southeast of Gansu, west of Sichuan, south of Guangdong, south of Fujian, north of Jiangsu, north of Anhui, southwest of Taiwan
D	1400-2200	4190-5020	Hubei, Hunan, Jiangxi, Zhejiang, Guangxi, north of Guangdong, south of Shaanxi, south of Jiangsu, south of Anhui, Heibngjiang, northeast of Taiwan, north of Fujian
E	1000-1400	3350-4190	Sichuan and Guizhou

Table 2 Solar Energy Resources Distribution in China

installed capacity of PV systems in China is over 60MW, 50% percent of which is used for electricity supply to rural areas with annual market growing of 20%.The industrial and commercial PV markets are also relatively stable. Annual production capacity for urban PV lighting systems is over 10MW, accounting for 70% of the world total.

Among all solar energy applications, production of solar thermal equipment, namely solar water heaters, is the first in the world. China now has a solar water heater production capacity of over 16 million square meters per year. PV cell production capacity in China has reached nearly 100MW. Thus, a firm basis for the large-scale development and utilization of solar energy resources in China has been established.

OTHER RENEWABLE ENERGY

Besides biomass energy, wind power and solar energy, which have been developed on a relatively large scale in China, the government of China has been playing close attention to the development and utilization of other new and renewable energy resources, such as geothermal resources, ocean energy sources, and hydrogen. The government has set up several pilot projects and demonstrations in geothermal power generation, wave power generation, geothermal heating and cooling and other areas. Geothermal pumping technology, in particular, has already begun to play a meaningful role in building energy conservation in China.

POLICIES AND ACTIONS TAKEN BY THE GOVERNMENT OF CHINA

POLICY AND LEGISLATION

The Chinese Government has been attaching great importance to the development and utilization of renewable energy for many years. In the 1980s, the State Council issued Several Recommendations on promoting the Development of Rural Energy, which made renewable energy a part of the plans for the development of rural energy and rural electrification. With the maturation of renewable energy power generation technologies, particularly wind power technologies, in 1994, the then Ministry of Power issued Several Recommendations on the Construction and Management of Wind Farms, establishing a firm foundation for wind power in China. In 1999, the Chinese Government issued Several Policy Recommendations on promoting the Development of Renewable Energy, making further progress in removing barriers to the development of renewable energy. In 2003, the Government sets about formulating its Renewable Energy Law and formally promulgates it in February, 2005. The goals of this law are to: (1) confirm the important role of renew-

able energy in China's national energy strategy; (2) remove barriers to the development of the renewable energy market; (3) create market space for renewable energy; (4) set up a financial guarantee system for the development of renewable energy; and (5) create a social atmosphere conducive to renewable energy. The whole content of Renewable Energy Law of China is attached as annex 1.

STRATEGIC PLANS AND DEVELOPMENT TARGETS

The Government of China has formulated its Medium and Long-term Energy Development Strategy and Plan to 2020. The basic principles of the energy strategy and plan related with renewable energy are as follows:

o Support the harmonious development of society, the economy, and the environment, with priority on the development of renewable energy technologies that are closely related with the realization of the goal, a basic level of comfort for all citizens in China. These technologies include PV, small hydropower and other renewable energy technologies, which can supply the basic electricity needs in rural areas. This principle also call for improvement in the quality of energy used by rural residents, which can be achieved through biomass energy technologies, particularly biogas technology, which can promote the development of ecological agriculture and organic food products.

o Stress should be put on the development of Small Hydropower, solar water heaters, geothermal heating and other renewable energy technologies that are already competitive on the market. The share of renewable energy in overall energy consumption should be raised as rapidly as possible, so as to make a strong contribution to the adjustment of Chinese energy consumption mix.

o The commercialization of renewable energy technologies should be promoted actively. In particular, wind power and biomass power generation, which have vast resources and bright prospects on commercialization and can play a very important role in improving energy structure of China, should be promoted through adoption of necessary measures to stimulate market demand, technical progress, and growth of manufacturing capability.

o Long-term technical progress should be integrated with short-term development and utilization. Renewable energy technologies that have both a market at present and great potential for the future should be actively developed. PV technology should be developed so as to serve in speeding up the realization of rural electrification in the short term and to accumulate technical results for large-scale grid-connected PV in the future. Ethanol gasoline and bio-diesel technologies should be developed through pilots and demonstration projects in the short-term to establish the necessary basis for future development and strategies and technologies for long-term development should be pursued, so as to realize large-scale use and the supplementing of insufficient petroleum supply in China.

The strategy for renewable energy development in the Government's energy plan calls for making use, by 2020, of most of the available resources for small hydropower, solar thermal (i.e. solar water heaters), geothermal, and other renewable energies that are already competitive on the market. It further calls for actively promoting the commercialization and development of related manufacturing capacity for wind power, biomass power generation, and solar energy-based power generation, so as to basically realize full commercialization and large-scale application by 2020. Specific target for renewable energy, as indicated in the Government's energy strategy and plan, are as follows:

o Power generation: By 2010, renewable energy installed capacity for power generation will reach 60GW in total and account for about 10% of total installed power generation capacity in China, of which 50GW for small hydropower, 4GW for wind power, 6GW for biomass power and 450MW for power generated from solar energy. By 2020, renewable energy installed capacity for power generation will reach 121GW, accounting for 12% of total installed power generation capacity in China, of which 80GW for small hydropower, 20GW for wind power, 20GW for biomass power and 1GW for power generated from solar energy.

o Gas supply: By 2010, 9600 big biogas projects and 1000 centralized gas station using straw and stalks will supply gas to 40million residents. By 2020, 16000 big biogas projects and 2000 centralized gas station using straw and stalks will supply gas to 70million residents.

o Heat supply: By 2010, collector area of solar heaters will reach 140 million square meters, heat supply area by geothermal energy will reach 25 million square meters and hot water supply to households by geothermal energy will reach 600 thousand. By 2020, collector area of solar heaters will reach 270 million square meters, heat supply area by geothermal energy will reach 50million square meters and hot water supply to households by geothermal energy will reach 1.1million.

o Liquid fuel: alcohol and bio-diesel production from agricultural straw and stalks and energy crops will have capacity of 4 million tons liquid fuel to substitute for petroleum annually by 2010 and 8 million tons liquid fuel annually by 2020.

RENEWABLE ENERGY ACTIVITIES AND PROGRAMS

The Chinese Government has undertaken a series of national activities and programs in order to promote the development and utilization of renewable energy, including the Comprehensive Rural Energy Planning and Construction Program; the Rural Electrification Program, pilots of which focus on the development of small hydropower; the Brightness Program; the Township Electrification Program, and the Wind Power Concession Program. Particularly in recent years, the Brightness Program, the Township Electrification Program, the Wind Concession Program, and the Government Bond Wind Power Program, have raised the development of renewable energy industry in China to a much higher level than before.

COMPREHENSIVE RURAL ENERGY PLANNING AND CONSTRUCTION PROGRAM

Starting in the 1980s, the Chinese Government began rural energy construction work that focused on renewable energy. The main work areas were in promoting energy efficient stoves, rural biogas digesters, fuel wood forests, and solar energy. The results of the energy efficient stove and rural biogas digester components were particularly outstanding. At present, the coverage of energy efficient stoves in Chinese rural areas is over 95%. Biogas work has moved from merely resolving energy needs to be a key component in the development of ecological agriculture and rural sanitation. Biogas has created the development mechanisms of "pigs, biogas and fruit", and "greenhouses, biogas, raising pig and planting vegetable". It has promoted the economic development of the countryside and improved the ecological level of agriculture. Since commencement of the twenty-first century, the Chinese Government has been investing over one billion RMB to build rural biogas digesters, with emphasis on providing these subsidies to biogas work in western region of China, thus benefiting the development of renewable energy in rural areas.

RURAL ELECTRIFICATION PROGRAM

Use of small hydropower to achieve rural elec-

trification is a major characteristic of renewable energy development in China. In the 1950s, the Chinese Government began to develop small hydropower in rural areas. In 1980s, the Government launched rural electrification pilot projects with focus on small hydropower. At present, there are over 600 counties, which accounting for 30% of total counties in China, rely mainly on small hydropower for electricity. Each year, the Chinese Government invests 300 million RMB in small hydropower development to attract additional investments from local governments, enterprises and individuals of over 100 billion RMB. The total installed capacity of small hydropower in China is now 30GW. To create synergies with the Sloping Cropland Conversion Program and the Western Development Program, the Chinese Government is in the midst of formulating a plan to substitute small hydropower development to power generated by fuel wood in rural areas of western China, and thus improving the ecological environment and promoting economic development.

BRIGHTNESS PROGRAM

In 1996, the former State Planning Commission formulated and put forward the Brightness Program. The aim of the program was to provide 23million rural residents, whom have no access to electricity, with daily power generated from PV modules and wind power systems. One target of the program was providing average 100W per person in such area, which is equivalent then to overall average installed power generation capacity per capital. The Brightness Program is not like other projects. It serves the widely dispersed population of 23 million farmers and pastoralists with access to electricity. These people are spread out over nearly half of Chinese land area. A substantial proportion of them suffer from poverty. Thus, the Brightness Program is a project that addresses poverty alleviation, large in land scale and relatively big in investment. According to estimates, the total investment in equipment and services needed to achieve the goals of the program is about ten billion RMB. Implementation is focused on the provinces in Western China with special support to Xinjiang, Inner Mongolia, Gansu, Qinghai and Tibet. At present, four provinces have established Brightness Program project companies to develop projects associated with the program. The program has attracted the attention of the world outside. The Government of Holland is supporting in Xinjiang the "Silk Road" Brightness Program. The German Government has given technical and financial support to the Brightness Program in Yunnan, Qinghai, Inner Mongolia and other areas.

TOWNSHIP ELECTRIFICATION PROGRAM

In 2002, in order to meet the power need of public utilities and residents of un-electrified townships in remote, border regions in Western China, the National Development and Reform Commission initiated the Township Electrification program.

1,065 townships encompassed in the program are spread across 12 provinces, including Inner Mongolia, Qinghai, Gansu, Sichuan, Tibet and Shaanxi, among which, 688 were targeted for PV power station construction with total installed capacity of 20MW. The first phase of the program included 585 townships with total installed capacity of 17MW and the rest 103 townships were listed in the second phase with installed capacity of 3MW. Small hydropower stations were planned for 377 townships with installed capacity of 264MW, among which, 114 were included in the first phase with installed capacity of 90MW and the rest 263 were in the second phase with installed capacity of 174MW. At present, major PV stations have been constructed and are generation power now and major planned hydropower stations are in the process of construction.

Article 6-Energy authorities of the State Council are responsible for organizing and coordinating national surveys and management of renewable energy resources, and work with related departments to establish technical regulations for resource surveys.

Relevant departments of the State Council, within their respective authorities, are responsible for related renewable energy resource surveys. The survey results will be summarized by the energy authorities in the State Council.

The result of the survey of renewable energy shall be released to the public, with the exception of confidential contents as stipulated by the Government.

Article 7-Energy authorities of the State Council sets middle and long-term target of the total volume for the development and utilization of renewable energy at the national level, which shall be implemented and released to the pubic after being approved by the State Council.

Energy authorities of the State Council shall, on the basis of the target of total volume in the previous paragraph, as well as the economic development and actual situation of renewable energy resources of all provinces, autonomous regions and municipalities, cooperate with people's governments of provinces, autonomous regions and municipalities in establishing middle and long-term target and release it to the public.

Article 8-Energy authorities of the State Council shall, on the basis of the middle and long-term total volume target of renewable energy throughout the country, prepare national renewable energy development and utilization plan, which is to be implemented after being approved by the State Council.

Energy authorities of the people's governments at the level of province, autonomous region and municipality shall, on the basis of the middle and long-term target for the development and utilization of renewable energy, cooperate with relevant authorities of the people's governments at their own level in preparing national renewable energy development and utilization plan for their own administrative regions, which shall be implemented after being approved by people's governments at their own level.

The approved plan shall be released to the public, with the exception of confidential content as stipulated by the government.

In case that the approved plan needs to be modified, approval of the original approving authorities shall be obtained.

Article 9-In preparing the plan for the development and utilization of renewable energy, opinions of relevant units, experts and the public shall be solicited and the scientific reasoning shall be done.

CHAPTER 3 INDUSTRY GUIDANCE AND TECHNOLOGY SUPPORT

Article 10-Energy authorities in the State Council shall, in accordance with the national renewable energy development plan, prepare and promulgate development guidance catalogs for renewable energy industries.

Article 11-Standardization authorities of the State Council shall set and publicize technical standard for renewable energy electric power and the technical standards for relevant renewable technology and products for which technical requirements need to be standardized at the national level.

For those technical requirements not dealt with

in the national standard in the previous paragraph, relevant authorities of the State Council may establish relevant industrial standard, which shall be reported to the standardization authorities of the State Council for filing.

Article 12-The government lists scientific and technical research in the development and utilization of, and the industrialized development of, renewable energy, as the preferential area for hi-tech development and hi-tech industrial development in the national program, and allocates funding for the scientific and technical research, application demonstration and industrialized development of the development and utilization of renewable energy so as to promote technical advancement in the development and utilization of renewable energy, reduce the production cost of renewable energy products and improve the quality of products.

Education authorities of the State Council shall incorporate the knowledge and technology on renewable energy into general and occupational education curricula.

CHAPTER 4 PROMOTION AND APPLICATION.

Article 13-The Government encourages and supports various types of grid-connected renewable power generation.

For the construction of renewable energy power generation projects, administrative permits shall be obtained or filing shall be made in accordance with the law and regulations of the State Council.

In the construction of renewable power generation projects, if there is more than one applicant for project license, the licensee shall be determined through a tender.

Article 14-Grid enterprises shall enter into grid connection agreement with renewable power generation enterprises that have legally obtained administrative license or for which filing has been made, and buy the grid-connected power produced with renewable energy within the coverage of their power grid, and provide grid-connection service for the generation of power with renewable energy.

Article 15-The Government supports the construction of independent renewable power systems in areas not covered by the power grid to provide power service for local production and living.

Article 16-The Government encourages clean and efficient development and utilization of biological fuel and encourages the development of energy crops.

If the gas and heat produced with biological resources conform to urban fuel gas pipeline networks and heat pipeline networks, enterprises operating gas pipeline networks and heat pipeline networks shall accept them into the networks.

The Government encourages the production and utilization of biological liquid fuel. Gas-selling enterprises shall, on the basis of the regulations of energy authorities of the State Council or people's government at the provincial level, include biological liquid fuel conforming to the national standard into its fuel-selling system.

Article 17-The Government encourages workplaces and individuals in the installation and use of solar energy utilization systems of solar energy water-heating system, solar energy heating and cooling system and solar photovoltaic system, etc.

Construction authorities of the State Council shall cooperate with relevant authorities of the

State Council in establishing technical economic policies and technical standards with regard to the combination of solar energy utilization system and construction.

Real estate development enterprises shall, on the basis of the technical standards in the previous paragraph, provide necessary conditions for the utilization of solar energy in the design and construction of buildings.

For buildings already built, residents may, on the condition that its quality and safety is not affected, install solar energy utilization system that conform to technical standards and product standards, unless agreement has been otherwise reached between relevant parties.

Article 18-The Government encourages and supports the development and utilization of renewable energy in rural areas.

Energy authorities of local people's governments above the county level shall, on the basis of local economic and social development, ecological protection and health need, etc., prepare renewable energy development plan for the rural area and promote biomass energy like the marsh gas, etc. conversion, household solar energy, small-scale wind energy and small-scale hydraulic energy, etc.

People's government above the county level shall provide financial support for the renewable energy utilization projects in the rural areas.

CHAPTER 5 PRICE MANAGEMENT AND FEE SHARING

Article 19-Grid power price of renewable energy power generation projects shall be determined by the price authorities of the State Council in the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable, where timely adjustment shall be made on the basis of the development of technology for the development and utilization of renewable energy. The price for grid-connected power shall be publicized.

For the price of grid-connected power of renewable power generation projects determined through tender as stipulated in the 3rd paragraph of Article 13 hereof, the bid-winning price shall be implemented; however, such a price shall not exceed the level of grid-connected power of similar renewable power generation projects.

Article 20-The excess between the expenses that power grid enterprises purchase renewable power on the basis of the price determined in Article 19 hereof and the expenses incurred in the purchase of average power price generated with conventional energy shall be shared in the selling price. Price authorities of the State Council shall prepare specific methods.

Article 21-Grid connection expenses paid by grid enterprises for the purchase of renewable power and other reasonable expenses may be included into the grid enterprise power transmission cost and retrieved from the selling price.

Article 22-For the selling price of power generated from independent renewable energy power system invested or subsidized by the Government, classified selling price of the same area shall be adopted, and the excess between its reasonable operation, management expenses and the selling price shall be shared on the basis of the method as specified in Article 20 hereof.

Article 23-The price of renewable heat and natural gas that enters the urban pipeline shall be determined on the basis of price management

authorities in the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable.

CHAPTER 6 ECONOMIC INCENTIVES AND SUPERVISORY MEASURES

Article 24-The Government budget establishes renewable energy development fund to support the following:

1. Scientific and technological research, standard establishment and pilot project for the development and utilization of renewable energy;
2. Construction of renewable energy projects for domestic use in rural and pasturing areas;
3. Construction of independent renewable power systems in remote areas and islands;
Surveys, assessments of renewable energy resources, and the construction of relevant information systems;
4. Localized production of the equipment for the development and utilization of renewable energy.

Article 25-Financial institutions may offer preferential loan with financial interest subsidy to renewable energy development and utilization projects that are listed in the national renewable energy industrial development guidance catalogue and conform to the conditions for granting loans.

Article 26-The Government grants tax benefits to projects listed in the renewable energy industrial development guidance catalogue, and specific methods are to be prepared by the State Council.

Article 27-Power enterprises shall authentically and completely record and store relevant materials of renewable energy power generation, and shall accept the inspection and supervision of power supervisory institutions.

Power supervisory institutions shall do the inspection in accordance with stipulated procedures, and shall keep commercial secret and other secret for inspected units.

CHAPTER 7 LEGAL RESPONSIBILITIES

Article 28-If energy authorities of the State Council and the people's governments above the county level as well as other relevant authorities breach this Law and have one of the following, people's government of their own level or relevant authorities of the superior people's governments may order them to make correction, and impose administrative penalty for competent personnel that are liable and other personnel directly liable; in case that such breaches constitute crime, criminal liabilities shall be legally pursued.

1. Failure to make administrative licensing decision in accordance with law;
2. Failure to make an investigation when illegal activities are discovered;
3. Other acts of not legally performing supervision and management responsibilities.

Article 29-If the power grid enterprises breach Article 14 hereof and fail to purchase renewable power in full, which results in economic loss to the renewable power generation enterprises, such power grid enterprises shall be liable for compensation, and the national power supervisory institutions shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than the economic loss of the renewable power generation enterprises shall be imposed.

Article 30-In case that enterprises of natural gas pipeline network and heat pipeline network breach paragraph 2 of Article 16 hereof and do not permit the connection of natural gas and heat that conform to the grid connection technical standard into the network, which results

in economic loss to the gas and heat production enterprises, relevant enterprises shall be liable for compensation, and energy authorities of the people's government at the provincial level shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than said economic loss shall be imposed against them.

Article 31-If gas-selling enterprises breach paragraph 3 of Article 16 hereof and fail to include biological liquid fuel that conforms to the national standard into its fuel-selling system, which results in economic loss to the biological liquid fuel production enterprises, relevant enterprises shall be liable for compensation, and energy authorities of the State Council or people's government at the provincial level shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than said economic loss shall be imposed against them.

CHAPTER 8 MISCELLANEOUS

Article 32-Terms used herein shall have the following meanings:

Biomass energy: means energy converted from natural plants, dejecta as well as urban and rural organic waste.

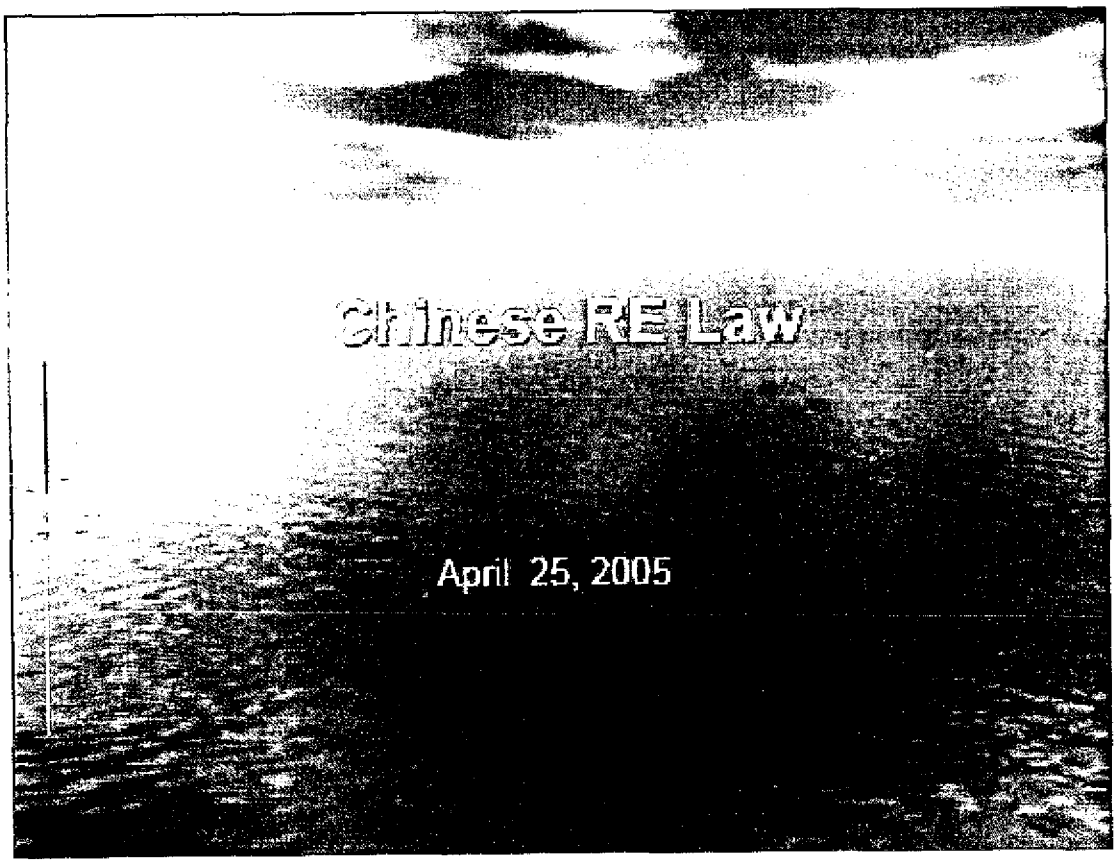
Renewable energy independent power system: means independent renewable power system not connected to the power grid.

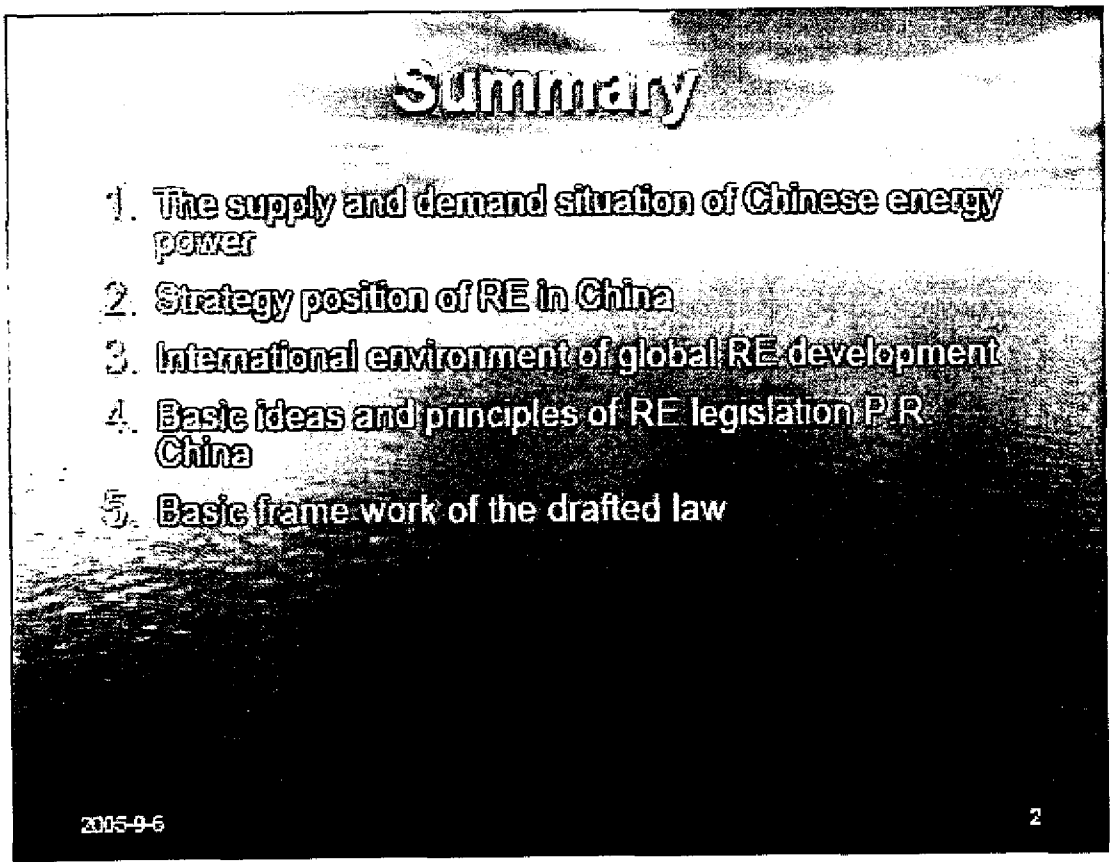
Energy crop: means herbage and wood plants specially planted and used as raw materials of energy.

Biological liquid fuels: means methanol, ethanol, bio-diesel and other liquid fuels derived from biomass resources.

Article 33-This Law shall become effective on Jan 1st, 2006.

Presentation - Policy China


Chinese RE Law
April 25, 2005


Summary
1. The supply and demand situation of Chinese energy power
2. Strategy position of RE in China
3. International environment of global RE development
4. Basic ideas and principles of RE legislation P.R. China
5. Basic frame work of the drafted law
2005-9-6
2

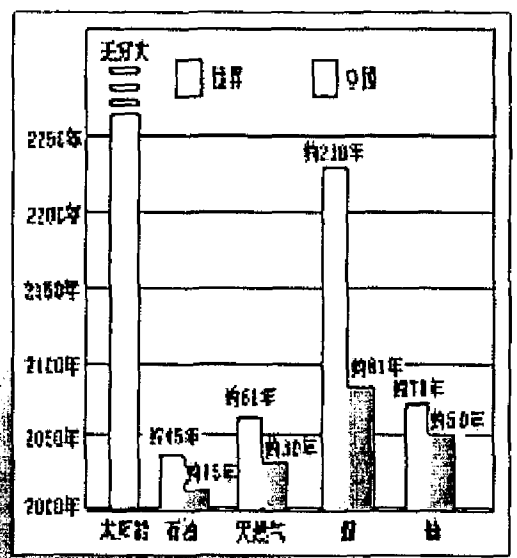
Part 1
The Supply And Demand Situation of Chinese Energy Power

- Comparison of energy resource characteristics between China and other countries
- Status of energy production and consumption
- Main conflicts and problems
- Situation analysis of energy supply and demand in 2020

2005-9-6 3

Comparison of Energy Resource Characteristics Between Chinese and Other Countries

- The capacity of resource discovered is 823 G TEC. Rest capacity which can be exploited is 139 G TEC.
  The periods of exploiting rest resources are 80 years for coal, 15 years for petrol and 30 years for nature gas.
- Main part of Chinese energy resources is coal. China is lack of petrol and nature gas, but with abundant of hydro power.
- In China, the per capita energy resource is less than that of global average.



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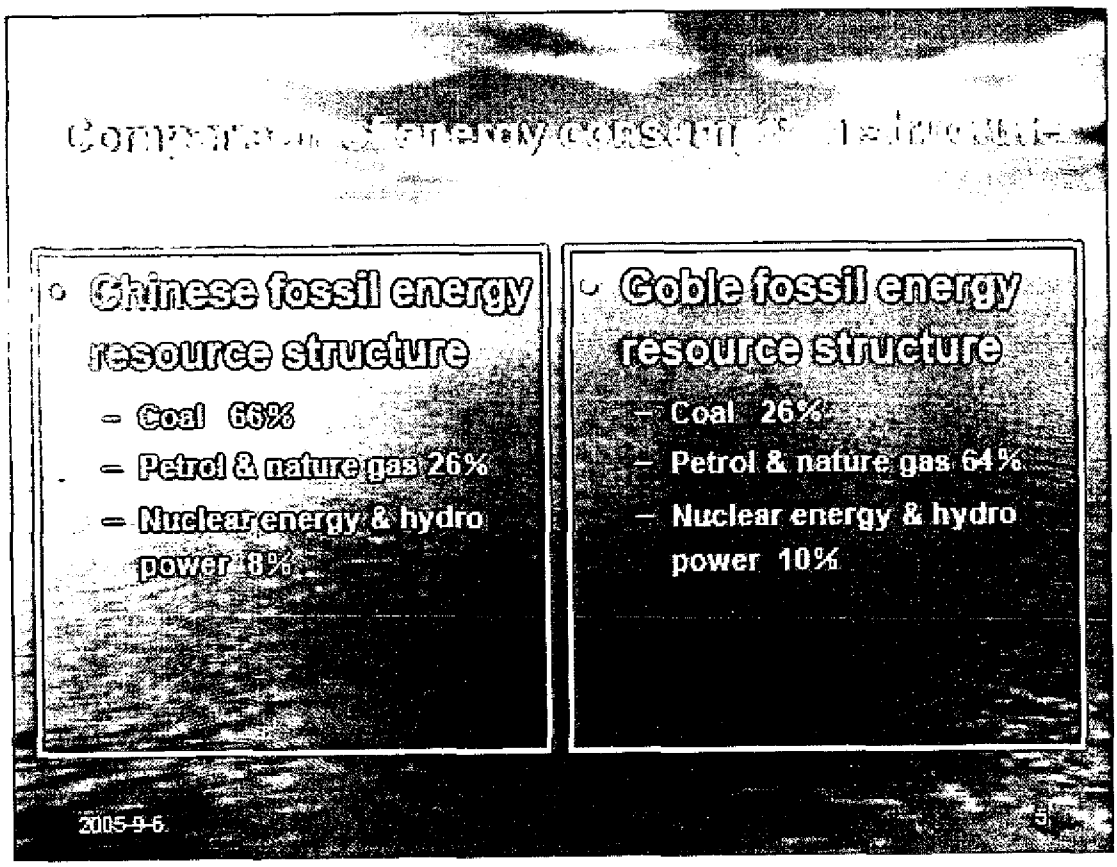
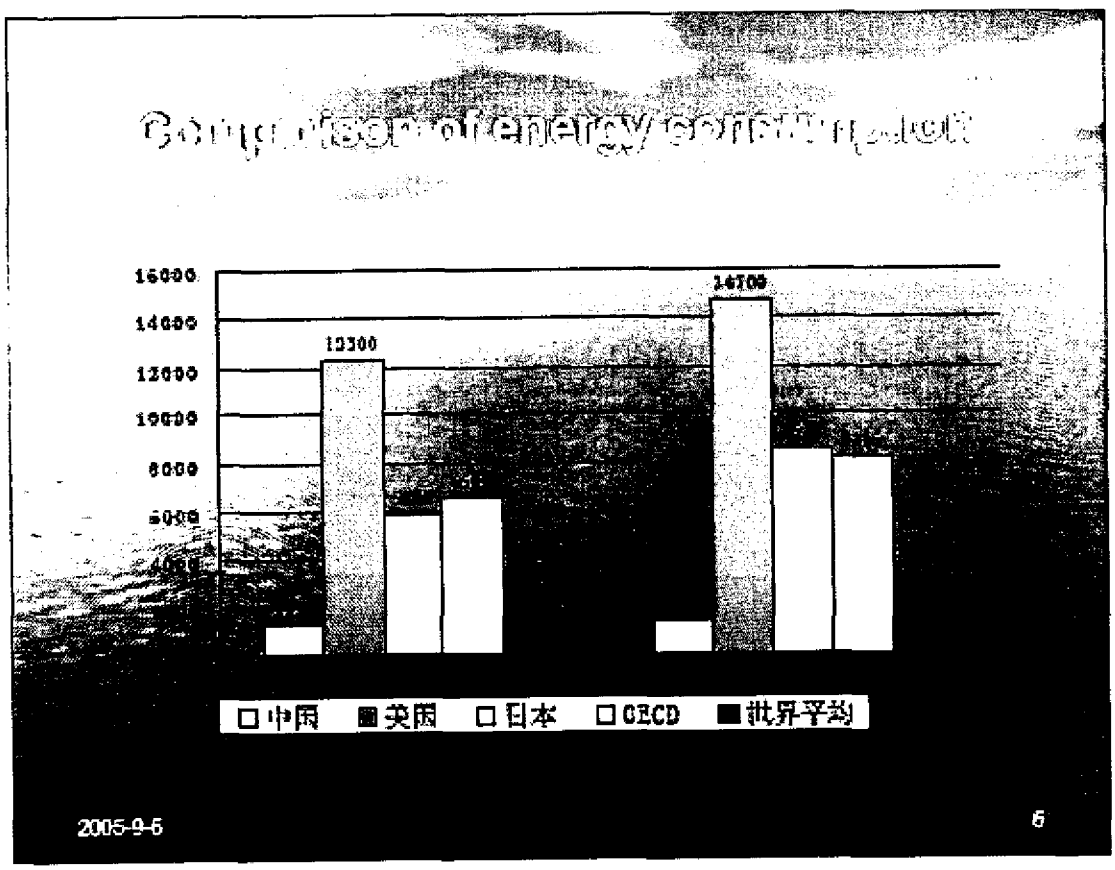

Chinese fossil energy resource structure
– Coal 66%
– Petrol & nature gas 26%
– Nuclear energy & hydro power 8%
Goble fossil energy resource structure
– Coal 26%
– Petrol & nature gas 64%
– Nuclear energy & hydro power 10%
2005-9-6


16000
14000
12000
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6000
4000
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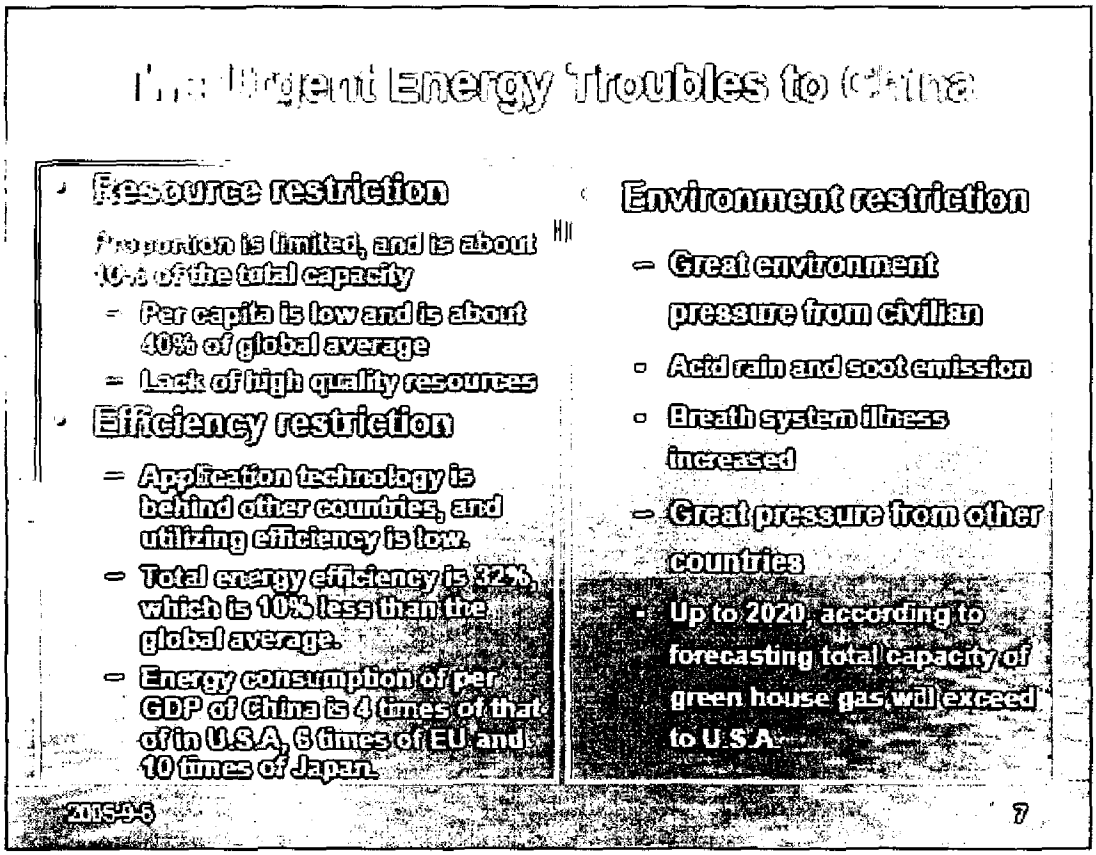
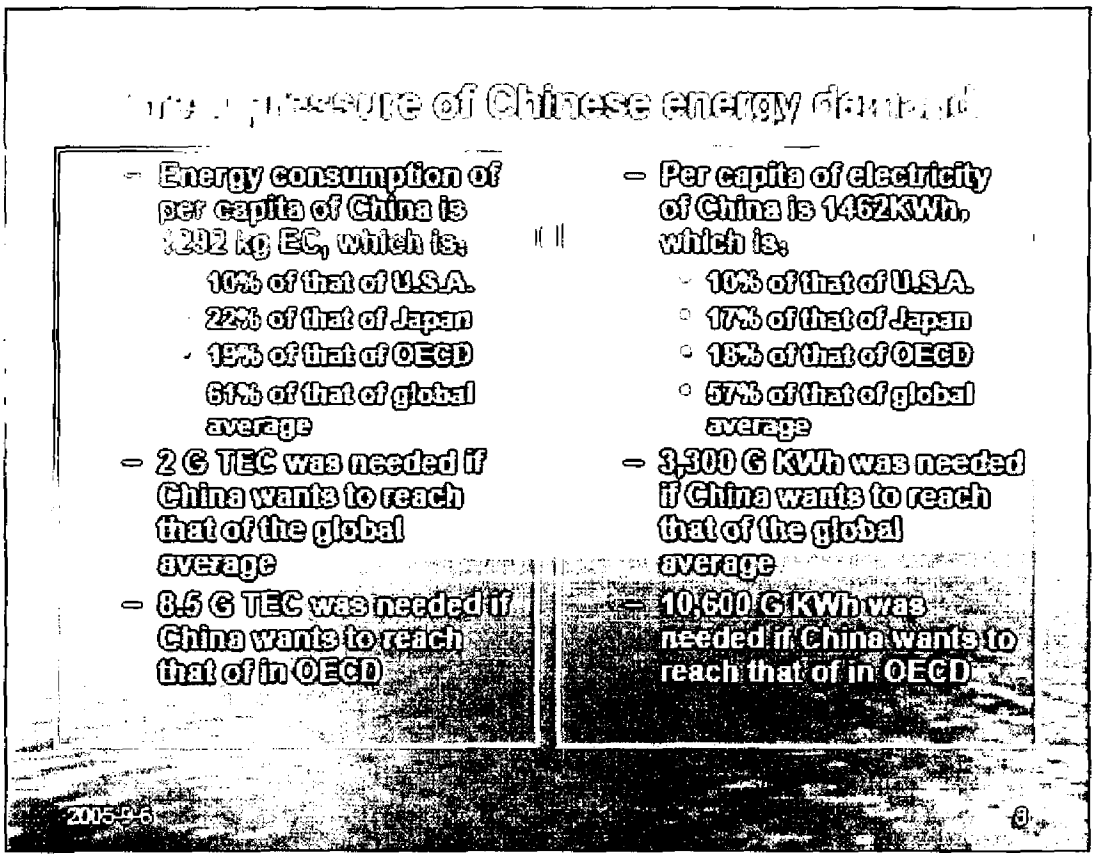
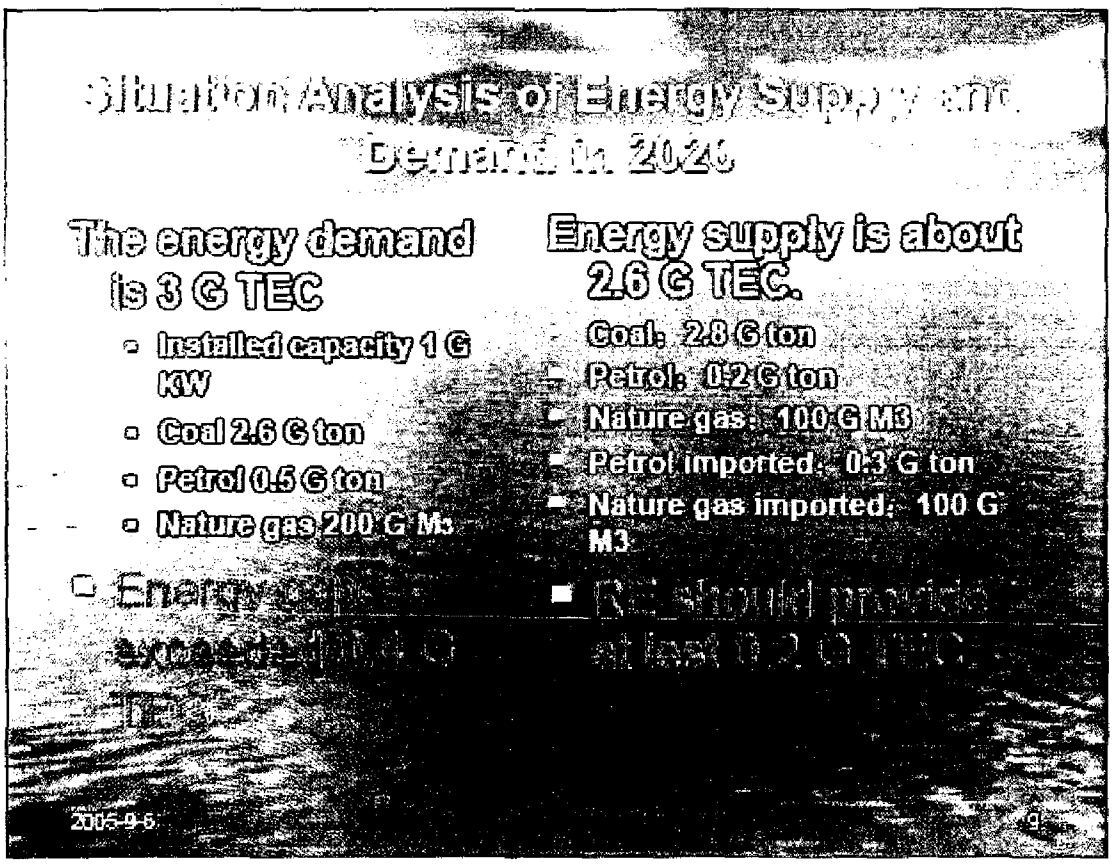
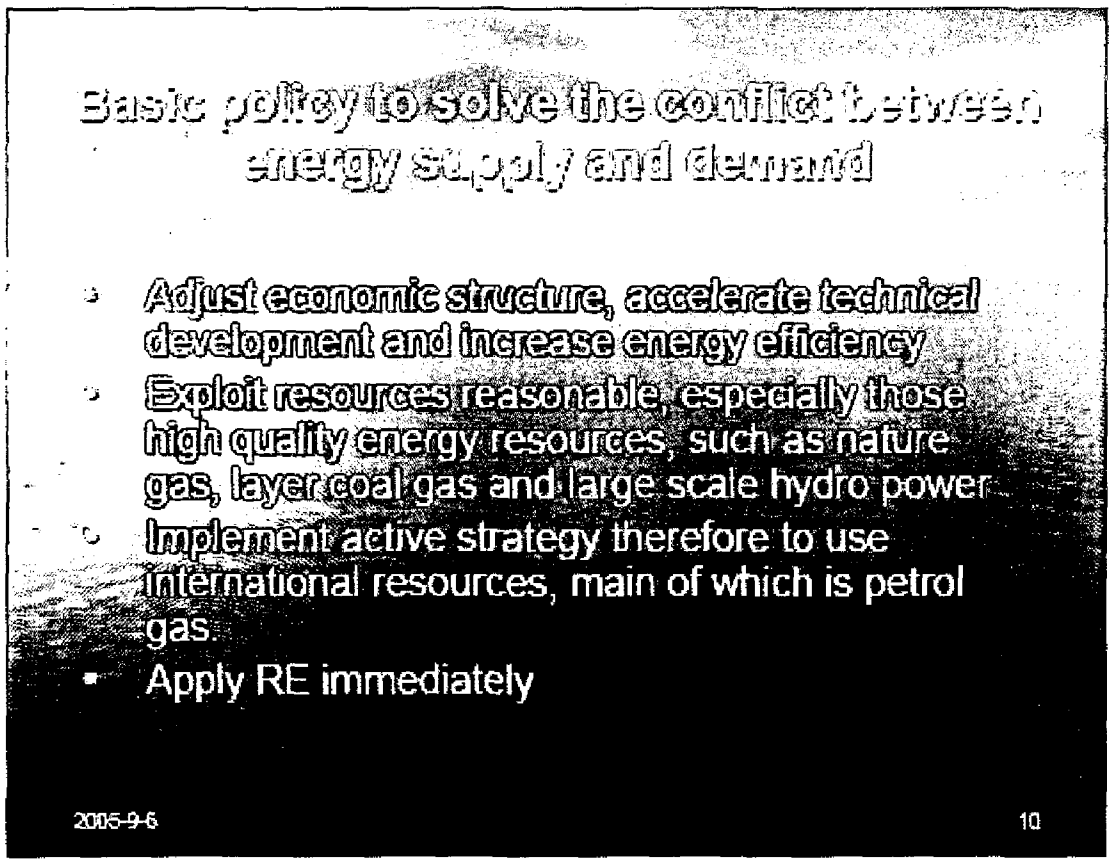
14709
□中国 ■美国 □日本 □OECD ■世界平均
2005-9-6
6


The Urgent Energy Troubles to China
Resource restriction
Proportion is limited, and is about 10% of the total capacity
Per capita is low and is about 40% of global average
Lack of high quality resources
Efficiency restriction
Application technology is behind other countries, and utilizing efficiency is low.
Total energy efficiency is 32%, which is 10% less than the global average.
Energy consumption of per GDP of China is 4 times of that of in U.S.A, 6 times of EU and 10 times of Japan.
Environment restriction
Great environment pressure from civilian
Acid rain and soot emission
Breath system illness increased
Great pressure from other countries
Up to 2020, according to forecasting total capacity of green house gas will exceed to U.S.A.
2005-9-5
7


The pressure of Chinese energy demand
Energy consumption of per capita of China is 1292 kg EC, which is,
10% of that of U.S.A.
22% of that of Japan
19% of that of OECD
61% of that of global average
2 G TEC was needed if China wants to reach that of the global average
8.5 G TEC was needed if China wants to reach that of in OECD
Per capita of electricity of China is 1462KWh, which is,
10% of that of U.S.A.
17% of that of Japan
18% of that of OECD
57% of that of global average
3,300 G KWh was needed if China wants to reach that of the global average
10,600 G KWh was needed if China wants to reach that of in OECD
2005-9-5
8


Situation Analysis of Energy Supply and Demand in 2020
The energy demand is 3 G TEC
Installed capacity 1 G KW
Coal 2.6 G ton
Petrol 0.5 G ton
Nature gas 200 G M3
Energy supply is about 2.6 G TEC.
Coal: 2.8 G ton
Petrol: 0.2 G ton
Nature gas: 100 G M3
Petrol imported: 0.3 G ton
Nature gas imported: 100 G M3
2005-9-6


Basic policy to solve the conflict between energy supply and demand
Adjust economic structure, accelerate technical development and increase energy efficiency
Exploit resources reasonable, especially those high quality energy resources, such as nature gas, layer coal gas and large scale hydro power
Implement active strategy therefore to use international resources, main of which is petrol gas
Apply RE immediately
2005-9-6
10

Part 2
Strategy position of RE in China

- The advantages of RE resources
- The technical conditions and practice experiences of RE application
- Strategy status of RE

2005-9-6 11

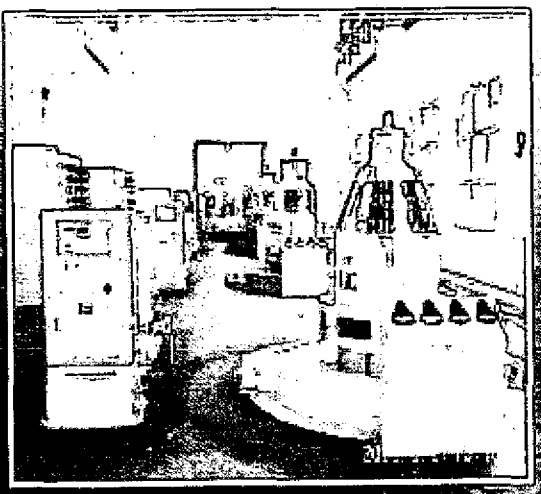
Hydro power resource and strategy status in China

- Total capacity is 0.4 G KW
- Total capacity which can be exploited is 92 MKW
- Annual generation capacity is 285 G KWh
- Installation of 2020 is 0.29 G KW
- Up to 2030, all hydro resource will be exploited and therefore will provide 0.4 G KW

2005-9-6 12

The technology and equipment level of Chinese hydro power

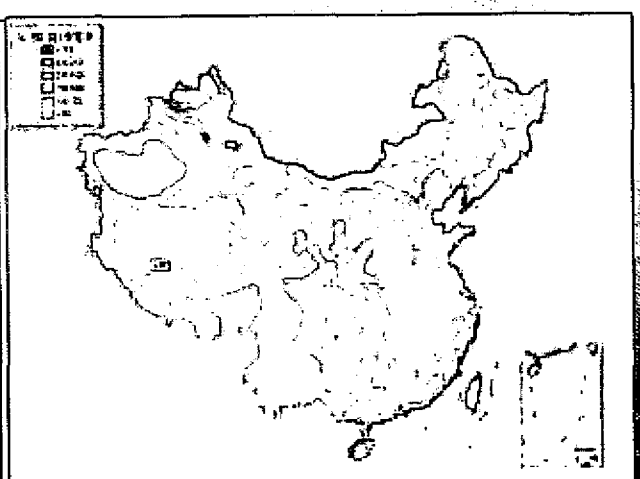
- Excellent ability of design, manufacture and construction
- These technology and equipment has exported to other countries.



2005-9-6 13

Wind power resource situation and strategy status in China

- Total resource capacity is 1 G KW namely is 3 times of that of total generation installation nowadays
- Possible to become the second main electricity resource and replace the status of nuclear energy and hydro power
- Only 0.56GW has been exploited
- By the end of 2020, total capacity will reach 20 GW
- By the end of 2030, it will reach 0.1 G KW



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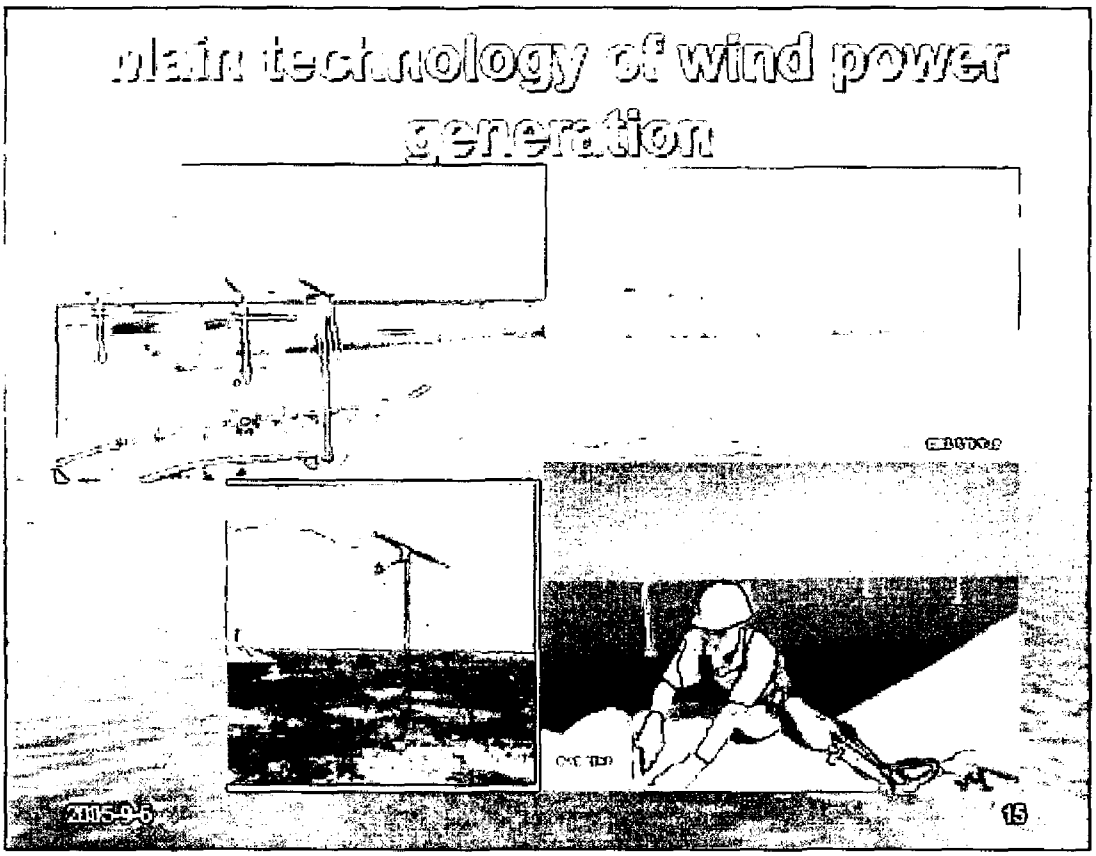
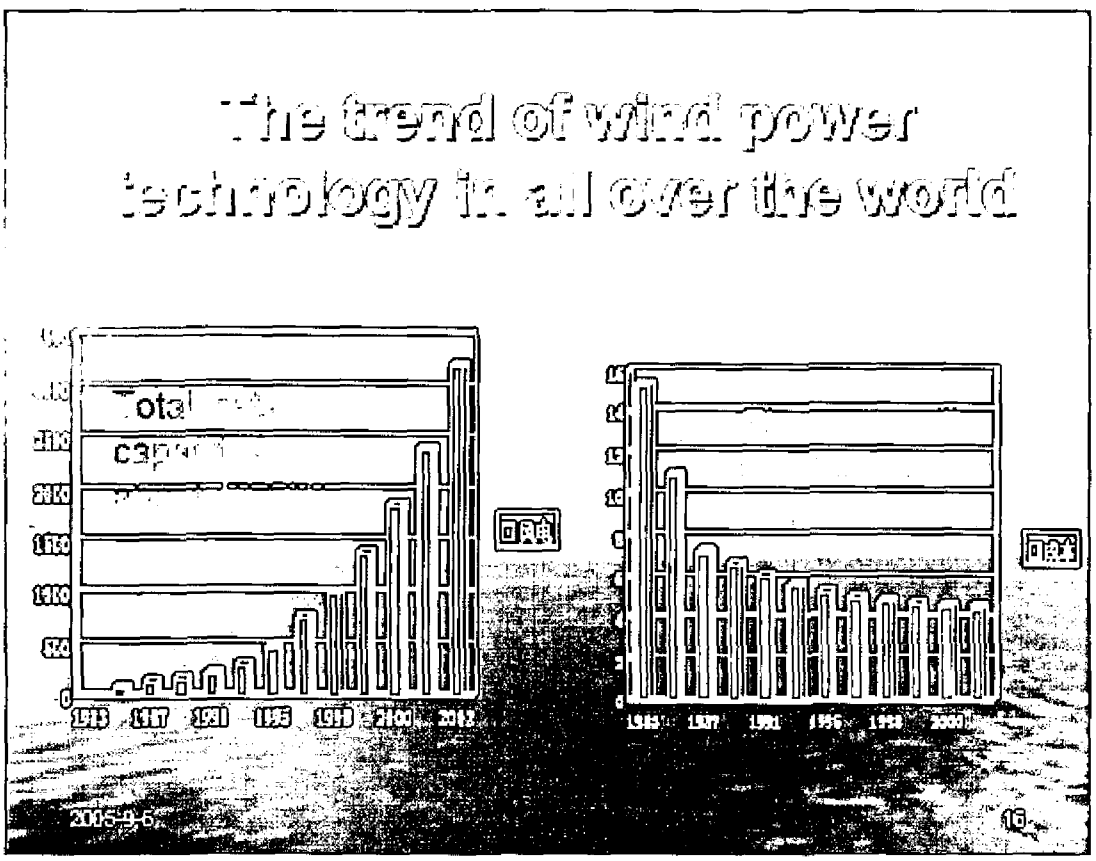
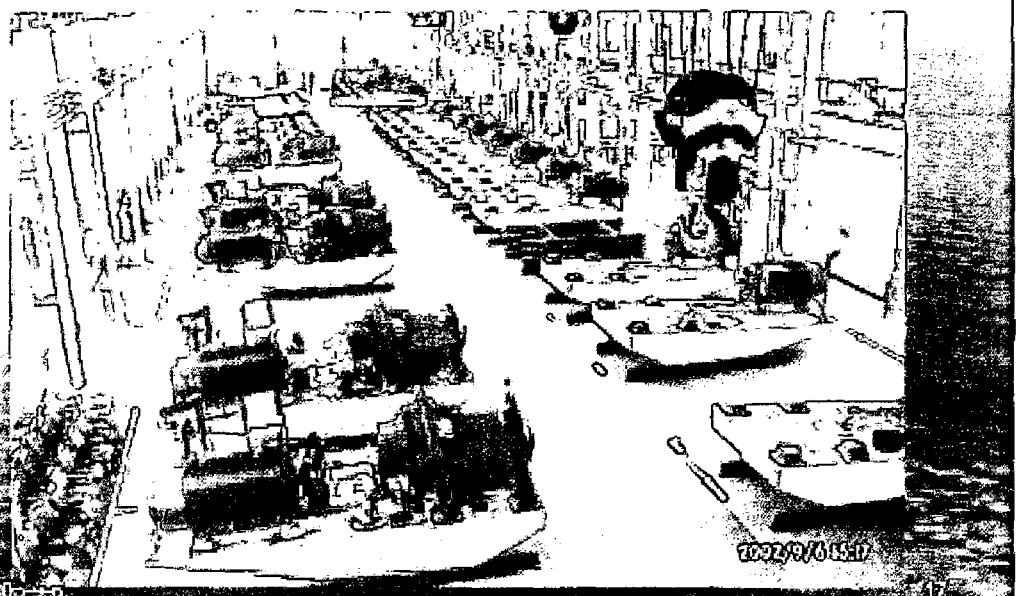

Main technology of wind power generation
15


The trend of wind power technology in all over the world
16

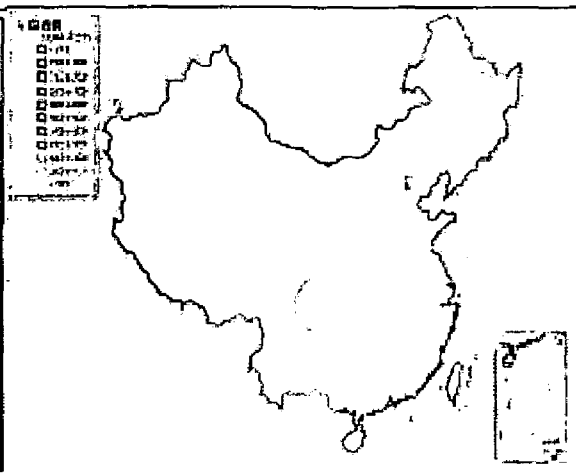
Manufacture industry of wind turbine

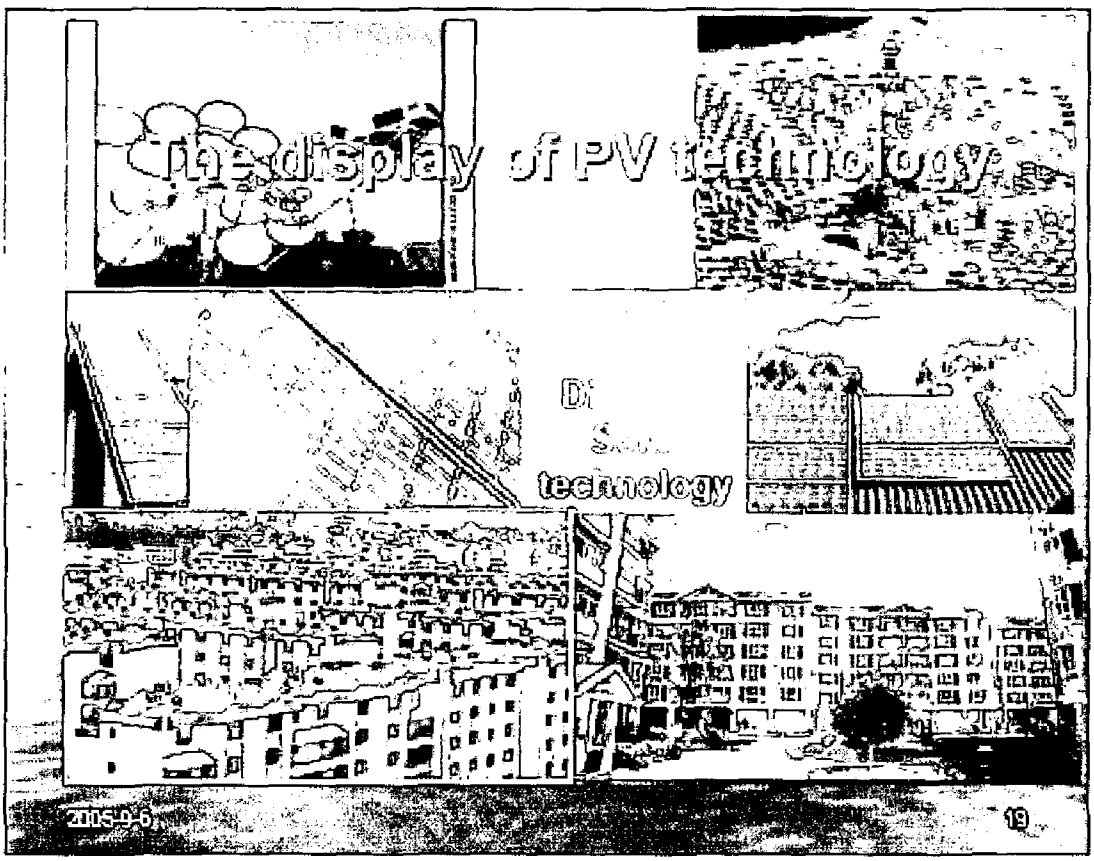
has the ability to produce wind turbine smaller than 750KW



Solar energy resource situation and strategy status in China

- With great potential resource
- The mature technology of heating water
- Photovoltaic technology is under development
- Up to 2020, the installed capacity of water heater will reach 0.27 G M², which can generate 1 GW electric power.
- Up to 2050, the generation capacity will reach 0.1 G KW.




technology
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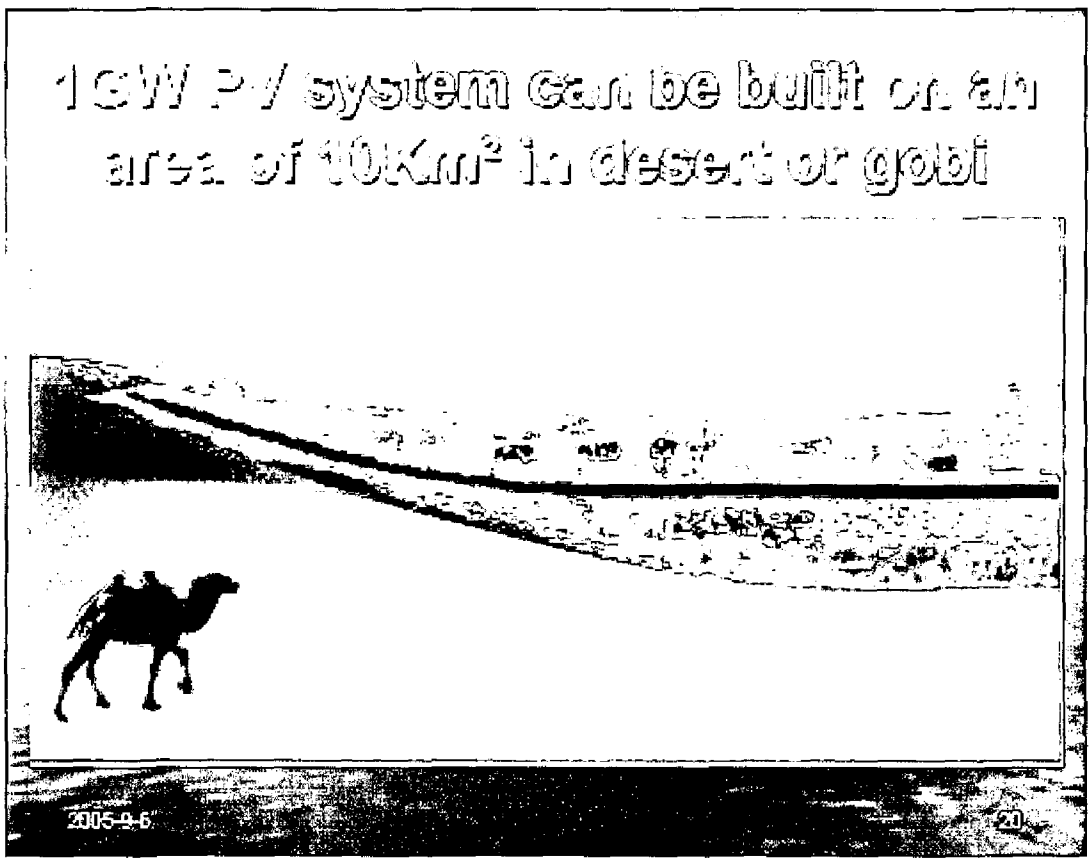
19


1 GW P.V system can be built on an
area of 10Km² in desert or gobi
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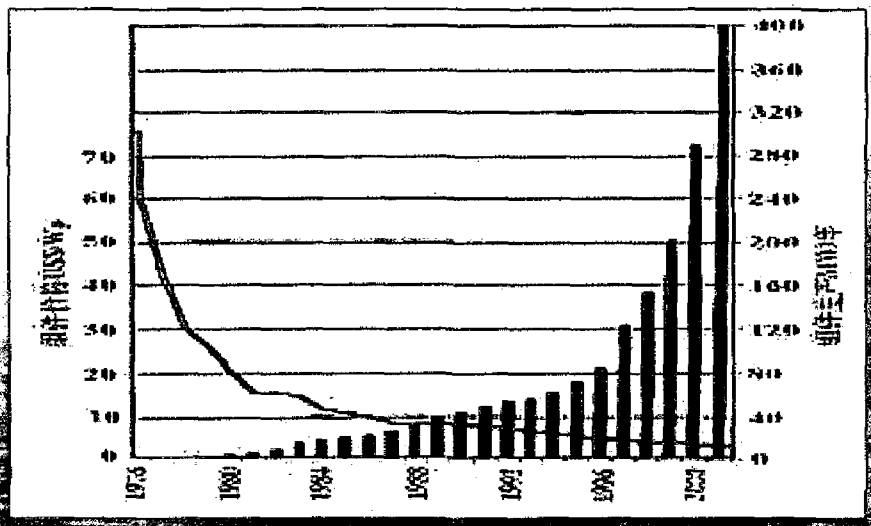
20

The development trend of PV technology

The costs of PV generation may be less than 10 cent /KWh in 2020

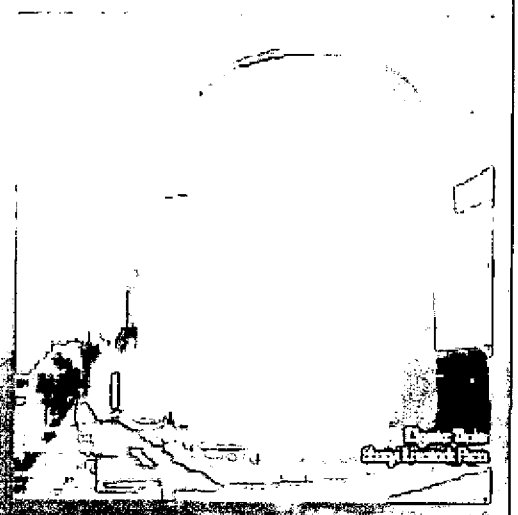


Biomass Energy Resource

- Biomass: 0.6 G ton/year, up to 2020, it is estimated that total capacity will reach 0.8—1 G ton/year.
  - ✓ Agriculture straw: 0.15 G TEC/year
  - ✓ Livestock farm and industry wastewater: 80 G M^3 biogas, 60 M TEC
  - ✓ Fuel wood, forest, timber residue: 0.2 G TEC/year
  - ✓ Land fuel gas: 15 M TEC/year
  - ✓ Energy cope: rapeseed, sweet jowar, sweet potato

The Technical Development and Application Status of Biomass

- Biomass application
  - Biogas: China has the technologies to manufacture all scales of biogas and can utilize 45 G M³ per year.
    - Biogas of household is 13 M units with the capacity of 3.3 G M³
    - Livestock farm and industry wastewater biogas is 2200 units with annual capacity of 1.2 G M³
  - Biomass : 1900MW
    - Bagasse power co-generation: 170MW
    - Rice husk power generation: 50MW
    - Land fuel gas power generation: 150MW
  - Liquid fuel (ethanol): with own ethanol production technology, the production capacity has reached 400,000 ton, and will be 1 M ton in the near future



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The Development Target of RE of China in 2020

- Generation capacity
  - Hydro power: 290GW (small hydro power is 70-80 GW)
  - Wind power: 20GW
  - biomass: 20GW
  - PV: 1GW
- Fuel and thermal application
  - Liquid fuel:11 M ton
  - Biogas:25 G M³
  - Solar water heater:270 M M³
  - Fuel wood: 50 M Mu
- Can provide energy power of 0.4 G TEC

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Conclusion

- RE has played a role in Chinese energy supply, and will become a significant energy resource in the future. By the year of 2020, installed capacity of RE will reach 30% of total power capacity. This proportion will rise to 30% in 2030 and more than 40% after 2030, therefore become an important energy resource to replace convention one.
- RE industry of China has come into being. And some industries have been advanced in whole of the world and began to commercialize. But average level of RE industry of China is still quite low, and without large scale of commercialization ability, therefore need to be supported in a long term.

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Part 3
International Environment of Global RE Development

- International trend of RE development
- The developing situation estimation after Bonn Conference
- Main measures of promoting RE development in whole of the world

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International Development Trend of RE

- Technology improved step by step, costs declined continuously
- Developing accelerated, market share enlarged
- Strategy status of RE rise step by step from complementary energy to alternative energy and then to strategic energy

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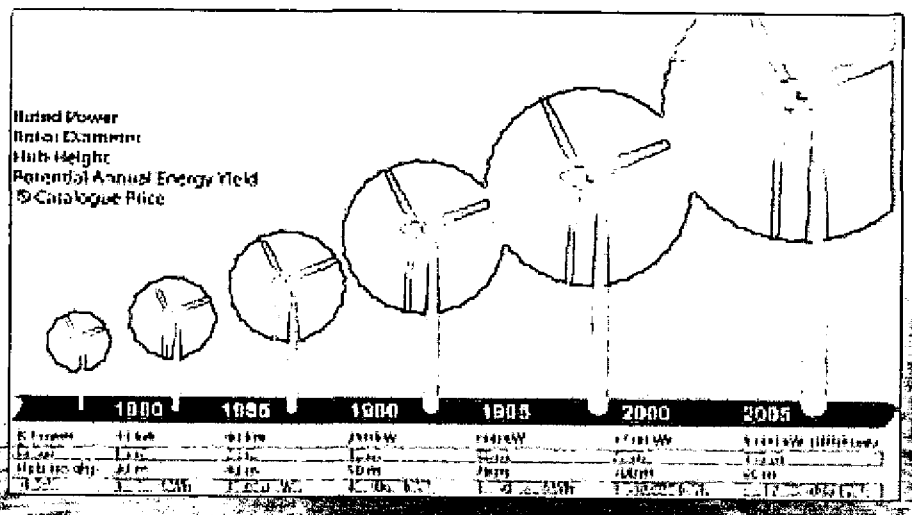
International Development Trend of RE



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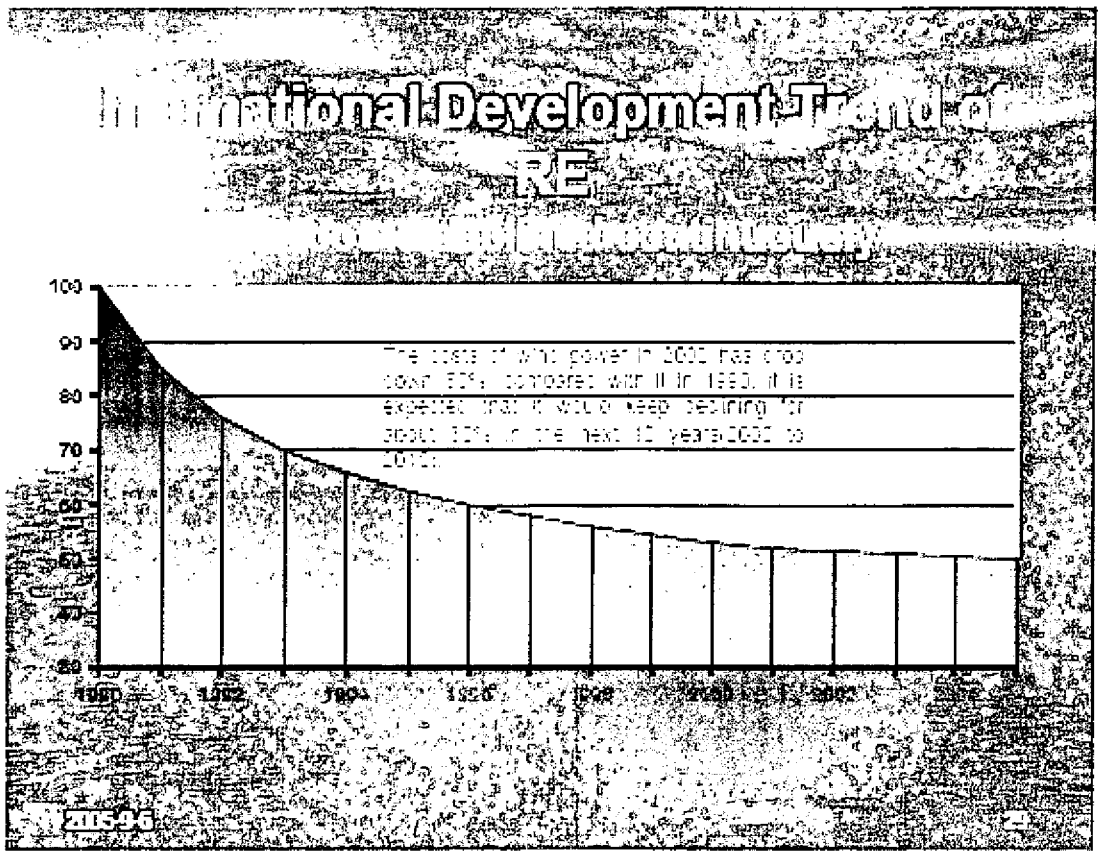
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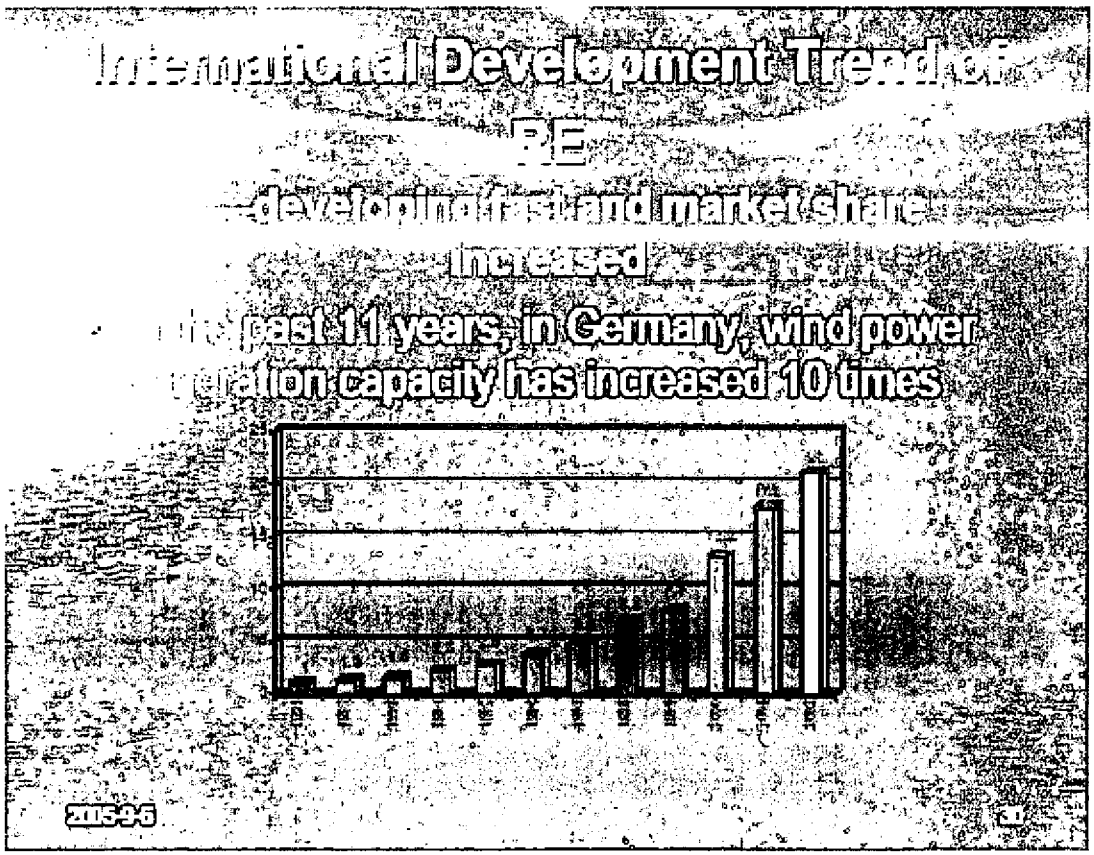
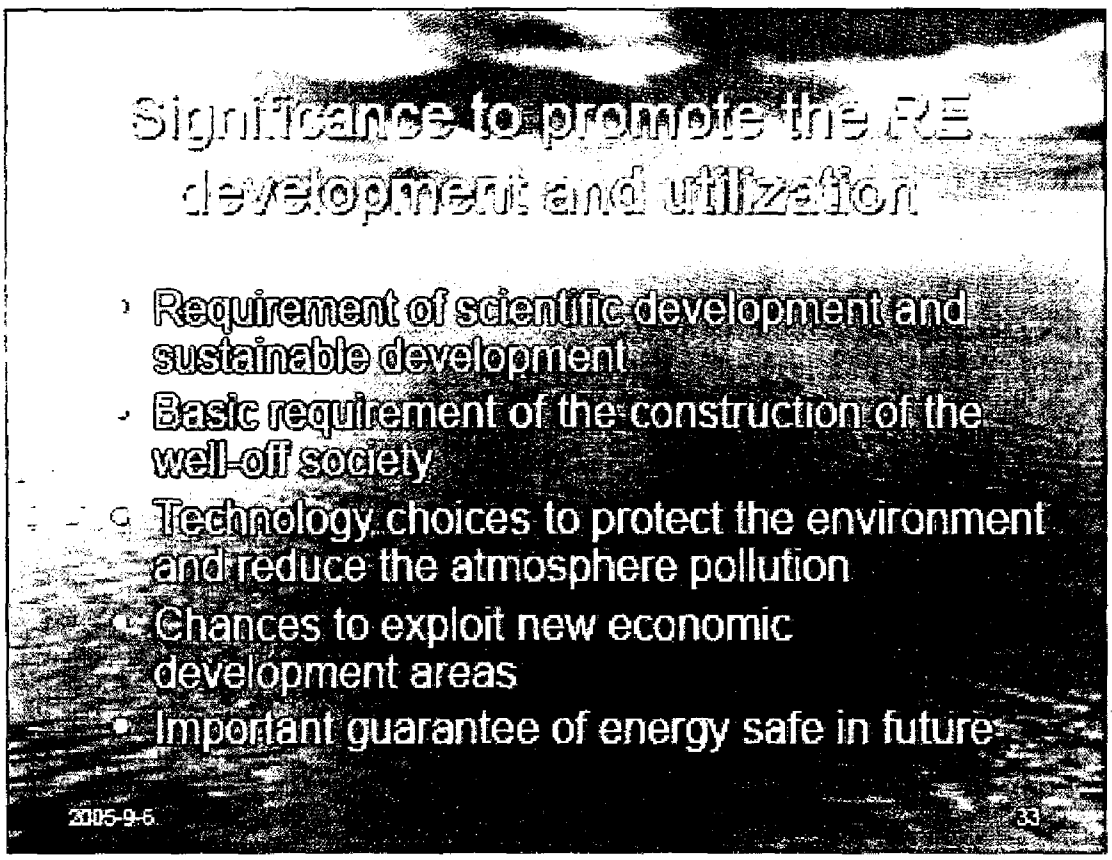

past 11 years, in Germany, wind power
ration capacity has increased 10 times

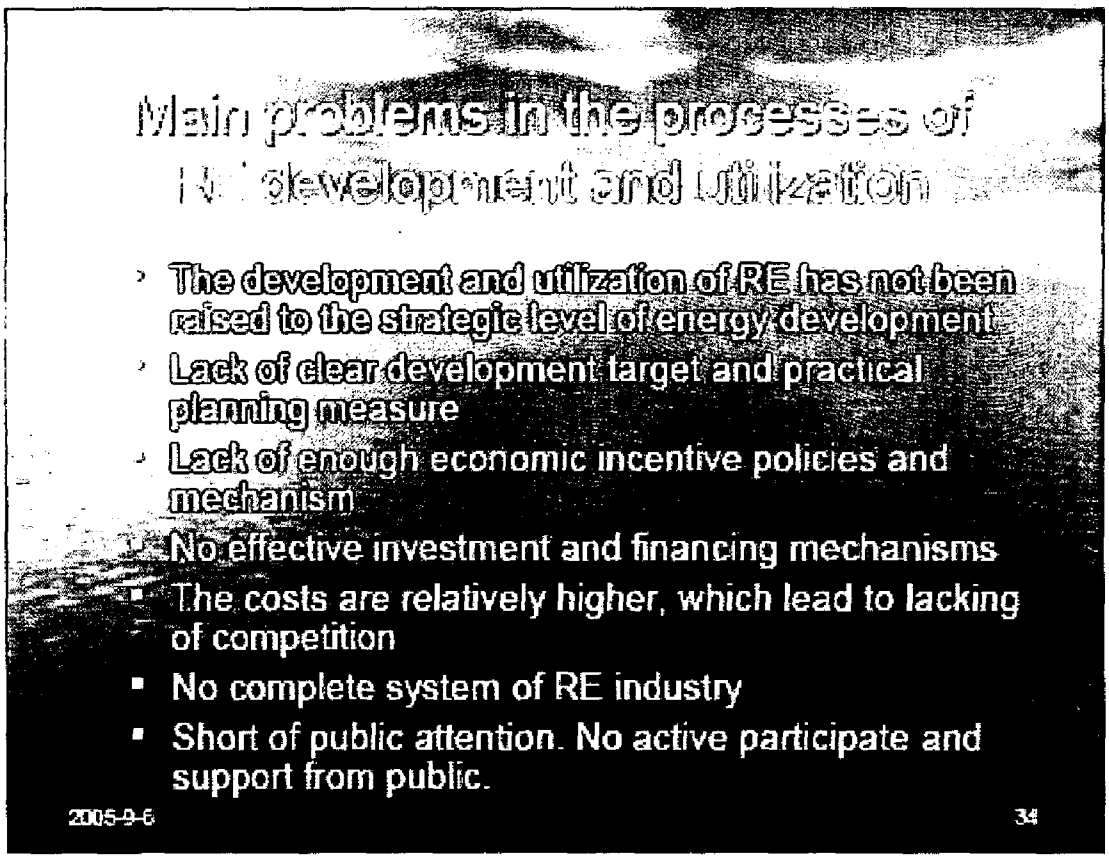
International Development Trend of RE

- Strategy status of RE rise step by step from complementary energy to alternative energy and then to strategic energy
  - EU: RE will be 50% of whole energy in 2050
  - German and UK: RE will be 20% of whole energy in 2020, which was defined in the law
  - Some countries in Europe: it is planed to use RE to replace nuclear energy before 2020

Part 4
Significance of the Renewable Energy Law

- Significance to promote the RE development and utilization
- Main problems in the process of RE development and utilization
- Target of the RE development and utilization promotion law
- Feasibility in formulating the RE development and utilization promotion law


Significance to promote the RE development and utilization
Requirement of scientific development and sustainable development
Basic requirement of the construction of the well-off society
Technology choices to protect the environment and reduce the atmosphere pollution
Chances to exploit new economic development areas
Important guarantee of energy safe in future
2005-9-6
33


Main problems in the processes of RE development and utilization
The development and utilization of RE has not been raised to the strategic level of energy development
Lack of clear development target and practical planning measure
Lack of enough economic incentive policies and mechanism
No effective investment and financing mechanisms
The costs are relatively higher, which lead to lacking of competition
No complete system of RE industry
Short of public attention. No active participate and support from public.
2005-9-6
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Main target of the law

- Identify the rules of public responsibility. Buildup the hardship consciousness of public on resource
- Identify the government's essential power, duty and obligation
- Bring forward the definite market directive signal
- Strengthen the confidence of the main market investors
- Accelerate the process of expanding the market scale and commercialization

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Feasibility of the legislation

- Plenty of RE resources, excellent technology bases and practical experience;
- New requirement on RE due to the insufficient supply of power and pressure of environment;
- Existed promotional policies and measures for RE
- Planning target of RE development
- Practical experience from other legislation
- Excellent international environment of RE development and successful experience on RE legislation

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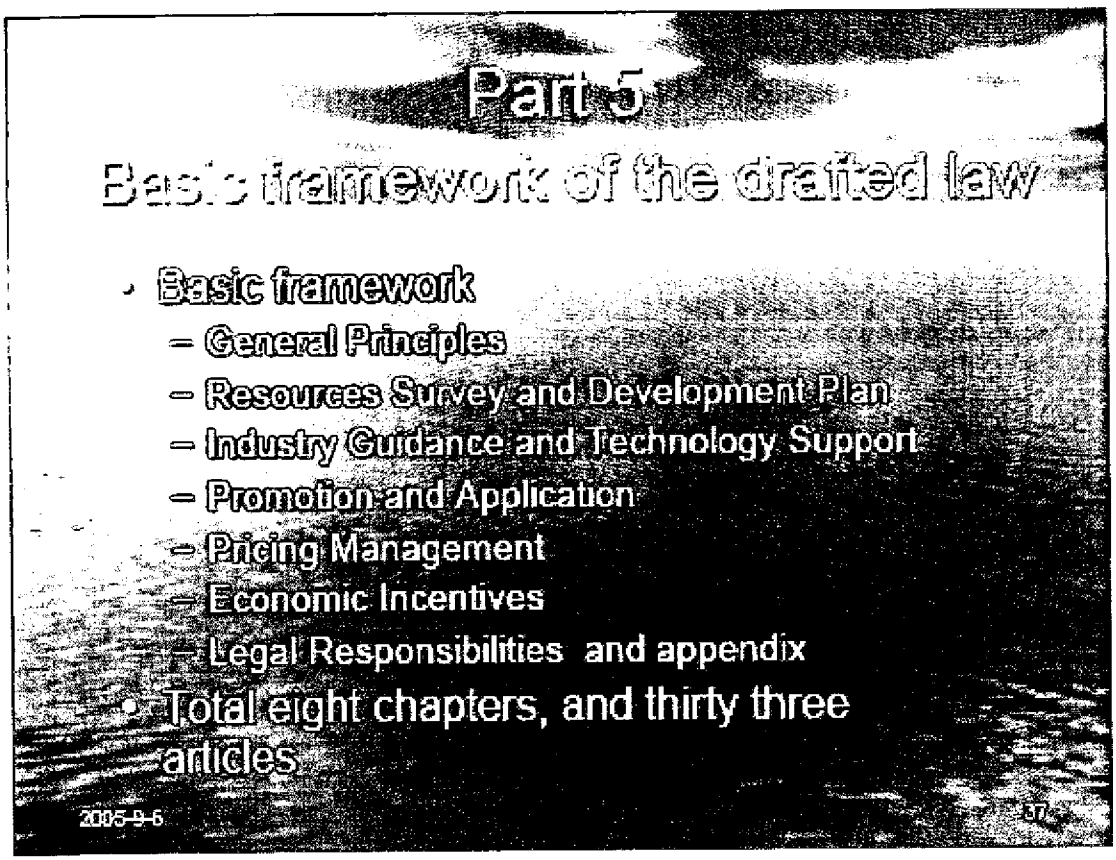
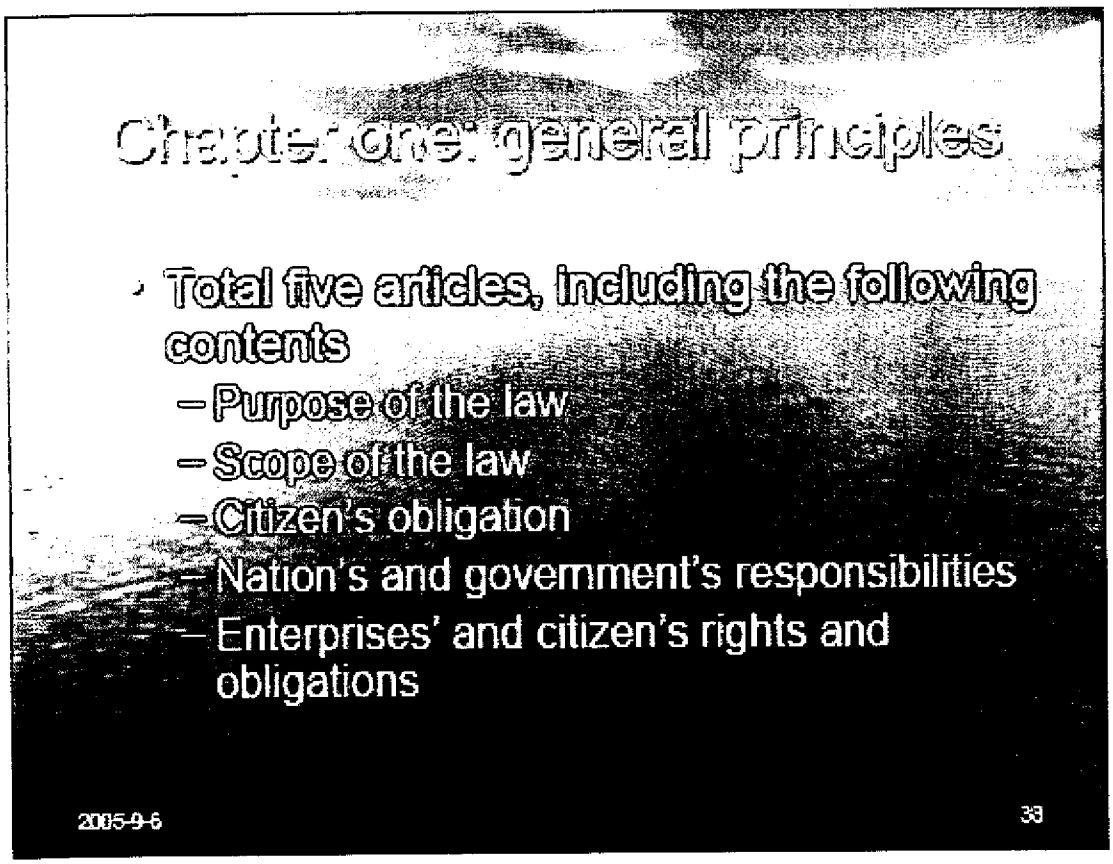

Part 5
Basic framework of the drafted law
Basic framework
– General Principles
– Resources Survey and Development Plan
– Industry Guidance and Technology Support
– Promotion and Application
– Pricing Management
– Economic Incentives
– Legal Responsibilities and appendix
Total eight chapters, and thirty three articles
2005-9-6
37


Chapter one: general principles
Total five articles, including the following contents
– Purpose of the law
– Scope of the law
– Citizen's obligation
– Nation's and government's responsibilities
– Enterprises' and citizen's rights and obligations
2005-9-6
38

Chapter 2: Resource survey and development plan

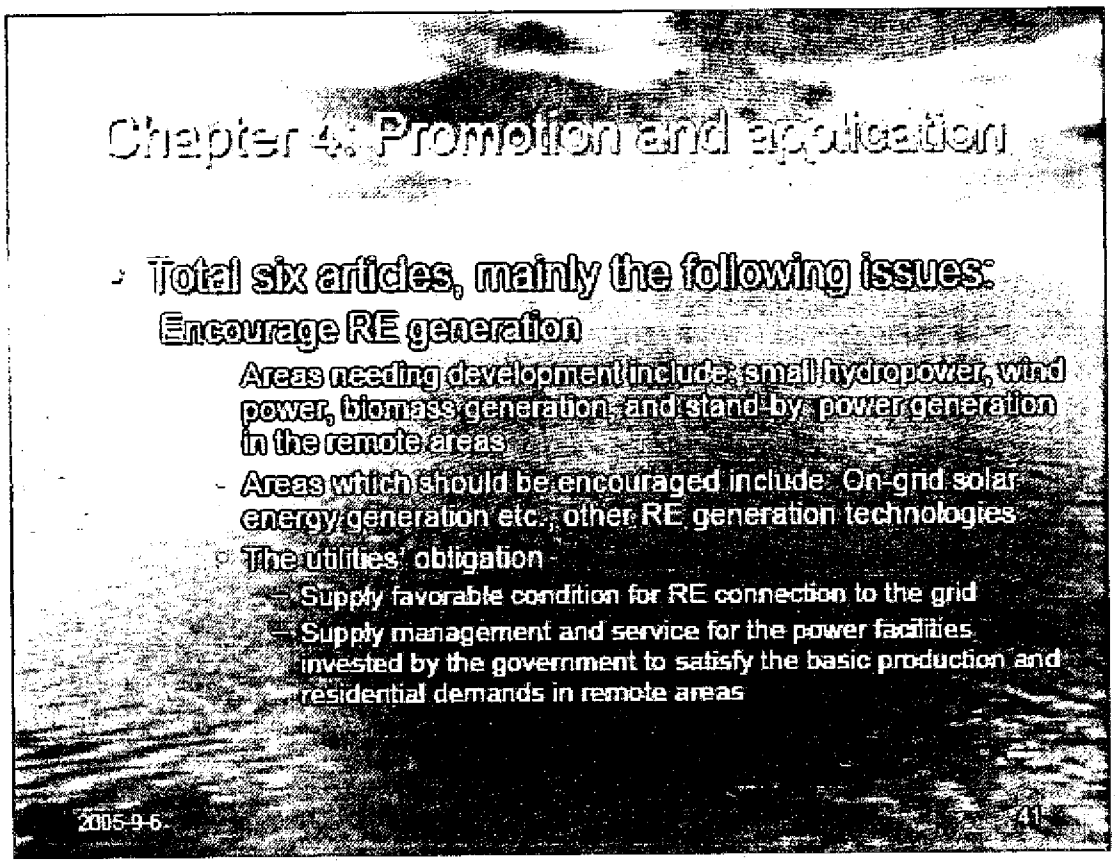
- Total four articles, mainly the following issues
  - Resource survey
    - Government has the responsibility for resource survey, and the obtained resource information belongs to the nation, can be released to the general public
    - Enterprises and individuals can obtain the right to explore and utilize renewable energy resources
  - Plan management, clarify:
    - Planning measures, planning principles and planning content
    - Requirements on the responsibility and obligation of the large-scale energy enterprises
    - Requirements on the transparence of planning information release system, published to the society

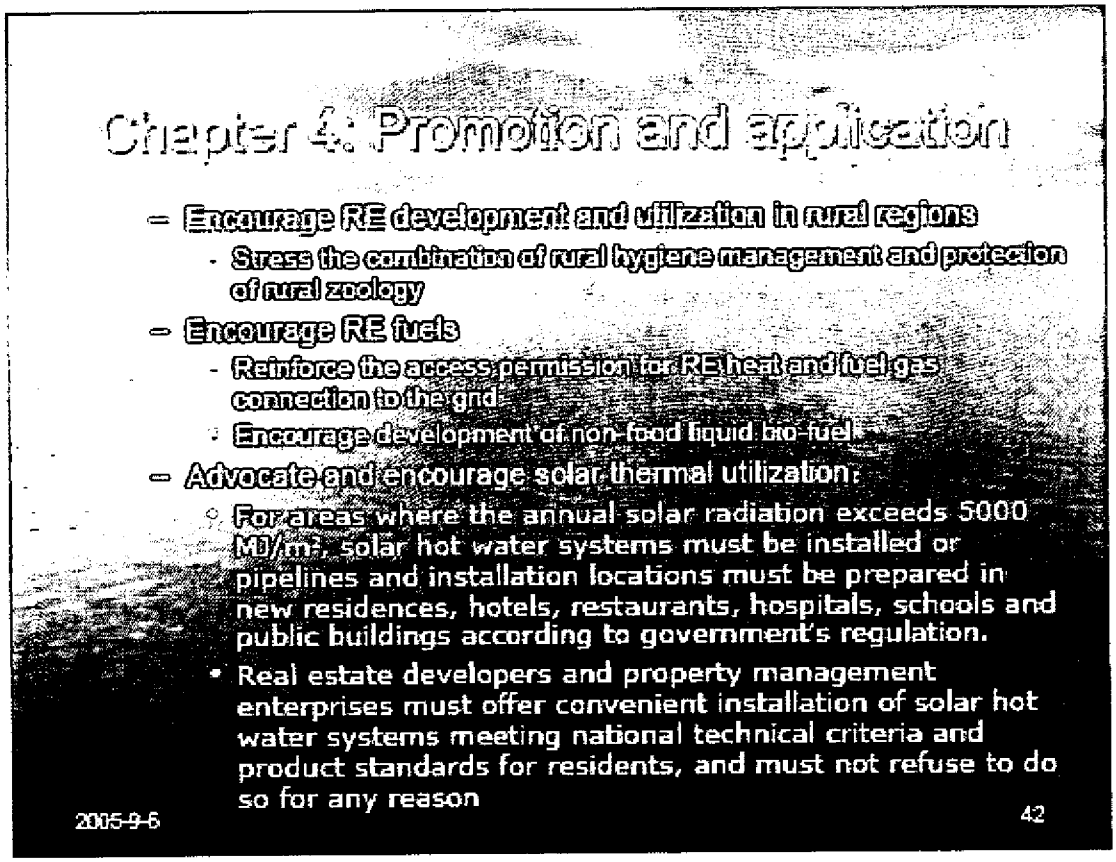
2015-9-6 39

Chapter 3:Industry Guidance and Technology Advancement

- Total three articles, basically identifying the government's responsibility in guiding the RE industries, including:
  - Issue industry inventory
  - Establish production criteria and technology standards
  - Quality testing and certification
  - Education and R&D

2015-9-6 40


Chapter 4: Promotion and application
Total six articles, mainly the following issues:
Encourage RE generation
Areas needing development include: small hydropower, wind power, biomass generation, and stand-by power generation in the remote areas
Areas which should be encouraged include: On-grid solar energy generation etc., other RE generation technologies
The utilities' obligation
Supply favorable condition for RE connection to the grid
Supply management and service for the power facilities invested by the government to satisfy the basic production and residential demands in remote areas
2005-9-6
41


Chapter 4: Promotion and application
Encourage RE development and utilization in rural regions
Stress the combination of rural hygiene management and protection of rural zoology
Encourage RE fuels
Reinforce the access permission for RE heat and fuel gas connection to the grid
Encourage development of non-food liquid bio-fuel
Advocate and encourage solar thermal utilization:
For areas where the annual solar radiation exceeds 5000 MJ/m², solar hot water systems must be installed or pipelines and installation locations must be prepared in new residences, hotels, restaurants, hospitals, schools and public buildings according to government's regulation.
Real estate developers and property management enterprises must offer convenient installation of solar hot water systems meeting national technical criteria and product standards for residents, and must not refuse to do so for any reason
2005-9-6
42

Chapter 5: Price management

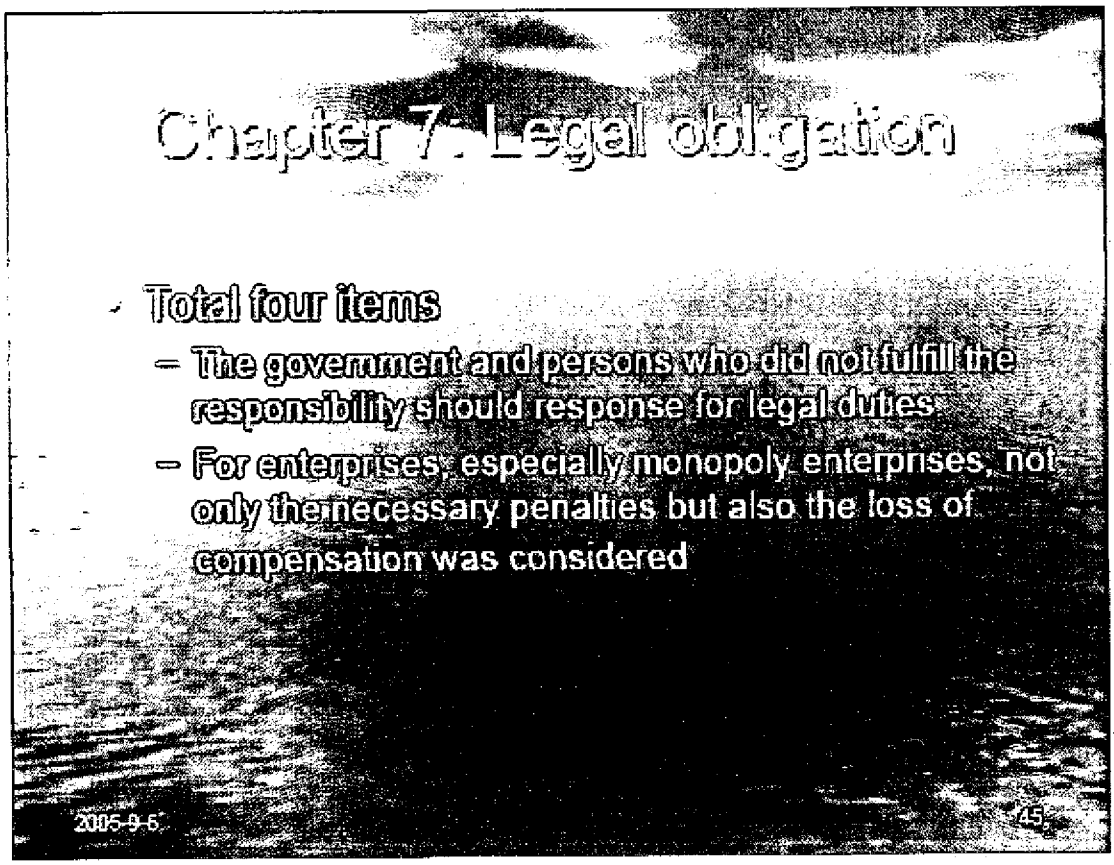
- Total five articles, including
- On-grid tariff
  - On-grid tariffs are set by the government, no competition for connection
  - Differential price system for different on-grid tariff
    - Identified by the advanced level, in different categories
  - Tariff public release system
    - Tariff should be released to the public and be reviewed
- Identify the cost share system
  - The fees for purchasing grid-connected renewable power are shared by all the power grid enterprises in the country. Fee sharing is calculated using the provincial grid operator as the basic unit. Inter-grid accounting, balancing transactions and payments are done at the end of each year.

2005-9-5 43

Chapter 6: Economic incentives

- Four articles
  - –Financial subsidy
  - –Loan and tax measures

2005-9-5 44


Chapter 7. Legal obligation
Total four items
– The government and persons who did not fulfill the responsibility should response for legal duties
– For enterprises, especially monopoly enterprises, not only the necessary penalties but also the loss of compensation was considered
2005-9-6
45


Thank You
2005-9-6
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Marine Current: Resources in China and Potential Sites for Power Plant

By Zhi YU[1], Changkun WANG[2], Wei LU[3] and Yuanchang DENG[1]

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2. National Second Institute of Oceanography, Hangzhou, China
3.Guangdong University of Technology, Guangzhou, China

MARINE CURRENT ENERGY RESOURCES IN CHINA

(RESEARCH ACTIVITIES IN MARINE CURRENT ENERGY RESOURCES

Although there is no marine current power plant in China, much work has been done concerning the marine current energy resources.

o In 1982, the marine current energy resources in Zhoushan archipelago, including the main water channels was calculated and estimated that the overall theoretical power is 2572.8MW.

o In 1984, a rough estimation of the marine current energy resources was made in the coastal areas in China and reached that the overall power is 12GW.

o In 1987, marine current energy resources in the near shore areas of Chengshanjiao, Shandong Province was calculated and got the overall power is 724kW.

o In 1989, "the regional layout of ocean energy resources in the coastal areas in China" (briefed as "the layout" hereafter) was published. The layout made statistics of more than 130 locations where the maximum velocity of marine current exceeded 1.28m/s.

o In 1997, the Sino-European cooperation was carried out concerning the feasibility study of the marine current energy exploitation in Zhoushan area. The study was supported by the JOULE II Program.

THE OVERVIEW OF THE MARINE CURRENT ENERGY RESOURCES IN CHINA

The layout published in 1989 made comprehensive and systematic analysis for the marine current energy resources. According to the layout, the average theoretical marine current power of the 130 water channels amounts to 13.95GW (some water channels with strong marine current were left out due to no information available). Table 1 and Figure 1 show the regional distribution of marine current energy resources.

The marine current energy resources are unevenly distributed along the coastal areas. In terms of provincial distribution, Zhejiang ranks No. 1 with the average theoretical marine cur-

rent power of 7.09GW (more than half of the total in China) and 37 water channels. Taiwan, Fujian, Shandong and Liaoning comes after with the average theoretical marine current power in the range of 1.13~2.28GW, and the total of the four provinces is 5.87GW, which accounts for 41.9% of the total in China. Other provinces have much less marine current energy resources with Guangxi at the bottom of the list, only 23MW. In terms of sea distribution, the most abundant area is in the East China Sea, with 95 water channels and average theoretical marine current power of 10.96GW, accounts for 78.6% of the total. The second is the Yellow Sea (mainly along the coastline of the north Yellow Sea) with 12 water channels and 2.3GW in power, which accounts for 16.5% of the total. The South China Sea has the least resources with 23 water channels and 0.68GW in power, accounts for 4.9% of the total.

The water channels with high power density (the maximum power density comes after in the parentheses) are: north side of Laotieshan water channel (17.41kW/m2) north to the Bohai Bay; north side of Beihuangcheng island (13.69kW/m2), south to the Bohai Bay; north harbor in the mouth of Changjiang River (10.30kW/m2); north to the mouth of Hangzhou Bay (28.99kW/m2); Jintang (25.93kW/m2), Guishan (23.89kW/m2) and Xihoumen (19.08kW/m2) water channels of Zhoushan archipelago; northwest of Shandujiao (15.11kW/m2), Shanduao, Fujian province; southwest of Yuweng Island (13.69 kW/m2), Pescadores, Taiwan.

According to the power density, theoretical resources reserves and the exploitation conditions, the layout recommended the following regions for the exploitation of marine current power: water channels in Zhoushan area and north to the mouth of Hangzhou Bay, Zhejiang province; water channels of Shanduao, Fujian province; Laotieshan water channel along the coastline of Lvshun, Liaoning province. Furthermore, it pointed out that Zhoushan archipelago, which has more than 1000 islands, should be considered as the most resourceful area with the best exploitation conditions in China.

MOST RESOURCEFUL PROVINCES OVERVIEW

ZHEJIANG PROVINCE

It's the most resourceful area. The marine current energy resource is very abundant with average theoretical power of 7.14GW, which accounts for 51% of the total in China. 96% of the overall resources are distributed in Zhoushan archipelago and the mouth of Hangzhou Bay, with the average theoretical power of 3.83GW and 3.09GW respectively. The water channels in these areas have high power density (top one in China), for example, the maximum power density of Jintang, Guishan, Xihoumen water channel and north to the mouth of Hangzhou Bay, is 25.93kW/m^2, 23.89kW/m^2, 19.08kW/m^2 and 28.99kW/m^2 respectively. The site for marine current power plant has many potential choices and the exploitation will not cause conflicts with marine traffic and other ocean engineering. The water channels are protected from islands and have stable sea conditions. The seashore is mainly composed of base rock. So, those areas should be considered the most ideal for marine current development. Table 2 and Figure 2 show the resources distribution.

In the table hereafter, we use the following symbols and formulas:

B: the width of water channel,
H: the average water depth,
Vm: the maximum velocity during the spring tide,
Vs: the maximum velocity during the neap tide,

$P_m = 0.512V_m^3$,
the maximum power density,
$P = \frac{1}{12\pi}(5 + 3a + 3a^2 + 5a^3)P_m$,
average power density,
(where $a = V_s / V_m$), $N = 10^{-3} BHP$
average theoretical power

FUJIAN PROVINCE

The marine current energy resources is relatively abundant, average theoretical power is 1.28GW. 87.5% of the overall resources are distributed along the coastline north to Haitan Island with the average theoretical power of 1.12GW. The power density of Shanduao is the highest with the maximum power density of 15.11kW/m2 in the northwest of Shandujiao. Northwest of Shandujiao is the most resourceful region with average theoretical power of 0.79GW, accounts for 61.3% of the total in the province. The sea condition is stable and the seashore is composed of base rock. Table 3 and Figure 3 show the resources distribution.

SHANDONG PROVINCE

Marine current energy resources are relatively abundant, average theoretical power is 1.18GW. 93% of the overall resources distributed in the water channels of Miaodao archipelago, north of Shandong Peninsula. The water channels have sound natural conditions. It should point out that the north side of Beihuangcheng, where the maximum power density is 13.69kW/m2, average theoretical power is 806MW and accounts for 68.5% of the provincial total. The region has many advantages in developing marine current except the high wave and severe sea conditions may cause some problems. Table 4 and Figure 4 show the resources distribution.

LIAONING PROVINCE

The marine current energy resource is relatively abundant, average theoretical power is 1.13GW. The overall resources is mainly distributed along the coastline of the Yellow Sea, for example, the water channels in inner-Changshan archipelago and the mouth of Dalian Bay. The north side of Laotieshan water channel, near shore of Lvshun, has high velocity of marine current and power density, with the maximum power density of 17.41kW/m2 and average theoretical power is 1047kW. Meanwhile, the marine difference is low and in the winter, the seawater doesn't ice up, the seashore is mainly composed of base rock. Though it is the key position in transportation, it has wide water channel and can avoid the marine traffic courses, so the water channel should be one of the best places with potential for marine current exploitation. Table 5 and Figure 5 show the resources distribution.

POTENTIAL SITES FOR MARINE CURRENT POWER PLANT

There are many potential sites along the coastal areas in China, while Zhoushan Archipelago should be the best choice for the experimental marine current power plant.
Zhoushan Archipelago has more than 1000 islands. The water channels are wide and deep while speed of the marine current is the most intensive along the coast of China. For quite some time, it has been considered as the most resourceful area with the best exploitation conditions in China.

NATURAL AND ECONOMIC CONDITIONS IN ZHOUSHAN

Zhoushan City is located in the northeastern Zhejiang Province and in the middle of the coastline of China. It has the nickname of "city of thousands islands". The city extends 181.7km from east to west, and 169.4km from south to north. It has a total area of 22,216km2, including Shengsi County 8,824km2, Daishan County 5,220km2, Dinghai District 1,444km2 and Putuo District 6,728km2.

Zhoushan City opens to the East China Sea and covers a spacious area with tortuous seashore, numerous harbors and islets. The climate is mild there and sea water is full of nutrition, conducive to the reproduction of various species.

GEOGRAPHICAL CONDITIONS OF ISLANDS

Zhejiang is a province with the most islands, with the number of 3,061 islands, 44% of the total in China. However, the islands in Zhoushan City are 1390, over 45% of those in Zhejiang Province. In Zhoushan City, there are altogether 16 large islands (an area of over 10km2 each) with total area of 1,071km2, such as Zhoushan island, Daishan island, Liuheng island, Jintang island, Zhujiajian island, Qushan island, Taohua island, Larger Changtu island, Xiushan island, Sijiao island, Xiazhi island, Dengbu island, Cezi island, Putuo island, Changbai island, Lesser Changtu island.

The seashore is mainly composed of base rock with a length of 1,851km, about 75.6% of the total seashore length, and it also includes the sandy and gravel beach and mud flat coast, with a length of 50km and 12.7km each.

CLIMATE

Zhoushan City is in the middle latitudes, affected by both sea and land, hence has a unique island climate. It is featured with a distinctive transition from summer to winter, moderate temperature, evident 4 seasons, no intensely hot summer or bitter cold winter, and a mild temperature change. There is abundant sunlight and heat, plentiful rain, mild and humid air.

The annual average temperature is 15.6-16.6? in Zhoushan City, monthly average temperature lowest of 5.5? in January and highest 27.0? in August. The sunlight radiation is about 4,127-4,599MJ/m2. The annual average wind speed ranges from 3.3m/s to 7.2m/s, which increases from the south to the north.

POPULATION

According to the statistics in 1995, the population totals 982,763 in Zhoushan City, and there are 86 islands with habitants.

Since there are shortages of energy and fresh water, inconvenient in local transport on islands, and the issues of education and medical care need to be addressed, the local government adopts the policy of "construction on large islands and moving from small islands" and the number of islands with population becomes less year after year.

ECONOMY

The traditional industries of Zhoushan City are fishery and salt production and so on. After the reform and opening policy, and especially in recent 10 years, the industries of fishery, harbor, tourism, transport and aquatic product processing etc. have been given a high priority and developed rapidly, and particularly the industries of harbor transport and tourism got a very fast growth. The GDP values of Zhoushan City and its distribution are shown in Table 10.

ENERGY RESOURCES AND POWER SUPPLY SITUATIONS

ENERGY RESOURCES

In Zhoushan City, there is no conventional fossil energy resource and the energy is totally relied on the outside, but there are rich ocean energy, wind power and solar energy resources. The annual sunlight hour ranges from 1,940h to 2,257h, and the annual sunlight radiation totals from 4,127MJ/m2 to 4,599MJ/m2. Zhoushan City has an average annual wind speed of 5.47m/s, and its northeastern area has an average annual wind speed above 7m/s. The middle and northern parts are among the richest wind energy resources areas in China. According to the statistics from the survey of islands in Zhejiang, those 97 dam sites (bays) in Zhoushan City have 63.5MW exploitable marine power resources, and can generate 117GWh annually. The theoretical wave power is 598.6MW. The average theoretical marine current power of 38 water channels amounts to 4814.1MW.

Considering the oceanic environment of Zhoushan, the middle and southern areas are crisscrossed with water channels and navigation openings (or hangmen), and the velocity of marine current is very high (many places have a max. speed of over 2.0m/s, the highest is 4.0m/s and the max. power density up to 25-30kW/m2), these areas are believed to have richest marine current resources in China and have the best exploitation conditions.

STATUS OF ENERGY CONSUMPTION

In Zhoushan City, the energy consumption is mainly relied on coal, then diesel fuel,

which respectively covers 52% and 30% of the total energy consumption. Coal is primarily used for power generation, with a proportion of 40% and the remaining is consumed for industries. Diesel fuel is mainly used to drive fishing boats (about 70%) and other 25% is consumed for marine transport, industry and agriculture.

POWER SUPPLY AT THE BEGINNING OF 1990S

At the beginning of 1990s, there are various power supply modes, such as Zhoushan island & its surrounding islands connected to the inland power grid, local power grid of Zhoushan City and stand-alone power supply (diesel power generation). Individual islands have no power supply.

The islands supplied by stand-alone diesel power generation system include the following 22 islands: Miaozihu, Huangxing, Qingbang, Xiaofushan, Lianghengshan, Xifeng, Hunishan, East Bailianshan, West Bailianshan, Guanshan, Jiannanshan, Dajiaoshan, Dayushan, Huanliaoshan, Lvhuashan, Bixia, Tanhu, Xugong, Dapanshan, Zhangqishan, Lesser Yangshan and Larger Yangshan.

The islands without electric power included the following 8 islands: Larger Wujiaoshan, Zhizhongshan, Chaishan, Dongku, Zhuzhu, Beidingxin, Larger mantoushan etc.

POWER FACILITIES CONSTRUCTION TODAY

Since the 1990s, Zhoushan City has accelerated the construction of its power infrastructures, and all of its adjacent islands have been connected via seabed cable or aerial cable for power supply, except these islands that are going to have no habitant. For remote islands with difficulty of grid-connection, such as Larger Yangshan, Lesser Yangshan, Miaozihu, Bixia, Tanhushan etc., the independent diesel power generators have been installed.

In 2004, the total power generation of Zhoushan city amounts to 2,154,181.3MWh. In order to meet the demand of harbor development etc., thermal power plants with the installed capacity of 135MW or 100MW are to be built in Dinghai, Sijiao and Liuheng respectively.

MARINE CURRENT ENERGY RESOURCES IN ZHOUSHAN CITY

Table 12 and Figure 6 are the distribution of marine current energy resources in Zhoushan.

POTENTIAL SITES FOR THE EXPERIMENTAL MARINE CURRENT POWER PLANT

Some premises are needed when preselecting potential sites for the experimental marine current power plant in Zhoushan. The premises are shown as below:

o There should be a strong marine current near the island, and the maximum velocity no less than 2.0m/s.

o The economy is relatively backward there, and a successful exploitation of the marine current power is expected to push forward the local socio-economic progress.

o There is difficulty in the supply of energy and fresh water.

o The island is not a hotspot for ocean development; there are fewer activities such as harbor construction, navigation, fishing, aquiculture etc.

o The local government supports the development of marine current power.

o Based on the above-mentioned preconditions, the water channels of Guishanhangmen, Daishan, Shiliumen, Xiaoliangtan-zhujiashan, Tiaoshaomen (point A,B,C,D,E in Figure 6 respectively), totaling 5, shall be recommended for developing experimental marine current power.

See Annex

Annex

TABLE 1 DISTRIBUTION OF MARINE CURRENT ENERGY RESOURCES IN CHINA

(Vm: the maximum velocity of the spring marine current, Unit:m/s)

Province or Area	Class 1 Zone Vm3. 06	Class 2 Zone 2.04Vm6 3 3.06	Class 3 Zone 1.28Vm2 2 2.04	Theoretical Power (MW)	Number of water channels
Liaoning	North of Laotieshan water channel 1		Changshandong water channel 1, Guapi water channel 1, Sanshan water channel 1, Xiaosanshan water channel·1	11305	5
Shandong		North of Beihuangcheng 1	Miaodao archipelago water channels 3, East coast 3	11779	7
Changjiangkou		Beigang 1, Nancao 1	Hengshaxiaoguangkou 1, Beicao 1	3049	4
Zhejiang	Zhoushan: (*Xihoumen, Jintang *, Guishan water channel and so on *7), North of Hangzhou Bay 1, Nanhui-Lvhua1	Zhoushan water channels *14, Jiaojiangkou 1	Zhoushan water channels 4, Xiangshangang 1, Sanmenwan 3, Taizhouwan 2, Leqingwan 3	70903	37
Fujian	Northwest of Sandujiao in Sanduao *1	East of Sandu Island *2, Minjiangkou 1, South of HaitanHaixia 1, Dazhuhangmen 1	Shachenggang 2, Xinghuawan 3, Haitan Strait channels 8	12805	19
Taiwan		North of Penghu*6, South of Penghu 4, North of Taiwan Island 3, Linshanbibei 1	Pescadores 9, West of Taiwan Island 11, Northeast of Sandiaojiao 1	22825	35
Guangdong		Qiongzhou Strait dongkou water channel 1, Wailuo water channel 1	Zhujiangkou 1, water channels of western Guangdong coastal area14	3766	16
Guangxi		Zhenzhu harbour 1	Dafengjiangkou, Longmengang 1, Fangchenggang 1	231	4
Hainan		Qiongzhou Strait dongkounan water channel 1	Chengmaiwankou 1, Yinggehai 1	2824	3
The whole country	11 places8 8.5%	41 places3 31.5%	78 places6 60%	139485	130
Note: The figure behind the place means the number of wat er channels. * means sound exploitable condition.					

TABLE 2 STATISTIC OF MARINE ENERGY RESOURCES IN ZHEJIANG COASTAL AREAS

Number	Water channel name	B (m)	H (m)	Maximum velocity (m/s)		Power density (kW/m²)		N (MW)
				Vm	Vs	Pm	P	
1	Jinjishan - Mantoushan	12000.0	20.0	1.54	0.59	1.87	0.34	81.79
2	Baijiexia	3145.0	30.0	2.06	0.78	4.48	0.81	76.59
3	Daishan - Dajushan	12000.0	16.0	3.09	1.17	15.11	2.74	526.03
4	Daishan	1480.0	26.0	2.06	0.78	4.48	0.81	31.24
5	Xiaobanmen	2775.0	45.0	2.06	0.78	4.48	0.81	101.37
6	Guanmen	555.0	50.0	3.08	1.17	14.96	2.72	75.39
7	Luotou	2035.0	70.0	2.83	1.08	11.60	2.11	300.79
8	Wushamen	371.0	40.0	2.47	0.93	7.72	1.40	20.72
9	Wusha	883.0	50.0	1.95	0.74	3.80	0.69	28.70
10	Qingzimen	1018.0	14.0	2.57	0.98	8.69	1.58	22.53
11	Xiashimen	926.0	70.0	2.31	0.88	6.31	1.15	74.38
12	Tiaozhoumen	1100.0	10.0	2.57	0.98	8.69	1.58	17.39
13	Xuanshan - Bijiashan	3750.0	7.9	1.54	0.59	1.87	0.34	10.10
14	Xiaoyangshan - Dayangshan	3900.0	12.0	3.09	1.17	15.11	2.74	128.22
15	Guishanhangmen	463.0	60.0	3.60	1.37	23.89	4.34	120.61
16	Shiliumen	50.0	16.0	3.09	1.17	15.11	2.74	2.19
17	Cezi	4300.0	75.0	2.06	0.78	4.48	0.81	261.80
18	Xihoumen	2000.0	50.0	3.34	1.27	19.08	3.47	346.60
19	Huoshaomen	278.0	40.0	2.06	0.78	4.48	0.81	9.03
20	Panshinan	185.0	30.0	2.57	0.98	8.69	1.58	8.77
21	Jintang	4375.0	75.5	3.70	0.63	25.93	3.87	1277.60
22	Xiangshuimen	278.0	35.0	2.47	0.94	7.72	1.40	13.64
23	Shuangyumen	2400.0	39.9	1.70	0.65	2.52	0.46	43.87
24	Taohuadao - Dashuangshan	750.0	82.0	2.32	0.82	6.39	1.13	69.42
25	Dashuangshan - Xiashidao	1275.0	62.0	1.96	0.74	3.86	0.70	55.21
26	Xiaoliangtan - Zhujiashan	2475.0	31.2	2.57	0.98	8.69	1.58	122.08
27-1	Nanhui - Ivhua(1)	9180.0	10.0	2.85	1.96	11.85	3.18	289.45

Table continued overleaf

-2	Nanhui - Ivhua (2)	8142.0	9.0	3.63	1.82	24.49	5.12	375.51
-3	Nanhui - Ivhua (3)	10557.0	9.5	2.04	1.02	4.35	0.91	91.06
-4	Nanhui - Ivhua (4)	12489.0	9.0	1.99	1.00	4.03	0.85	95.03
-5	Nanhui - Ivhua (5)	13869.0	14.8	1.69	0.85	2.47	0.52	106.35
-6	Nanhui - Ivhua (6)	14835.0	22.0	1.73	0.87	2.65	0.56	181.38
Subtotal								1138.78
28-1	Hangzhouwankou(1)	11660.5	11.0	3.84	1.96	28.99	6.13	786.90
-2	Hangzhouwankou (2)	8675.1	12.5	3.18	1.62	16.64	3.48	377.35
-3	Hangzhouwankou (3)	11239.0	11.0	2.44	1.24	7.44	1.57	194.05
-4	Hangzhouwankou (4)	10887.8	10.0	2.85	1.45	11.85	2.50	272.52
-5	Hangzhouwankou (5)	10290.7	11.7	2.46	1.25	7.62	1.61	193.65
-6	Hangzhouwankou (6)	19246.8	6.0	2.15	1.10	5.09	1.08	124.54
Subtotal								1949.01
29	Xiangshan port	7200.0	12.0	1.42	0.68	1.47	0.30	25.78
30	Baijiao	2250.0	3.5	1.29	0.58	1.10	0.22	1.70
31	Shepan	1600.0	6.4	1.70	0.76	2.52	0.49	5.05
32	Changshidao - Xiawanshan	2500.0	8.9	1.29	0.58	1.10	0.22	4.81
33	Left of toumenshan	3200.0	6.5	1.57	0.88	1.98	0.45	9.30
34	Jiaojiangshan	1400.0	10.3	2.66	1.49	9.64	2.17	31.33
35	Xuanmenwan	900.0	2.0	1.29	0.63	1.10	0.23	0.41
36	Kanmengang	500.0	10.0	1.29	0.63	1.10	0.23	1.13
37	Leqingwankou	11600.0	15.5	1.56	1.11	1.94	0.54	96.92
	The whole province							7090.28

TABLE 3 STATISTIC OF MARINE ENERGY RESOURCES IN FUJIAN COASTAL AREAS

Number	Water channel name	B (m)	H (m)	Maximum velocity (m/s)		Power density (kW/m²)		N (MW)
				Vm	Vs	Pm	P	
1	North of Guayuan	1100	20.0	1.80	1.04	2.99	0.69	15.18
2	East of Huaguangyu	4000	9.0	1.54	0.89	1.87	0.43	15.48
3	East of Sandu Island	4300	25.0	2.01	1.23	4.16	1.00	107.50
4	East of Qingshan Island	6000	35.0	2.06	1.26	4.48	1.08	226.80
5	Northwest of Sandujiao	3100	40.0	3.09	1.88	15.11	3.64	451.36
6	Kemen	1800	45.0	1.70	1.04	2.52	0.61	49.41
7	Wuzhu port	4500	2.0	1.54	0.94	1.87	0.45	4.05
8	Hujiang - Chuanshi	2100	4.0	2.06	1.26	4.48	1.08	9.07
9	Southwest of Dalian Island	9300	4.0	1.29	0.81	1.10	0.27	10.04
10	Southwest of Bitoujiao	3600	6.0	1.29	0.83	1.10	0.28	6.05
11	West of Nangongyu	3200	18.0	1.54	0.99	1.87	0.47	27.07
12	South of Yemayu	8100	16.0	1.80	1.15	2.99	0.75	97.20
13	South of Renyu	9100	13.0	1.70	1.09	2.52	0.63	74.53
14	South of Dayu	1300	10.0	2.57	1.59	8.69	2.12	27.56
15	Dazhuhangmen	3200	18.0	2.47	1.53	7.72	1.88	108.29
16	Xiaozhuimen	1900	3.0	1.70	1.05	2.52	0.62	3.53
17	Northeast of Jinmen	2300	10.0	1.54	0.95	1.87	0.46	10.58
18	Jinmen	1800	16.0	1.96	1.22	3.86	0.94	27.07
19	Lishihangmen	2700	12.0	1.34	0.83	1.23	0.30	9.72
	The whole province							1280.49

TABLE 4 STATISTIC OF MARINE ENERGY RESOURCES IN SHANG-DONG COASTAL AREAS

Number	Water channel name	B (m)	H (m)	Maximum velocity (m/s)		Power density (kW/m²)		N (MW)
				Vm	Vs	Pm	P	
1	North of Beihuangcheng	5000	65.0	2.99	1.13	13.69	2.48	806.00
2	Daqin	2000	35.0	1.54	0.84	1.87	0.41	28.70
3	Beituoji	11000	38.0	1.44	0.79	1.53	0.34	142.12
4	Dengzhou	7500	20.0	1.90	1.04	3.51	0.78	117.00
5	South of Haliv Island	2500	40.0	1.54	0.84	1.87	0.41	41.37
6	Dingzikou	1500	30	1.54	0.78	1.87	0.39	1.77
7	Jiaozhouwankou	3000	35.5	1.54	0.78	1.87	0.39	40.95
	The whole province							1177.91

TABLE 5 STATISTIC OF MARINE ENERGY RESOURCES IN LIAONING COASTAL AREAS

Number	Water channel name	B (m)	H (m)	Maximum velocity (m/s)		Power density (kW/m²)		N (MW)
				Vm	Vs	Pm	P	
1	Changshandong	1650	14	1.70	0.92	2.52	0.55	12.78
2	Sanshan	1900	33	1.54	0.86	1.87	0.42	26.38
3	Xiaosanshanl	3250	27	1.29	0.70	1.10	0.24	21.06
4	Guapi	3750	25	1.29	0.70	1.10	0.24	22.50
5	Laotieshan	5000	55	3.24	1.76	17.40	3.81	1047.75
	The whole province							1130.47

TABLE 6 STATISTICS OF ISLANDS IN EACH COUNTY OR DISTRICT OF ZHOUSHAN CITY

Name of County or district	*Shengsi*	*Daishan*	*Dinghai*	*Putuo*	*Total*
Number of Islands	404	404	127.5	454.5	1390
Regional Area (km²)	8824	5220	1444	6728	22216
Area of Island & Land (km²)	67.95	269.10	531.06	388.83	1256.94
Length of Coastline (km)	471.35	717.02	428.07	831.43	2447.87

TABLE 7 STATISTICS OF HABITANT ISLANDS AND POPULATION

Name of County or District	Shengsi	Daishan	Dinghai	Putuo	Total
Number of Habitant Islands	18	11	31.5	25.5	86
Population	86021	218653	352483	325606	982763

TABLE 8 ISLANDS OF DIFFERENT POPULATION DENSITIES

Population density (persons/km ²)	1 1000	5001 1000	1005 500	1 100
Amount of Islands	27	28	25	6

TABLE 9 THE NUMBER OF ISLANDS WITH HABITANTS

Year	1964	1982	1990	1995
Number	107	98	88	86

TABLE 10 GDP VALUE OF EACH COUNTY OR DISTRICT IN ZHOUSHAN CITY

Name of County or District	Shengsi	Daishan	Dinghai	Putuo	Total
GDP Value(RMB billion yuan)	2.69	3.73	7.84	6.77	21.20

*GDP value is based on the statistics of Zhoushan City in 2004

TABLE 11 ISLANDS CONNECTED TO POWER GRIDS IN ZHOUSHAN CITY

Name of power grid		Islands connected to power grid
Power grid of Zhoushan City		Zhoushan island & its surrounding islands, Zhujiajian island and Taohua island in Putuo District, altogether 33 islands (connected to the mainland power grid).
Shengsi	Sijiao grid	Sijiao, Jinjishan, Dahuanglong, Jinping, Majishan, Shengshan, Gouqi, Larger Yangshan and Lesser Yangshan etc.
	Shengshan grid	
	Yangshan grid	
Daishan	Daishan grid	Daishan island, Larger Changtu, Lesser Changtu, Shuangheshan island and so on.
	Daqu grid	Daqu island, Xiaoqu island, Shulang island etc.
Power grid of Dinghai		Jintang island, Dapeng island and so on (connected to the mainland grid).
Power grid of Liuheng		Liuheng, Xiazhi, Fudu, Xuanshan, Liangtan, Duimianshan, Larger Shuangshan, Lesser Shuangshan, Zoumatang etc. (connected to the mainland grid).

TABLE12 DISTRIBUTION OF MARINE CURRENT POWER IN ZHOUSHAN

Number	Water channel name	B (m)	H (m)	Maximum velocity (m/s)		Power density (kW/m²)		N (MW)
				Vm	Vs	Pm	P	
1	Jinjishan - Mantoushan	12000.0	20.0	1.54	0.59	1.87	0.34	81.79
2	Baijiexia	3145.0	30.0	2.06	0.78	4.48	0.81	76.59
3	Daishan - Dajushan	12000.0	16.0	3.09	1.17	15.11	2.74	526.03
4	Daishan	1480.0	26.0	2.06	0.78	4.48	0.81	31.24
5	Xiaobanmen	2775.0	45.0	2.06	0.78	4.48	0.81	101.37
6	Guanmen	555.0	50.0	3.08	1.17	14.96	2.72	75.39
7	Luotou	2035.0	70.0	2.83	1.08	11.60	2.11	300.79
8	Wushamen	371.0	40.0	2.47	0.93	7.72	1.40	20.72
9	Wusha	883.0	50.0	1.95	0.74	3.80	0.69	28.70
10	Qingzimen	1018.0	14.0	2.57	0.98	8.69	1.58	22.53
11	Xiashimen	926.0	70.0	2.31	0.88	6.31	1.15	74.38
12	Tiaozhoumen	1100.0	10.0	2.57	0.98	8.69	1.58	17.39
13	Xuanshan - Bijiashan	3750.0	7.9	1.54	0.59	1.87	0.34	10.10
14	Xiaoyangshan - Dayangshan	3900.0	12.0	3.09	1.17	15.11	2.74	128.22
15	Guishanhangmen	463.0	60.0	3.60	1.37	23.89	4.34	120.61
16	Shiliumen	50.0	16.0	3.09	1.17	15.11	2.74	2.19
17	Cezi	4300.0	75.0	2.06	0.78	4.48	0.81	261.80
18	Xihoumen	2000.0	50.0	3.34	1.27	19.08	3.47	346.60
19	Huoshaomen	278.0	40.0	2.06	0.78	4.48	0.81	9.03
20	Panshinan	185.0	30.0	2.57	0.98	8.69	1.58	8.77
21	Jintang	4375.0	75.5	3.70	0.63	25.93	3.87	1277.60
22	Xiangshuimen	278.0	35.0	2.47	0.94	7.72	1.40	13.64
23	Shuangyumen	2400.0	39.9	1.70	0.65	2.52	0.46	43.87
24	Taohuadao - Dashuangshan	750.0	82.0	2.32	0.82	6.39	1.13	69.42
25	Dashuangshan - Xiashidao	1275.0	62.0	1.96	0.74	3.86	0.70	55.21
26	Xiaoliangtan - Zhujiashan	2475.0	31.2	2.57	0.98	8.69	1.58	122.08

TABLE 13 SITES SUGGESTED FOR THE EXPERIMENTAL MARINE CURRENT POWER PLANT IN ZHOUSHAN SEA AREA

Name of water channel	Max. velocity (m/s)	Area of nearby islands (km^2)	Population	Power supply	Industry
Guishanhangmen (point A)	2.57	Dajiaoshan island with an area of 1.805	One village with 210 households and 581 resident (2003)	Diesel generation	Fishery, prawn breeding, transportation
Daishan (point B)	3.00	Guanshan island with an area of 3.12	2 villages with 483 households and 1271 residents (2003)	Diesel generation	Fishery, agriculture
Shiliumen (point C)	3.09	North is Changzhi island with an area of 6.30km^2 and in the south is Aoshan island with in 5.15	At Changzhi island is located the township composed of 6 villages, with 1447 households and 4594 people (1998)	Connected to Zhoushan grid	Agriculture, fishery, salt-producing and industry
Xiaoliangtan-zhujiashan (point D)	2.57	Liangtan island in 1.1	One village with 156 familis and 490 residents (1990)	Connected to Liuheng grid	Fishery
Tiaoshaomen (point E)	2.57	Zoumatang island in an area of 0.71	One village with 147 households and 546 residents (1990)	Connected to Liuheng grid	Fishery

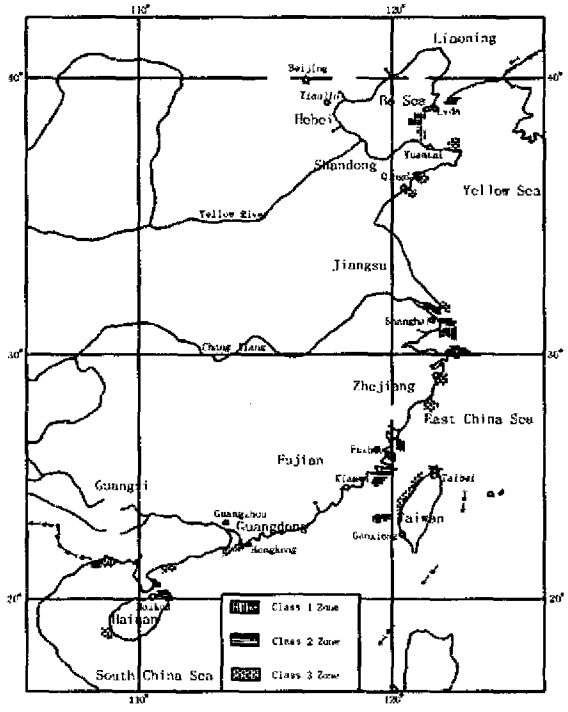

Figure 1 Distribution of marine current energy resources in China

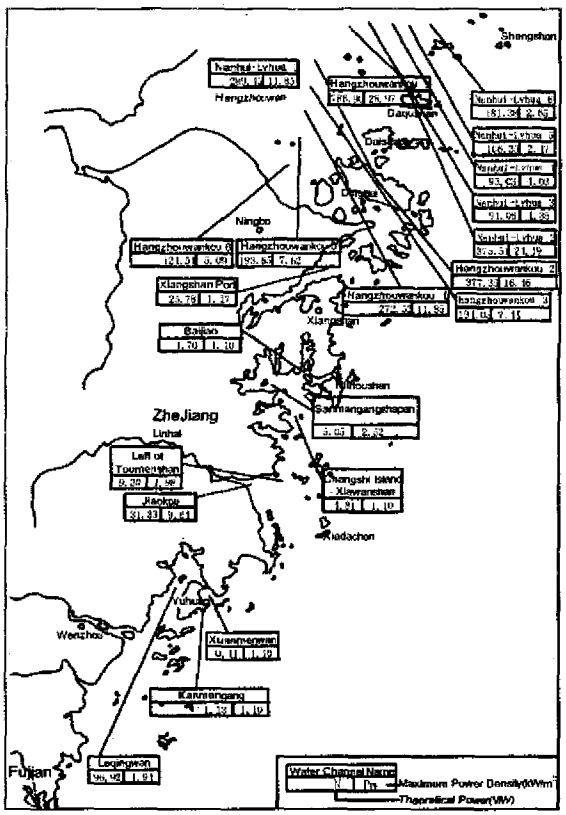

Figure 2 Distribution of marine current energy resources in Zhejiang Province

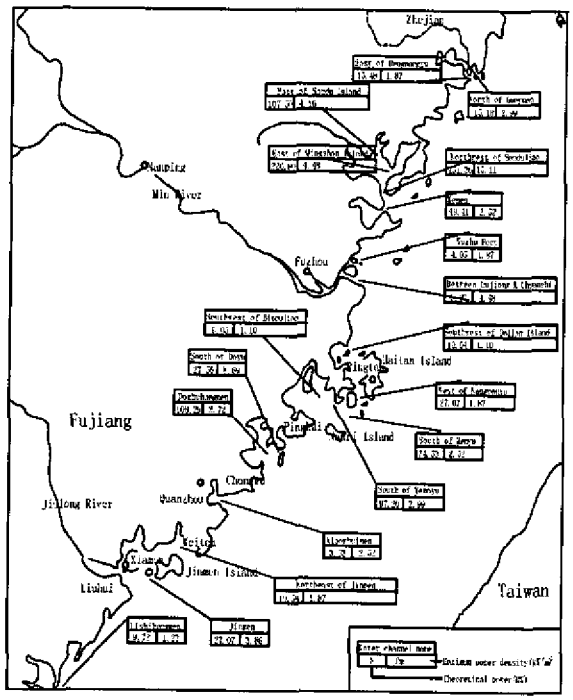

Figure 3 Distribution of marine current energy resources in Fujian Province

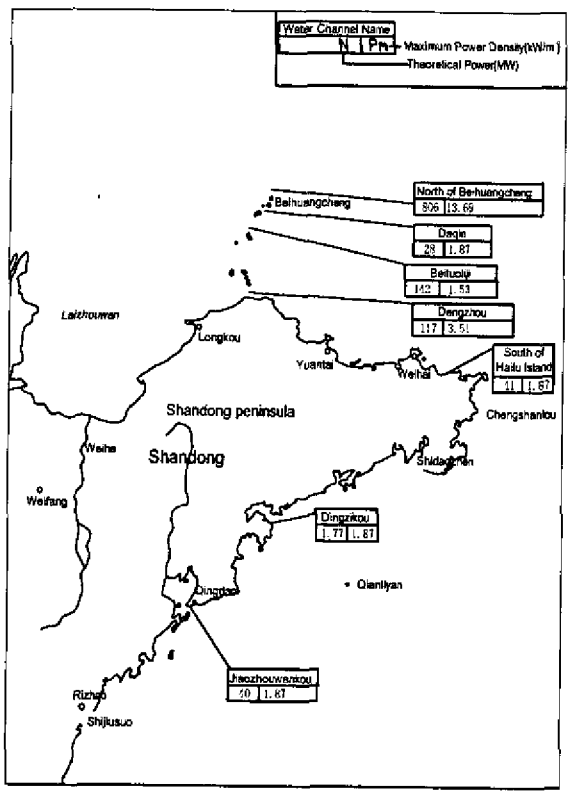

Figure 4 Distribution of marine current energy resources in Shandong Province

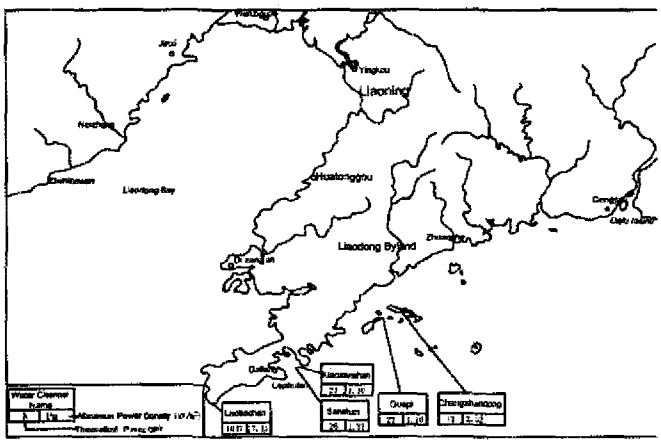

Figure 5 Distribution of marine current energy resources in Liaoning Province

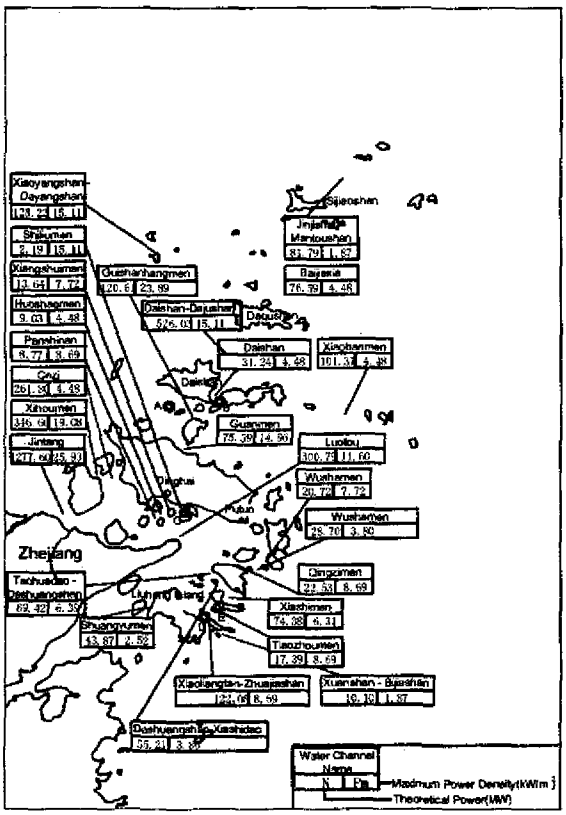

Figure 6 Distribution of marine current energy resources in Zhoushan

Government Policy on Provision of Electricity and Emphasis of Renewable Resources of Energy

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ABSTRACT

The rate of growth of electricity demand in the last three years in Indonesia exceed the capability of the government to provide the supply. The goverment, realizing the increasing problem of fossil fuel based generated electricity and the abundantly availability of renewable resource of energy, promugates a new regulation of electricity supply provision.

In Indonesia, there are many alternatives of renewable resource of energy that are available, namely: geothermal, solar, wind, biomass, hydro and marine. Apart from the marine current energy, others have been explored and partly exploited, however only a small portion that are ustilize for providing electricity.

The new regulation encourage the exploitation of renewable resource of energy as well as the participation of coopertiave and private entities in fulfilling the demand. By the year 2025, the government - through the Blue Print of National Energy Management - has aimed at materializing 6.4 % of the installed electricty capacity through the utilization of renewable resource of energy.

Keywords: Electricity, Renewable, Supply, Energy Policy.

PREFACE

The Medium Term National Development Plan of the Republic of Indonesia 2004 - 2009 promulgated as the basic substance of the Presidential Decree No. 7/2005 states that the national development on science and technology (S&T) is essentially aimed at improving the prosperity of the society . One of the measureable of the prosperity level is the energy consumption per capita and the ratio of electrification.

Energy consumption per capita in Indonesia is 3 BOE which is approximately one third of the average energy consumption of ASEAn member countries. One half of overall household have not been electrified. The UNDP data of the Human Development Index shows that electricity consumption of

the Indonesian society reaches 469 kWh/cap. This number is far less than the neighbouring countries such as Malaysia (3,039 kWh/cap), Thailand (1,084 kWh/cap), Philippine (599 kWh/cap), and Singapura (8.010 kWh/cap).
Among the priority of the S&T Development stated within the Medium Term National Development Plan of the Republic of Indonesia 2004 - 2009 is, therefore, energy , especially the creation and utilization of renewable resources of energy.

One of the problems in the energy sector is due to the low level of energy diversification. This can be shown by how dependence the national government to the oil. The national planning and utilization of energy, until at ther present time, is still depending on the fossil fuel based one. On the other hand, the fossil fuel based reservation is geting less and less . The Blue Print of National Energy Management 2005 - 2025 published by the Department of Energy and Minseral Resources states that in the year of 2003 the role of oil has reached 63% of the total energy consumption . In that document, it is stated, among others: (i) the access of the society to the energy is limited, (ii) if the energy export increases, then the import of oil show the same propensity, (iii) the energy industry has not optimal, (iv) the of energy price is not representing the real one, (v) the dynamism of crude oil price in international market in the recent years tends to increase, and it is expected that it will not be able to return to former price in the early 2005.

The subsidy policy, as it is adopted by the government until at the present time, will bear the following consequences: (i) the development of energy alternative will be hampered, (ii) expediting the Indonesian condition to become one of the oil net importer countries, and (iii) the subsidy will jump up.

Various problems on energy has triggered many instituions to seek a retort. The Department of Energy has published The Blue Print of National Energy Management (in Indonesian Pengelolaan Energy Nasional. The State Ministry of Research and Technology embarks on the Landmark of Energy 2025 that become the basis of the White Paper on Energy which is part of the National Strategic Policy on S&T Development 2025. The Department of Marine and Fishery produces the Marine Policy in which the energy concern has been raised up. The Indonesia National Oil Company (Pertamina) and the National Electricty Board (in Indonesian Perusahaan Listrik Negara) have launched policies as to how they will cope with the increasing oil price and fulfill the electricity demands. Those institutions realize that if the problems are not solved immediately, it will give a wide impact that tend to disturb the national energy supply and its sustainability. The disturbance will affect other aspects of life such as investment on new industries decreasing, socio-economic problems and even politics. Apart from that, the higher the subsidy the smaller the budget for the development becomes.

The role of S&T in supporting the achievement of the objectives stated in the Blue Print of the National Energy Management 2005 - 2025, is mainly related with the capacity and utilization of technology. The objectives are, among others: (i) the increase of energy consumption per capita should be balanced with the increase in efficiency in energy utilization, (ii) ratio of electrification as percentage of population, (iii)

the security of energy supply and its sustainability, (iv) the utlization and the percentage of renewable resources based energy within national energy mix supplies, (v) increasing the local content within the preparedness of energy infrastructure.

Under the assumption of good energy management, the followings condition in the year 2025 are expected : (i) the increase of access to energy, (ii) security in the energy supply, (iii) increasing the purchasing power of the society, (iv) the energy price represent the real cost. Whereas, the National Energy Management as targeted: (i) the national consumption per capita increase to 10 BOE and the ratio of electrification is 95% in which 5% of it is fulfilled by renewable resources based energy, (ii) the materialization of domestic energy supply, and (iii) the realization of energy mix scenario.

The following discusses the national policy in facing the increasing demands of energy, especially concerning the renewable one.

THE PRESENT CONDITION

The utilzation of energy in Indonesia increases proportionally with the increasing national economic and population growth. On the other hand, access to energy is one of the prerequisite to improve the life standard of society. The access to energy is presumably one of the causes that has made the level of energy consumption of the Indonesian people very low as compared to her ASEAN neighborhood.

The utilization of the energy has not been optimal yet. This can be seen by the fact that the elasticity of energy utilization of the Indonesian is exceeding 1, whereas the intensity of energy is higher than ASEAN member countries. In the year of 2002, Indonesia needed 4.7 SBM to produce US$ 1,000,- GDP, whereas other ASEAN countries needed only 3.9 SBM.

The primary energy resources, be it fossil or non-fossil, available in Indonesia is depicted in Table - 1. The renewable resources is abundant e.g. geothermal, biomass, solar energy, wind and marine. However, the non-fossil ones have not been optimally explored due to the non-availability of technology.

Table 1. Primary energy sources in Indonesia (2003)

FOSSIL BASED ENERGY	AVAILABILITY	RESERVATION	ANNUAL PRODUCTION	RATIO CAD/PROD
Oil	86,9 Billion Barrel	9 Billion Barrel	500 Million Barrel	18
Gas	384,7 TSCF	188 TSCF	3,0 TSCF	62
Coal	57 miliar ton	31,5 miliar ton	130 juta ton	242

NON-FOSSIL ENERGY	AVAILABILITY	EQUIVALENT	UTILIZATION	INSTALLED CAPACITY
Water	845,0 Mill BOE	75,67 GW	6.8851,0 GWh	4,2 GW
Geothermal	219,0 Mill BOE	27,00 GW	2.593,59 GWh	0,8 GW
Mini/micro hydro	0,46 GW	0,46 GW		0,064 GW
Biomass		49,81 GW		0,302 GW
Solar		4,80 kWh/m2/hari		0,005 GW
Wind		9,29 GW		0,0005 GW
Uranium	34.112 Ton*	33,0 GW		

*only in Kalan - Kalimantan

Although the energy resource is abundantly available, the reserve per capita of energy is not big enough. The used of fuel increasing very fast, especially for transportation and it is not replaceable by other form of energy. The dependence of the fuel to oil is still high reaching more than 60% of the total energy. The electricity generators in several area are usually also oil and coal dependence because the location is quite far from, for example, geothermal resources.

The domestic oil resulted domestically is exported, and the domestic demand is fulfilled by importing oil from other countries. The ratio of the exported to the imported oil is lessening due to the problem of new resources as well as exploration capability. New oil resources are rarely found recently, and the exploration capability is remain. The establishment of new refineries is getting

less and less built within the last 10 years. On the other hand, the domestic demand increases. In the year of 2002, 30% of domestic demand of oil and fuel has been fulfilled by import.

Utilization of renewable resource based energy has not been so much, because its production cost is not competitive as compared to the conventional energy. Until 2002, installed capacity of renewable resource based generated electricity (Solar, Geothermal, Hydro, etc) is only about 59.5 MW. The biomass generated one is about 302.5 MW. The production cost of nuclear based one has been economical, but hindered by society acceptance and initial investment cost.

DOOMSDAY SCENARIO

The tendency of being dependence on fuel, of being wastefully utilizing energy, of being unstoppable and increasing on fuel subsidy, and of being high population growth may, at a certain time, lead to a situation that will impede the economic growth. If this condition cannot be avoided (doomsday), the state will be in difficult situation to restore it.

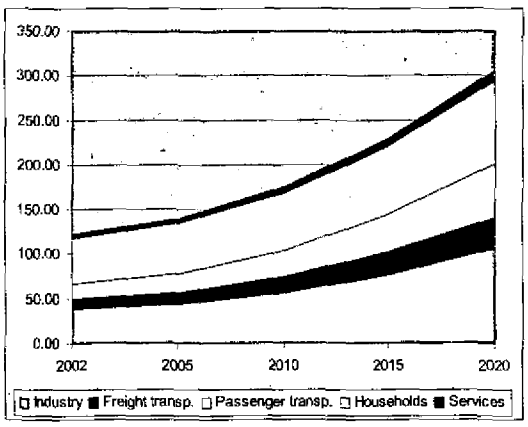


Fig - 1 Projected energy demand

At the present time, the energy policy is in the state of transition from centralized and monopoly to decentralized and tranparent one. The trend of globalization and political reform has forced energy restructurization in order to improve the efficiency and transparency. Energy utilization increases in proportion with economic and population growth. Whilst, limited access to commercial energy has caused the energy utilization per capita lower than other countries.

This scenario is widely accepted and developed on the basis of assumption that there is a wide disparity between big and small islands, Java and other islands in Indonesia. Furthermore, this assesment has projected that the annual population growth is 1.4% . The population will grow from 212 million in 2003 to 273 million in 2020. The economic growth has been assumed to be about 6% per year. The oil price per barrel is 25 $ increases to 28 $. Based on that, the projected energy demand and supply can be seen in Figs - 1 and -2, respectively. Whereas, Figs - 3 and - 4 show the projected capacity of electricity generated and the electricity production in Java and Bali area based on the fuel used. However, recently the oil price hikes three times as high as the projected scenario. This situation sees to worsen the crisis.

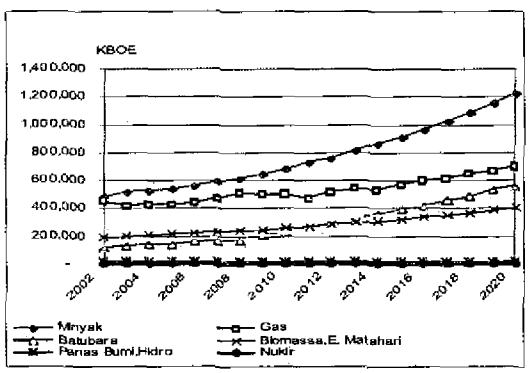


Fig - 2 Projected energy supply

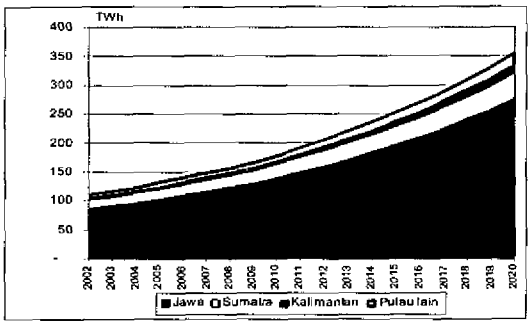


Fig - 3 Projected generated electricty (TWh)

Therefore, a long term national policy on onergy that can solve the main challenges to materilize the energy sustainability, is of necessitate. The State Ministry of Research and Technology has developed a white paper on energy sustainability, partly based on the doomsday scenario. The condition within which the energy availability is getting worse and worse affecting the political, social and economical condition of national life.

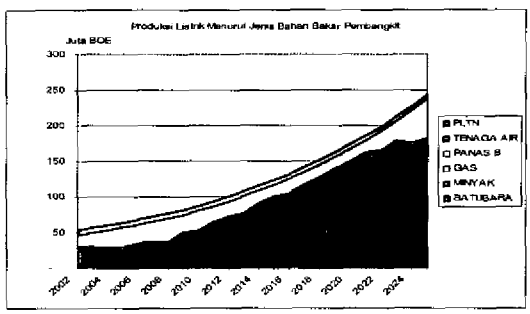


Fig - 4 Electricity produced based on the fuel in Java and Bali

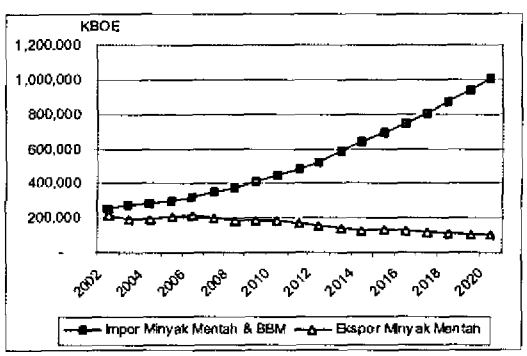


Fig - 5 Import and export projected of Indonesian crude oil

Under the doomsday scenario, the Team has also calculated the projected imported energy from 2002 till 2020. Indonesia is one of the richest oil countries, but the situation describes different story. The major part of the crude oil produced domestically is exported, whilst the domestic demand is fulfilled by importing from other country, namely mid-east. The refinery process takes place partly abroad, and needs subsidy. The projected volume of import shows in Fig-5.

Under the assumption of this scenario, the imported oil amplifies, while the exported one declines. Considering that, it can be clearly understood that the subsidy will rise. Furthermore, the amount of subsidy will be depending on the foreign exchange as well as the price of oil per barrel on the spot market. The rise of subsidy will burden the national developmet budget that impede social, economical as well a political life.

ELECTRICITY DEMANDS

Electricity is an essential part that cannot be separated from people daily life. Therefore, sustaining electricity supply is very important. However, the demand of electricity increases. As mentioned, the growth of demand is proportional to the economic activity, population growth as well as infrastructure development. In the big towns, the factor may be doubled due to industrialization, property development, etc. In Indonesia, the classification broadens due to the fact that Indonesia is an archipelagic country. In addition to unbalance growth of demand in the small and big towns, the disparity also emerges between big islands and the small ones, the western and the eastern parts of the country.

AREA	Installed Capacity (MW)	Dependable Capacity (MW)	Peak Load (MW)	Waiting List (MW)	Reserve (MW)
Middle Kalimantan	66.9	50.5	43.8	11,186	6.7
South Kalimantan	312	254.1	185.7	13,842	68.4
East Kalimantan	315.0	193.0	177.3	23,389	15.7
North Sulawesi & Gorontalo	198.1	153.7	145.2	15,177	8.5
Middle Sulawesi	108.5	71.6	63.7	480,002	7.9
South Sulawesi	455.4	357.1	348.4	41,619	8.7
South-East Sulawesi	24.5	19.0	14.4	11,574	4.6
Area IX	108.2	61.7	56.0	492	5.7
Area X	116.8	87.5	72.4	15,299	15.1
NTB	133.8	98.4	103.7	6,314	-5.3
NTT	97.3	53.2	54.3	5,690	-1.1
TOTAL	1,936.5	1,399.8	1264.9	623,784	134.9

Tabel - 2 Electricity load in Indonesia in 2003

Statistic data of PLN in 2001 shows that in the area of Java, Madura and Bali (Jamali) the installed capacity is 18.636 MW, and the load capacity is 17.602 MW, whereas the peak load reaches 13.272 MW. In other big islands such as Sumatera, Kalimantan, Sulawesi and Papua, the installed capacity is 5.565 MW, and the load capacity is 4.327 MW, whereas the peak load reaches 3.732 MW. As seen, inJamali and other islands, the ration of the installed capacity reaches one third.

As projected, the rate growth of demand in Jamali area will be higher than other islands or than those at the eastern part of Indonesia. It can also be noted that since 1998 till 2003, the development on electricity generator or investment on electricity is not so much, if it may not be stated none. The problem on fulfilling the electricity demands is not only caused by the the unbalanced growth between Jamali, but also the un-evenly distribution of supply between Jamali and other are outside Java islands. This causes many electricity generators in the Java area works overloaded.

In the area outside Java, the opportunity of development of electricity generators is related with the projected demand in the future. However, its development pre-requisites infrastructure availability in which most of the investors is being reluctant, because the infrastructure outside of Java, Bali and Madura is not as much developed as compared with Jamali.

Table-2 shows the electricity load in Indonesia in the year of 2003. The total waiting list in the whole area attains 624 MW. It can also be dechipered that there a wide disparity between the west and the eastern part of Indonesia. The demand in the eastern part is high; however, the development of generator is constrained by the geographical condition, primary energy back up resources and infrastructure, man-power, technology as well as logistics.

ALTERNATIVE OF ELECTRICITY PRODUCTION

There are many alternatives choices of primary energy resources for electricity production that is available abundantly in Indonesia. The fossil fuel based seems to have been unpopular recently due to oil price hike. Global warming, carbon emission, climate change is also contribute to the constrained in developing new fuel based electricity generators. Due to that, government and also environmentalists often encourage researchers to find better alternative of energy resources.

Such alternatives are wind, solar, biomass, geothermal, nuclear and marine. Common alternative of generators are water or geothermal based ones. However, these types of generator demand infrastructure and logistical support availability as a prerequisite for the development of generators.

The solar energy has long been investigated. Solar based energy is still expensive due to the state-of-the-art of the present technology. It is predicted that until 2013, the solar energy will not serve as the best alternative for the low-income people. Price is not the only constrained. The fabrication of solar cell

has not been available. Moreover, the patterns of sun rise and sun set, as well as cloud pose other problems in storing the energy produced. A better method to store the energy is needed. Fig - 7 shows the calculated price per kilo-watt hour of fossil fuel based as compared to the alternative resources of energy .

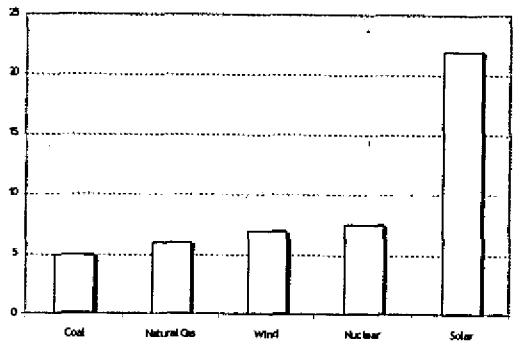


Fig - 7 The price per kilo-watt hour electricity production in [c$]

To avoid the patterns of sunset, sunrise and cloud, the wind can be selected, instead. Basically, the wind arises caused by air warming. It can also be noted that this is another way to collect the solar power, but it can be done during the dark. The use of wind as the primary resource has also been widely investigated.

The biggest one has recently been established in Denmark. More than 18 ton of carbon fibre was used to construct propellers whose length is 61.3 m and turbine whose hight is 183 m, six times as high as the Liberty Statue in New York. In the northern part of German Coastal, a 5 MW prototype of wind energy will be constructed thal will light up more than 5000 houses. The construction of wind energy in Europe and USA depicted in MW per year installed capacity is shown in Fig - 813. The popular wind energy in Europe is encouraged by the incentive of carbon credit materialized through tax reduction policy.

Another alternative that is also popular is biodiesel. In fact, this type of energy has been used through the years as old as the world age started when the people used wood to burn and warms their body. The biodiesel also presents the preliminary hydrogen era of energy. The hydrogen is still a mere challenge. The process of capturing hydrogen from water is a bit expensive due to the state-of-the-art of the present technology. Indonesia has a large amount of quantity of CO in Natuna Island as well as water. This present the potential reserve for the future energy based on hydrogen.

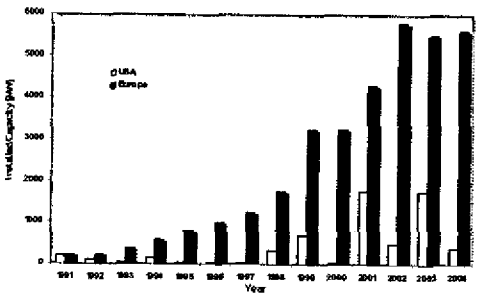


Fig - 8 Installed capacity of wind energy [MW] in Europe and USA

German and Brazilia are two countries that used biodiesel as the alternative fuel for transportation. In German, 3% of the diesel demand is fulfilled by biodiesel. Brazillia is famous for the Saudi of Ethanol. As an alternative of fuel for air transportation, biodiesel has been commonly used instead of avtur in Brazillia. There are more 320 ethanol production factories in Brazillia.

Nuclear serves the most efficient way to produce energy. However, the shadow of atomic bomb in Hiroshima, Nagasaki as well as the leak of Three mile Islands in the USA and the Chernobyl of Russia has increased some concerns on the safety of nuclear power generation. Though economically and

technologically viable, the nuclear faces the problem of acceptance, at least in another 5 years to come.
Another alternative that has not been explored yet is the ocean. The marine serves as the potential resources of energy. The potentiality shows by the fact that its wave gives 10 - 35 kW/m coastal line, the thermal prospects more than 240 MW of energy, and the tide guarantee to serve more than 3000 MW. There have been several investigation worldwide, however, the structure of waves pose difficulties to construct power generators in the off-shore.

In the last 10 ten years, a type of renewable resource of energy based on marine current has been developed. Among others is Enermar Project. The project is developed based on the technology invented and patented by Ponte di Archimede of Italy utilizing the inner current to drive the turbin fan sunk under the sea current. This generator can be established off-shore at a distant not more than 100 m from the coast line. A typical so-called Kobold power plant can generate 200 kW at the current speed of 2 m/s. The Kobold is driven by three airfoil type of fan moving on the vertical axis sunk under the sea. This power plant is environmentally sound due to non-carbon emitted as compared to the traditional generator or fossil fuel based ones.

INDONESIAN SITUATION ON RENEWABLE RESOURCE ENERGY ALTERNATIVES

To develop electricity generator, especially in the Eastern part of Indonesia, needs a strict consideration on the geographical condition, population distribution, and infrastructure as well as logistic. In West Papua, for example, where water is abundant, the water based power plant may provide an alternative. However, infrastructure and logistical as well as geographical problems - at least at the present state - seems to constrain the development of water based electricity generator.

Indonesia poses many energy alternatives apart from the fossil based one. The sun shines in 12 hours per day, 360 days per year. The potential of solar energy is abundant. However, since the technology and the price per kilo-watt hour is still expensive, the development of equipment such as ingot and solar cell is far from economic achievable price. In the laboratory scale, the activity of solar cell development takes place in the Indonesian Science Institute (LIPI in Indonesian) and the Agency for the Assessment and Application of Technology (BPPT in Indonesian). The Lab scale of solar cell developed by BPPT has successfully connected to the national grid in August 5, 2005. However, the application of solar energy for industrial purposes is still far from reality. Moreover, for mass supplied, the use of solar cell is hindered by the fact that there is not any solar cell industry in Indonesia.
In the northern part of Sangihe and Talaud Islands, also in the Northern part of West Papua and other places, sucah as Nusa Tenggara, the wind speed may reach 15 mps at certain time of the year. This might give other alternative of wind energy. The wind based energy will be efficient if the wind speed exceed the cut-off speed that is approximately 12 mps. Apart from what have been mentioned above, there are not so many places in Indonesia that the wind speed arrives at 12 mps. The development of laboratory scale of wind engineering has been conducted at the National Aeospace Institute (LAPAN in Indonesian) and at BPPT. A small scale prototype made by BPPT is now being installed in the southern Yogyakarta. Whereas, a small scale type established by LAPAN is constructed in

Nusatenggara Timur. The further development of wind engineering is also still far from industrial type one. Furthermore, the wind velocity does not remain at the same speed, at some period of the year; the speed is less than that of cut-off speed. This poses another problem with the converter.

Since a year ago, BPPT has investigated and developed biodiesel and bioethanol. The result of which has been used for its own vehicle. The Minister for Research and Technology even uses his vehicle to be fueled by the ethanol produced by BPPT in mixture based. The use of pure bioethanol needs necessary modification of the engine due to its burning characteristics. But, the utilization of ethanol in mix with petrol within the ratio of 10 : 90 has a better effect in the environment.

The research on biodiesel as part of the renewable source of energy has resulted a good impact. The demand increases everyday. An alternative of raw material has been proposed that is the Jatropha Curcus. This plant is famous for nothing except for veterinary feeds stock. As the investigation progreses, the people expect the outcome. The use of biodiesel for electricity purpose has, however, not been investigated yet.

Further, the State Ministry of Research and Technology, in one of the National Priority Fields stipulated within the National Strategic Policy on the Development of Science and Technology submitted to the President at the day of commemorating the 10th National Technology Day, has emphasized the necessitate of sustaining the creation and use of new and renewable source of energy. In addition to that, the Department of Energy and Mineral Resource stated that the use of biodiesel has been projected up to 2% at the year of 2010, 5% of the energy demand should be fulfilled with renewable sources.

The one that has not been explored and exploited is the ocean. The length of coastal line in Indonesia is about 80.000 km. This provides a potential energy up to 2,800 GW. This number is twice as high as the world peak power. Yet, it's never been touched. Some years ago, BPPT started the investigation of Ocean Thermal Energy Conversion (OTEC). The prototype of OTEC had been placed in the Bali Strait. Bali Strait, in fact, poses the best place that ocean thermal can support for such a type of power plant. But, further investigation is no-where when the project aid was concluded.

In the Laboratory of Coastal Dynamics of BPPT, a lab scale prototype of an Ocean Wave Conversion (OCW) is now being developed (Fig - 9). The real simulation has been conducted at this lab. The lab has capability to run a real simulation of any offshore installation.

The alternative of utilizing the current energy has started gain attention in the last 5 years. Though technology has not been matured yet, but, the potential energy that can be resulted attracts many investigators to look into the possibility of exploiting the marine current. A Gorlov Type Marine Current has been started to be developed by one of businessman in Bandung. The fiberglass helical type of turbine propels and drives a floating generator turbine at about 100 - 200 per minute. The electricity is expected to be connected with national grid.

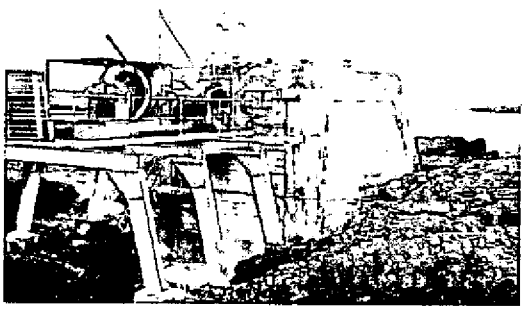


Fig - 9 Installation of Ocean Wave Conversion in Yogyakarta (Courtessy of Coastal Dynamics Lab)

Another type under investigation is Kobold Marine Current developed by Ponte di Archimede. The Kobold is driven by three airfoil type attached to the vertical axis which is connected with floating generator. The fan rotates in a very slow rotation at 8 rpm. This rotation will not disturb the fish and other marine creature.

POLICY ON RENEWABLE RESOURCES OF ENERGY

The installed capacity and the peak load in the year 2005 at some places is shown in Table-2. There are a lot of deficits. If it is compared with the installed capacity in the year of 2003 (Table-1), one can calculate the rate of demand and rate of new supply provided by the National Electricity Board (in Indonesian PLN). Fig - 11 shows the coverage areas of distribution that has been reachable to the national grid.

The projected deficits will be much higher as the new power plants are not developed in the last 5 years. The PLN has targeted that by 2020, 90 % of housing electricity should be satisfied. It means that starting 2005, the PLN should add and develop a new power plant that can supply 450 MW/year.

AREA	CAPACITY [MW]	PEAK LOAD [MW]	RESERVE [MW]
North Sumatera	940,0	1.016,0	(-) 76,0
Riau	114,0	168,0	(-) 64,0
South Sumatera	1.189,0	1.265,0	(-) 76,0
Java - Bali	19.500,0	15.500,0	4.000,0
Kalimantan	32.6	33,8	(-) 0,8
NTB - Mataram	75,0	74,0	(-) 1,0
South Sulawesi	343,0	367,0	(-) 4,0
Papua	28,0	29,0	(-) 1,0

Table - 3 Total Power Deficits in 2005

The investment needed to develop such a huge objective from 2005 to 2015 is about 28.072 Million US$ the allocation of which is for the power plants is 50.6%, for the transmission facility is 31.2%, and for the distribution is 18.2%.

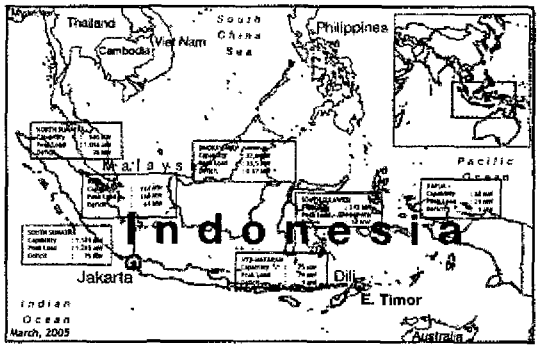


Fig - 10 The Mapping of Electricity Deficit in Indonesia by 2005

Indonesia is the largest archipelagic countries in the world, not all of her islands are "reachable" from the point of view infrastructure development and thus the national electricity grid, especially islands in the eastern part of Indonesia and also many of her small islands scatterd surrounding the bigs islands. More than 6,000 villages and around 20 million households in the country are still left not electrified. The electricity, if any, is supported by diesel-based generator, which is not only environmentally damaging, but also - from the supply perspective - climate and weather dependent. Therefore, if infrastructure is not sufficiently available, the diesel fuel transportation will be logistically difficult.

Figure - 10 shows the electricity deficit in the year of 2005. The electrification targets cannot be met since PLN is currently unable to expand its power generating and distribution capacity due to the financial difficulties using the traditional electrification (fossil fuel based) approach of grid extension. Government can fulfill only 10 - 20% of the demands. The remaining is left fulfilled by

private entities.

It is in this perspective that the government has stipulated policy to regulate the energy growth the availability of which also encourages private entities to participate. The Government Regulation No. 3/2005 pertains to furnish national electricity demands. This regulation is the revised version of the regulation No. 10/89 which addresses the same problem. This regulation is very prospective in term of renewable energy small scale power plant, because it puts the renewable resource of energy as the first priority.

The Blue Print of National Energy Management 2005 - 2025 states that based on the national energy mixed scenario, the goal of overall renewable energy utilization in 2025 is 6.4%. The segment of renewable resource energy for electricity in the year of 2020 is 5 % of the total installed capacity. Within this document, the scenario of role of renewable energy has been accelerated and targeting to fulfill 4.82 % of installed electricity capacity in the year of 2025. And the remaining 1.33 % is fulfilled by biofuel. This scheme of policy is part of the promotion on the "Green Energy Program" under the proposed "Energy Law".

RESOURCES	POTENTIAL [MW]	INSTALLED [MW]	EXPECTED INVESTMENT [US$/kW]	EXPECTED ENERGY COST [US$/kWh]
Hydro (big scale)	75,764	4,200	1,500 - 2,000	0.035 - 0.045
Mini/Micro Hydro	459	32	1,000 - 2,000	0.035 - 0.060
Geothermal	27,000	800	900 - 1,500	0.03 - 0.05
Biomass	49,810	302	1,200 - 1,500	0.04 - 0.06
Solar	4 - 6.5 kWh/m²/day	5	4,000 - 6,000	0.5 - 0.9
Wind	> 8 m/s	0.5	1,000 - 1,500	0.05 - 0.06
Marine (Coastal)	35 kW/m coastal line	None	500 - 1,000	0.045 - 0.09

Table - 4 Indonesian's Renewable Energy Potential

The potential support of renewable resource of energy to supply the electricity can be seen in Table - 4. The hydro plant is potentially in the big islands such as in Java (4.2 GW), Sumatera (15.6 GW), Kalimantan (21.6 GW) and other islands (33.6 GW). Curently, total capacity of hydro plant is just 6% of its total potential. By 2004, approximately 32 MW Mini and 22 MW Micro Hydro Power Plants had been installed.

The geothermal is mostly located in Java, Sumatra, Bali, Nusa Tenggara, Sulawesi and Maluku. The total installed capacity is about 800 MW, and all of them are interconnected to the national network grid system. The potential of biomass is about 49,810 MW. The biomass based electricity is generated through the farming/plantation waste (rice husk skin, coconut shell, palm oil bunch, etc). Curent total installed capacity is 302 MW. The potential location is in Sumatera (1,800 MW), Kalimantan (500 MW), Java (380 MW), and other islands approximately 120 MW.

The heat radiation in Sulawesi, Bali and West Papua reaches 6 - 6.5 kWh/m2/day. This range is the most effective cut-off radiation. In the mountain area the radiation decreases till 4.5 - 5.5 kWh/m2/day. In Kalimantan, Java and Sumatra has an average radiation of about 4.5 kWh/m2/day. Total installed capacity is 5 MW and mostly used for private households.

Indonesia lies in equatorial line which is likely to have less wind. The total potential is approximately 448 MW. Curently installed capacity is 0.5 MW, but most of electricity is for pumping, refrigeration and battery charging. The potential area for wind energy is Nusa Tenggara and Sulawesi that have about 10 - 100 kW size of wind.

As stated above, that the length of coastal line in Indonesia is about 80.000 km. This provides a potential energy of about 2,800 GW. This number is twice as high as the

world peak power. However, none of the report shows that this type of energy has been exploited for electricity purpose.

The approach of Renewable Energy Small Scale Power Plant (RESSPP) is basically not only solely to provide energy but also to create a better social life. Having the community actively participates in electricity generation, it is expected that the supply would be more sustain in the long run. Vice versa, the activity will give a mutual benefit between local community and local government as well as investor. Therefore, the policy of the development RESSPP is put under the communicaty based development concept. The concept emphasizes the participation of local community.

The interconnection to the national grid which is managed by PLN is regulated whether the connection is made to the medium or low voltages distribution system. In the case of the connection is made to the medium voltage distribution system, thence the tariff is about 0.8 LN's medium voltage production cost. On the other case, the tariff is only 0.6 of PLN's low voltage production cost.

Concerning the electricity supply, the government promulgated a new law in electricity (Law No. 20/2002) that put PLN as regulator instead of a sole authority in providing electricity and in distributing it. But, the Law 20/2002 has been annulled by the Constitution Commission on December 2004. Therefore, the regulation on electricity supply and also the authority are based on the Law No. 15/1985.

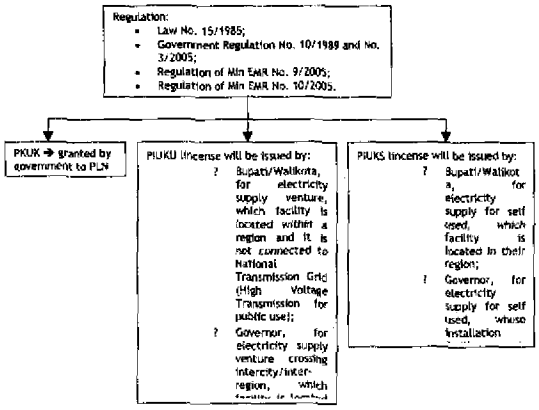


Fig - 11 The mapping of licensing process of electricity venture

Under this Law, the electricity venture is conducted by the Government and run by State Owned Company (PLN). Based on rule and regulation, PLN is the sole holder of Electricity Supply Venture Authority (PKUK). There are two license holders that can participate to supply electricity: PIUKU - license holder of electricity for public use and PIUKUS - license holder of electricity for own use. The license is issued by head of local government (City Mayor/Regent - Walikota/Bupati, Governor or Minister depending on their respective jurisdiction), under following regulation:

o PIUKU lincense will be issued by:
o Bupati/Walikota, for electricity supply venture, which facility is located within a region and it is not connected to National Transmission Grid (High Voltage Transmission for public use);

o Governor, for electricity supply venture crossing intercity/inter-region, which facility is located within one province and it is not connected to National Transmission Grid;
o Minister, for electricity supply venture crossing inter-province, which facility is connected or not connected to National Transmission Grid;
o PIUKS lincense will be issued by:

o Bupati/Walikota, for electricity supply for self used, which facility is located in their region;
o Governor, for electricity supply for self used, whose installation facility is located crossing intercity/inter-kabupaten (regent) within one province;
o Minister, for electricity supply for self used, which facility is crossing inter-province.

The mapping process of the license as far as the national electricity supply is shown in Fig-11. The Ministerial Decree No. 10/2005 regulates the lincense issued by the Minister. Acordingly, the regional/local regulation directs the issuance of a license by Walikota or Bupati or Governor.

The electricity supply, in accordance with Law No. 15/1985, can be done by PKUK or PIUKU, or purchase from other entities. The electrity purchase can be done in two ways: direct appointment or public tender. The purchase shall be matched with the National Electricity Master Plan issued by Minister. Figure - 12 shows the electricity supply provision by PKUK and PIUKU.

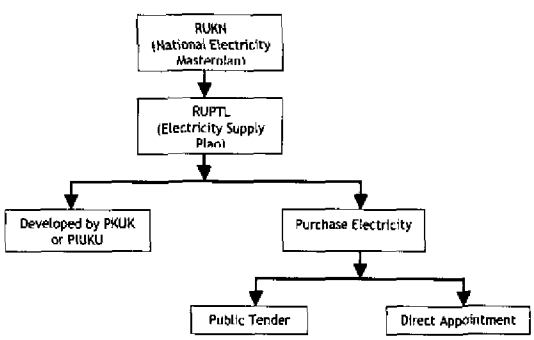


Fig - 12 Alternative of electricity supply provision by PKUK and PIUKU

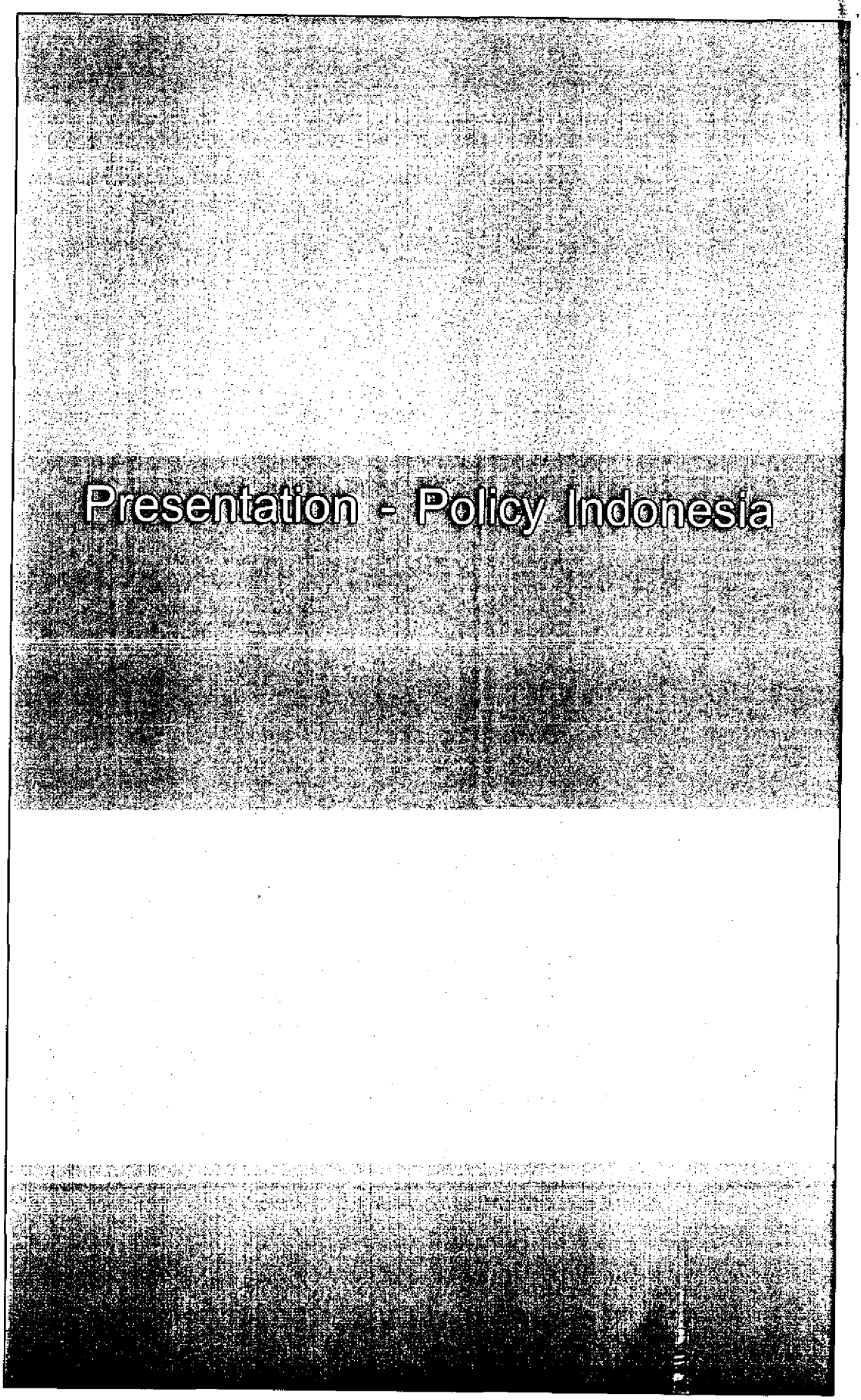
The purchasing methodology through direct appointment is arranged by the Ministerial Decree18 No. 9/2005. PKUK or PIUKU submit a plan with its rationale for electricity purchase, which will be done by direct appointment, to the Minister through Director General of Electricity and Energy Utilization, to ge approval; while for cooperatives and other business entities may submit a proposal to sell electricity to PKUK or PIUKU through direct appointment. The direct appointment by PKUK in electricity purchasing can be done in case of one of the followings: (i) its generation is utilizing renewable resource of energy including mini/microhydro, geothermal, biomass, wind, solar, marginal gas, coal at mine mouth, and other local energy, (ii) excess power, and (iii) if local electricity system is in critical shortage of electricity, the critical condition of which is decided and determined by the Director General of Electricity and Energy utilization.

CONCLUDING REMARKS

Despite the abundant resources of energy, Indonesia faces a critical situation in fulfilling the electricity demand. The rate of growth of the demand cannot be met by the government. Accordingly, the new government regulation No. 3/2005 stipulates not only inviting the participation of cooperative and private entity in supplying electricity but also emphasizing the new look into the renewable resource of energy.
Through Blueprint of National Energy Management, the government has targeted that the renewable resource of energy shares 6.4 % of the installed capacity by the year 2025 upon which by the year 2010 the objective can be materialized within 2%, and 5% by 2020.

The electricity supply provided by private entities has to fufill the national electricity masterplan. The mechanism can be done through public tender or direct appoinhtment. The participation of private entities, be it local or national; have to get an approval

through the local/national authority (PKUK/PIUKU), according to the regulation, depending on the location of facility and the connection with national grid.


Presentation - Policy Indonesia

GOVERNMENT POLICY ON THE PROVISION OF ELECTRICTY AND THE EMPHASIZEMENT OF RENEWABLE RESOURCE OF ENERGY

THE STATE MINISTRY OF RESEARCH AND TECHNOLOGY
INDONESIA

CONTENT

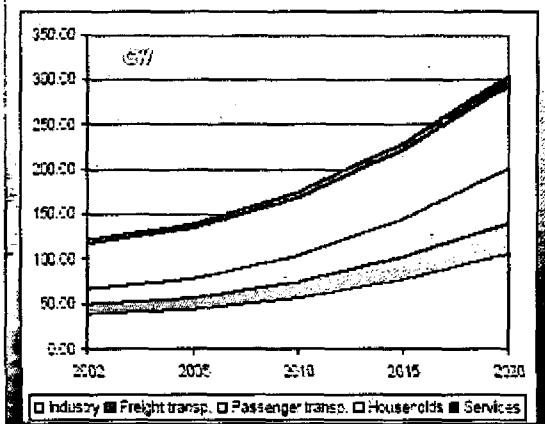
1. Introduction;
2. The Present Condition ;
3. Doomsday Scenario;
4. Electricity Load;
5. Potentiality of Renewable Source of Energy;
6. Activity of the Marine Object Related Testing;
7. Ocean Wave Generator;
8. Electricity Deficit;
9. Policy Toward Electricity Supply:
   - Renewable Source of Energy;
   - Landmark Energy 2025;
   - Electricity Supply;
10. Concluding Remarks.

PRIMARY ENERGY SOURCE IN INDONESIA - 2003

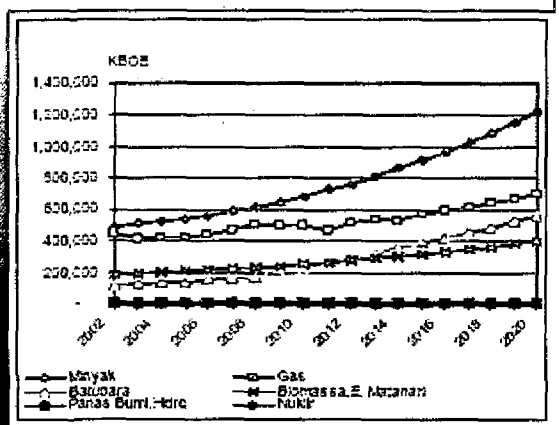
FOSSIL BASED ENERGY	AVAILABILITY	RESERVATION	ANNUAL PRODUCTION	RATIO CAD/PROD
Oil	86,9 Billion Barrel	9 Billion Barrel	500 Million Barrel	18
Gas	384,7 TSCF	188 TSCF	3,0 TSCF	62
Coal	57 miliar ton	31,5 miliar ton	130 juta ton	247

NON-FOSSIL ENERGY	AVAILABILITY	EQUIVALENT	UTILIZATION	INSTALLED CAPACITY
Water	845,0 Mill BOE	75,67 GW	6.8851,0 GWh	4,2 GW
Geothermal	219,0 Mill BOE	27,00 GW	2.593,50 GWh	0,8 GW
Mini/micro hydro	0,46 GW	0,46 GW		0,054 GW
Biomass		49,81 GW		0,302 GW
Solar		4,80 kWh/m2/day		0,005 GW
Wind		9,29 GW		0,0005 GW
Uranium	3.451,12 Ton	33,0 GW		
Marine		3000 GW		

DOOMSDAY SCENARIO OF INDONESIA - 1

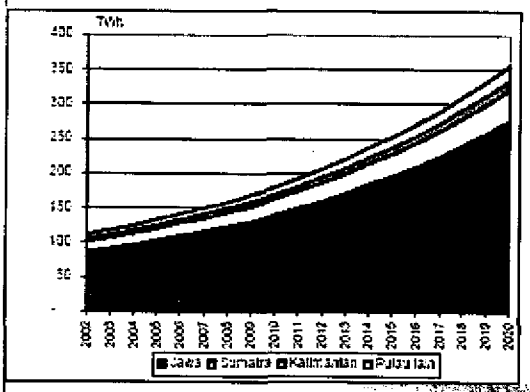


Projected energy demand

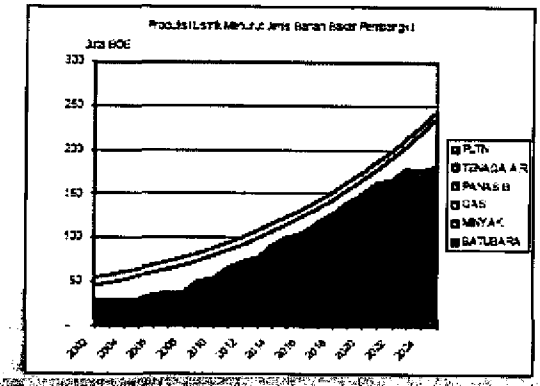


Projected energy supply

DOOMSDAY SCENARIO OF INDONESIA - 2

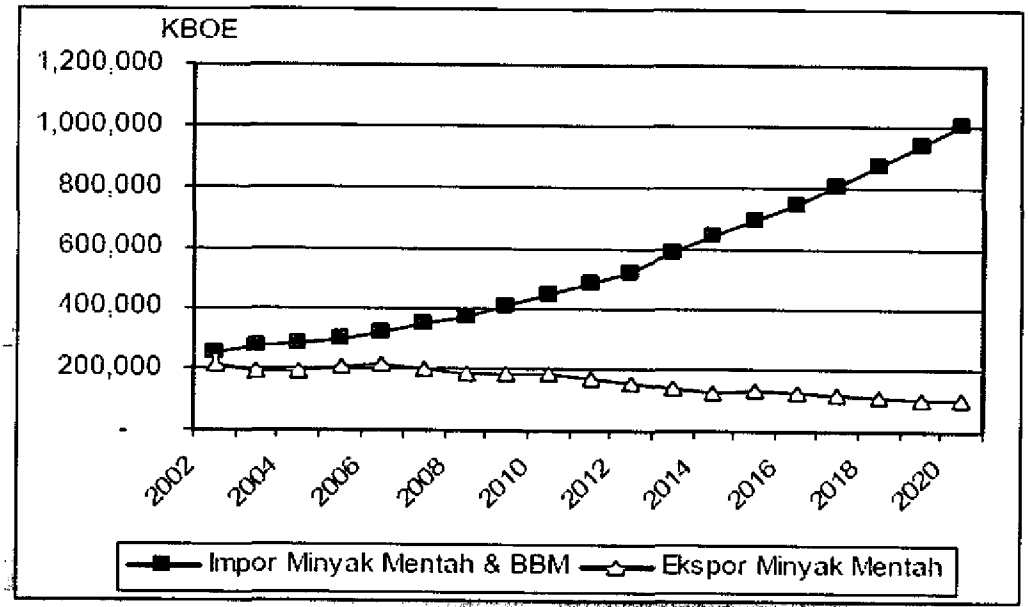


Project Electricity produced



Project Electricity in Java and Bali

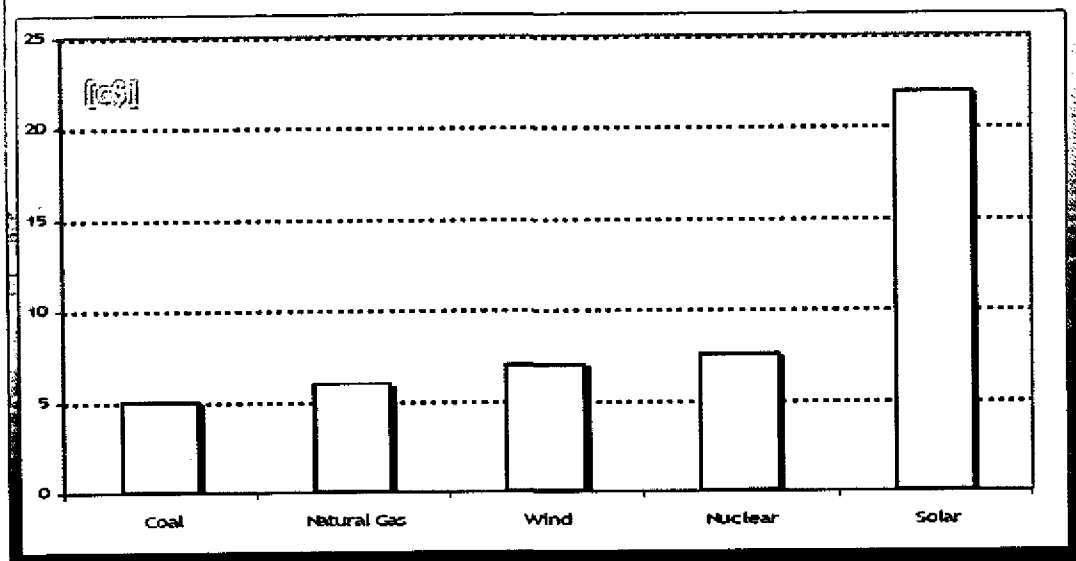
RATIO OF EXPORTED AND IMPORTED OIL

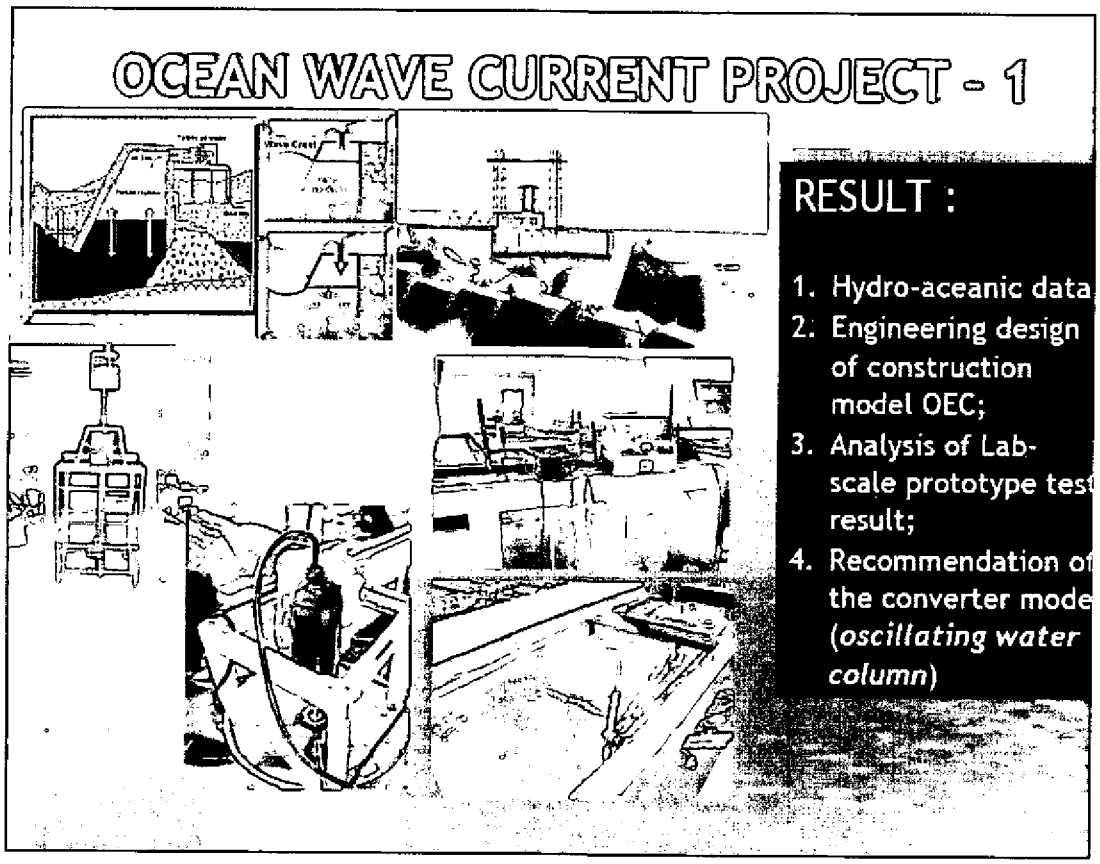


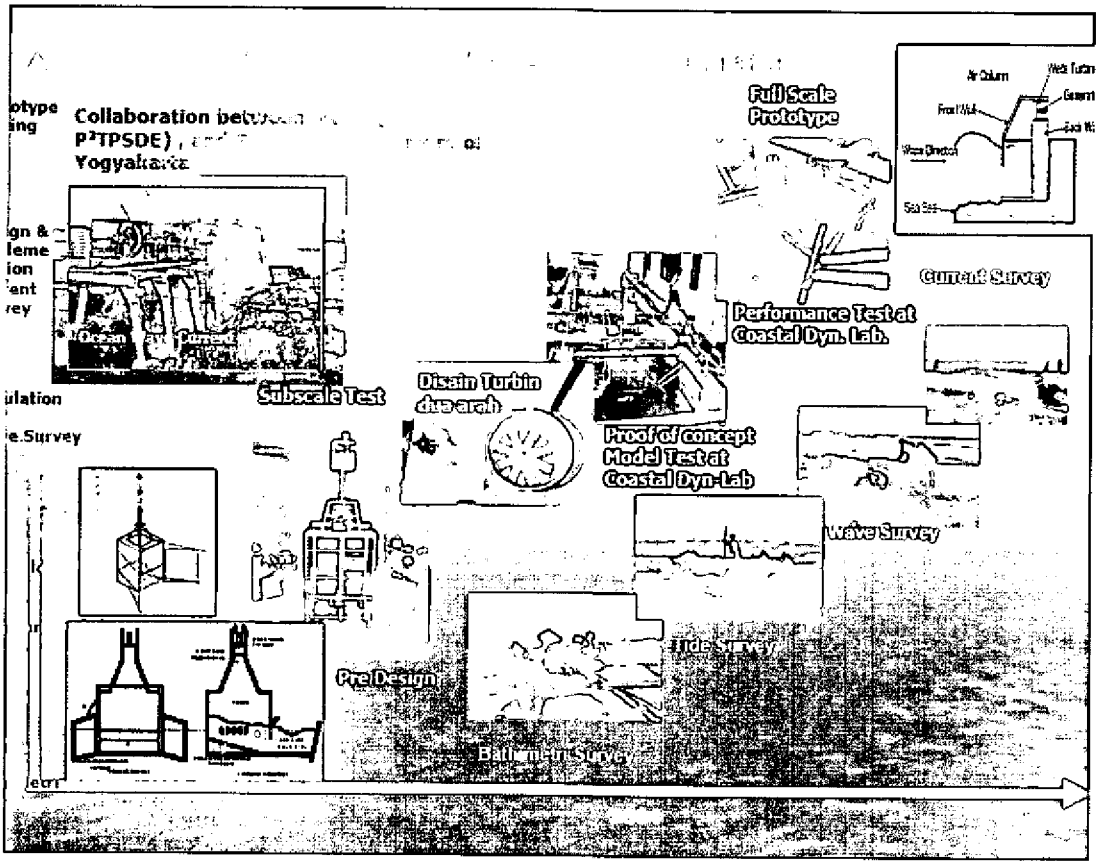
ELECTRICITY LOAD IN 2003

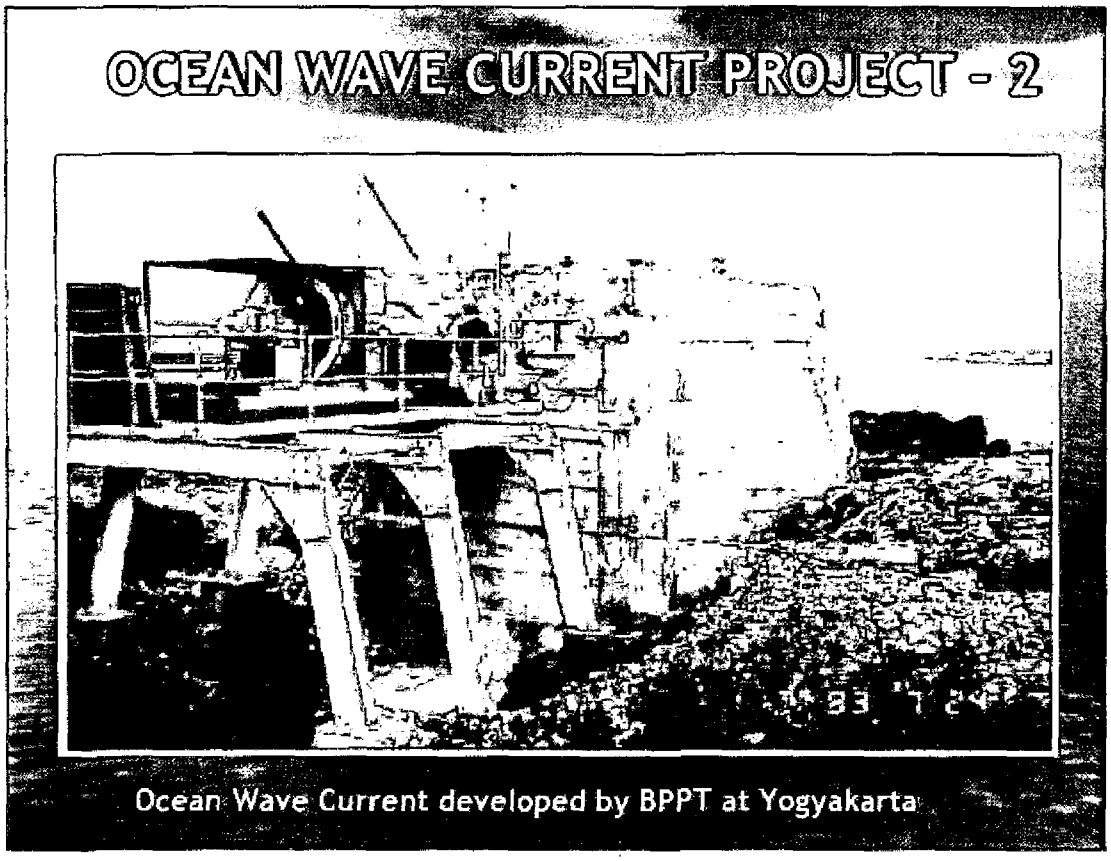
AREA	Installed Capacity (MW)	Dependable Capacity (MW)	Peak Load (MW)	Waiting List (kVa)	Reserve (MW)
Middle Kalimantan	66.9	50.5	43.8	11,186	6.7
South Kalimantan	312	254.1	185.7	13,042	68.4
East Kalimantan	315.0	193.0	177.3	23,389	15.7
North Sulawesi & Gorontalo	198.1	153.7	145.2	15,177	8.5
Middle Sulawesi	108.5	71.6	63.7	480,002	7.9
South Sulawesi	455.4	357.1	348.4	41,619	8.7
South-East Sulawesi	24.5	19.0	14.4	11,574	4.6
Area IX	108.2	61.7	56.0	472	5.7
Area X	116.8	87.5	72.4	15,299	15.1
NTB	133.8	98.4	103.7	6,314	-5.3
NTT	97.3	53.2	54.3	5,690	-1.1
TOTAL	1,936.5	1,399.8	1264.9	623,764	134.9

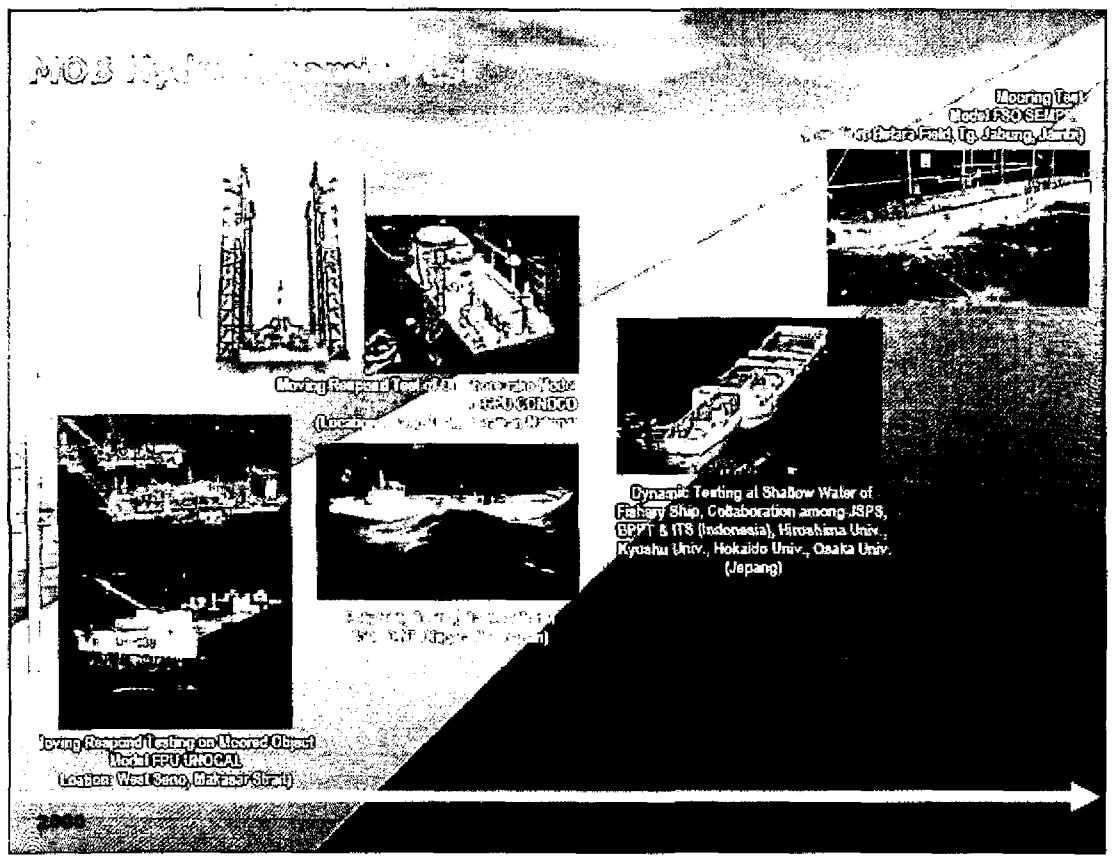
PRICE OF KWH RENEWABLE ENERGY




OCEAN WAVE CURRENT PROJECT - 1
RESULT :
1. Hydro-aceanic data
2. Engineering design of construction model OEC;
3. Analysis of Lab-scale prototype test result;
4. Recommendation of the converter mode (oscillating water column)


Collaboration
Yogyakarta
Subscale Test
Full Scale Prototype
Current Survey
Performance Test at Coastal Dyn. Lab.
Disain Turbin
Proof of concept Model Test at Coastal Dyn-Lab
Wave Survey
Tide Survey
Pre Design
Bathimetri Survey

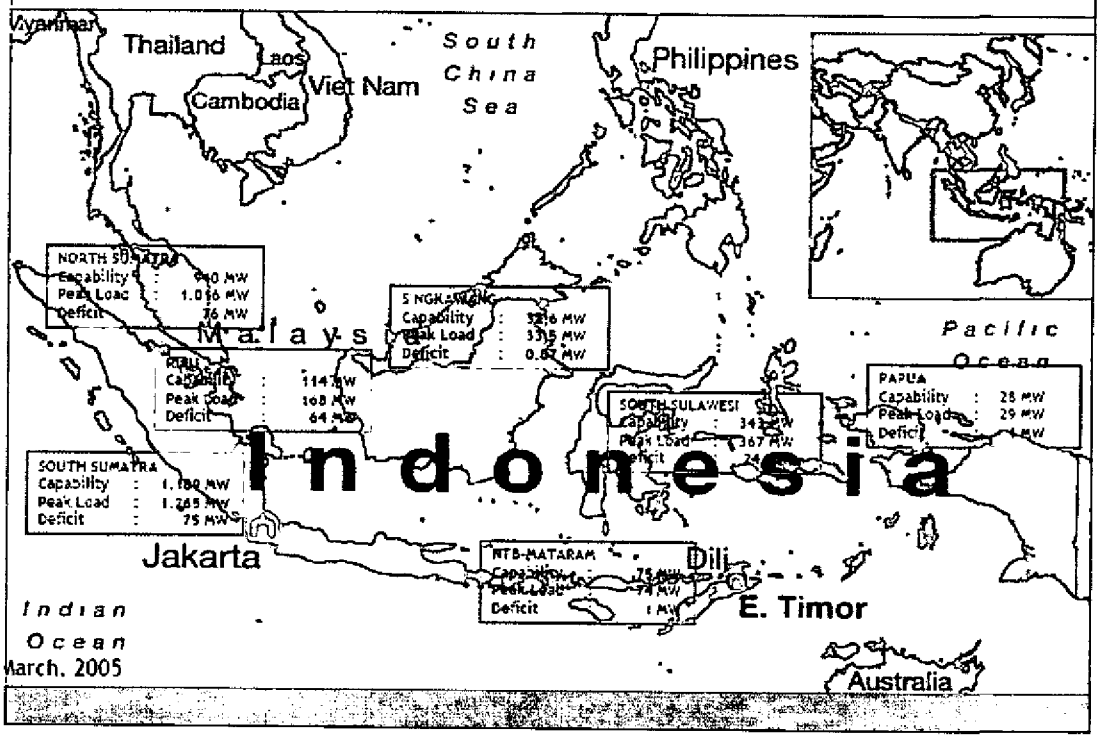

OCEAN WAVE CURRENT PROJECT - 2
Ocean Wave Current developed by BPPT at Yogyakarta

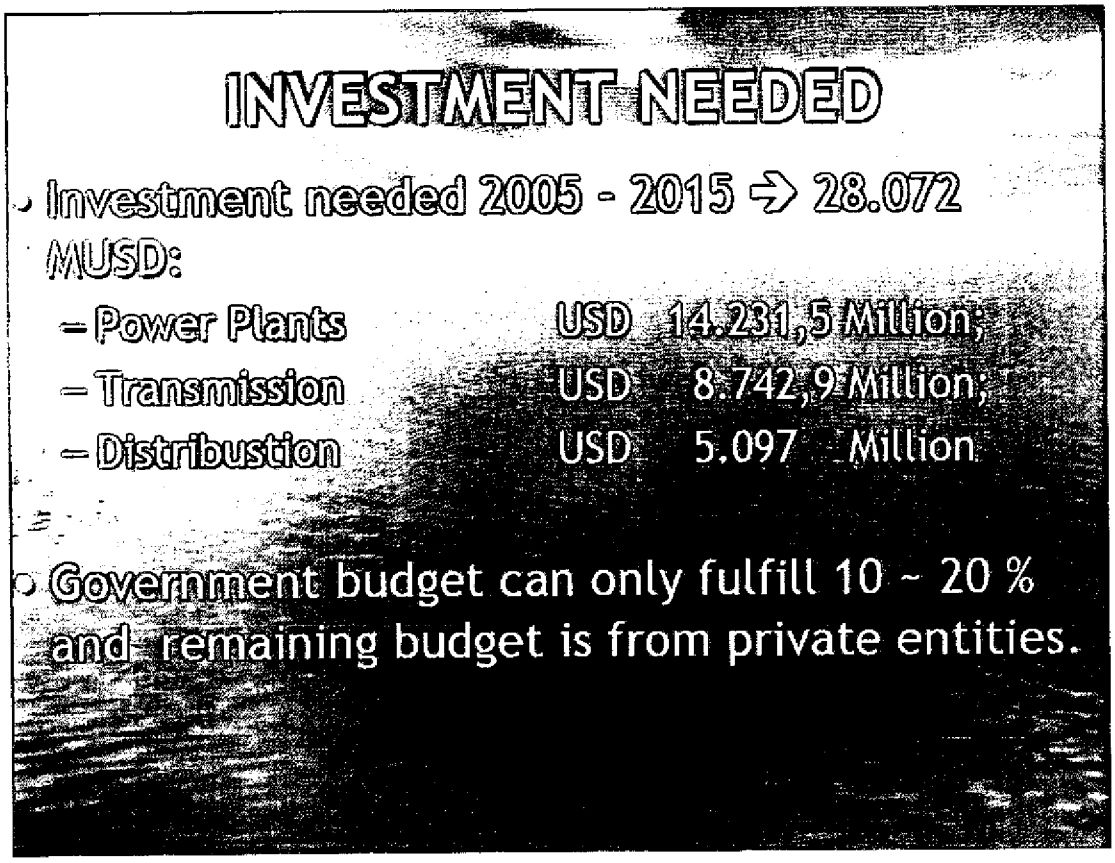

Mooring Test
Model PRO SEMP
Dynamic Testing at Shallow Water of Fishery Ship, Collaboration among JSPS, BPPT & ITS (Indonesia), Hiroshima Univ., Kyushu Univ., Hokaido Univ., Osaka Univ. (Jepang)

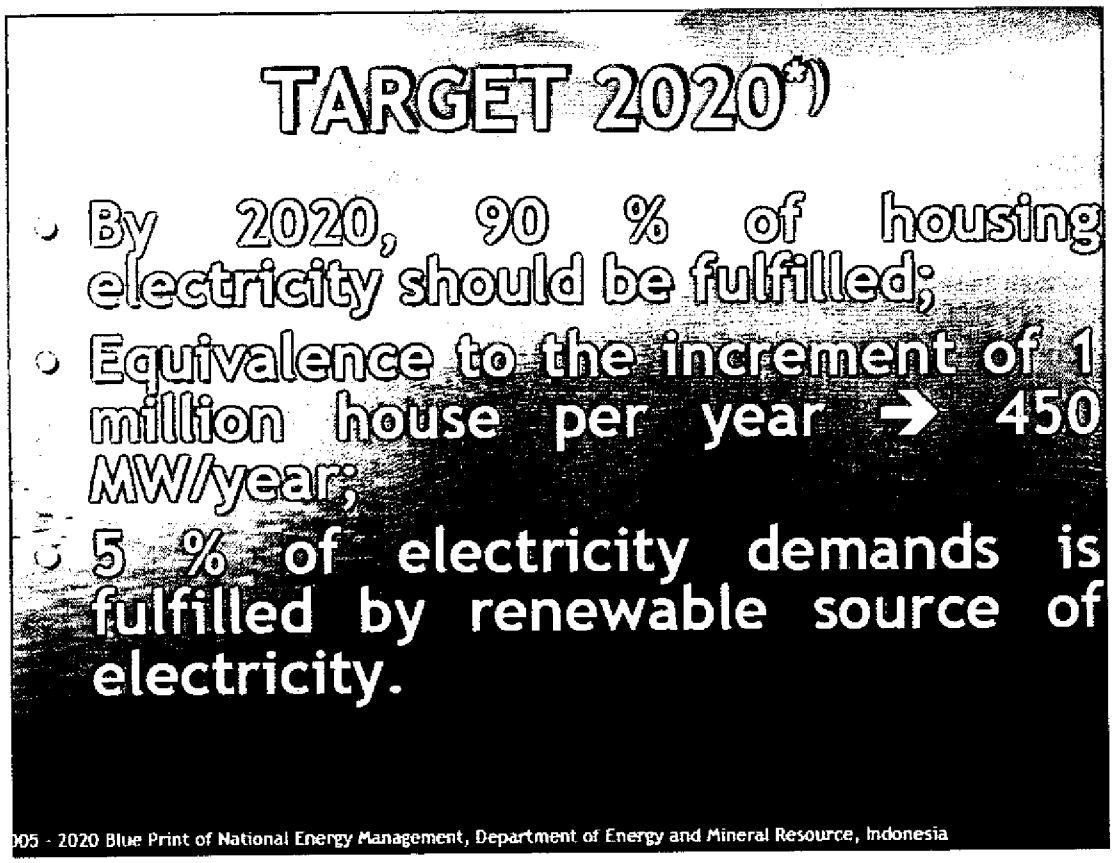
ELECTRICITY DEFICIT IN 2005

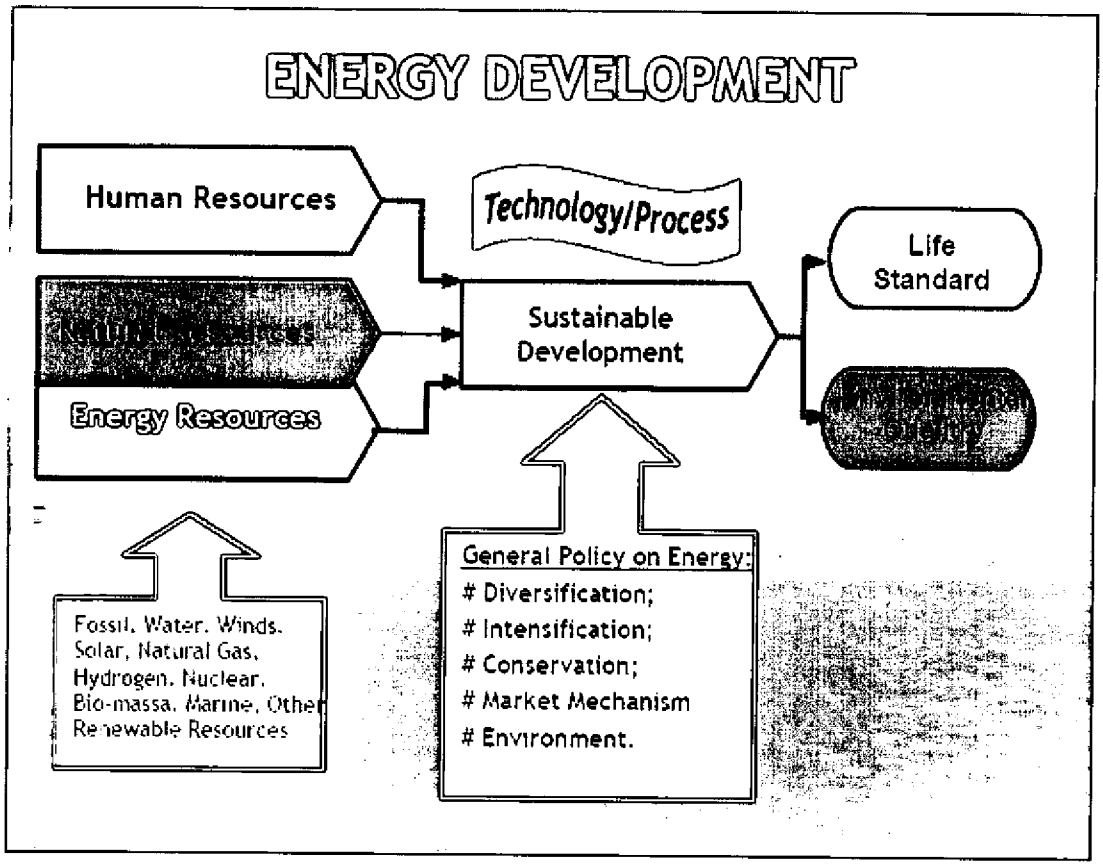
AREA	CAPACITY [MW]	PEAK LOAD [MW]	RESERVE [MW]
North Sumatera	940,0	1.016,0	(-) 76,0
Riau	114,0	168,0	(-) 64,0
South Sumatera	1.189,0	1.265,0	(-) 76,0
Java - Bali	19.500,0	15.500,0	4.000,0
Kalimantan	32,6	33,8	(-) 0,8
NTB - Mataram	75,0	74,0	(-) 1,0
South Sulawesi	343,0	367,0	(-) 4,0
Papua	28,0	29,0	(-) 1,0

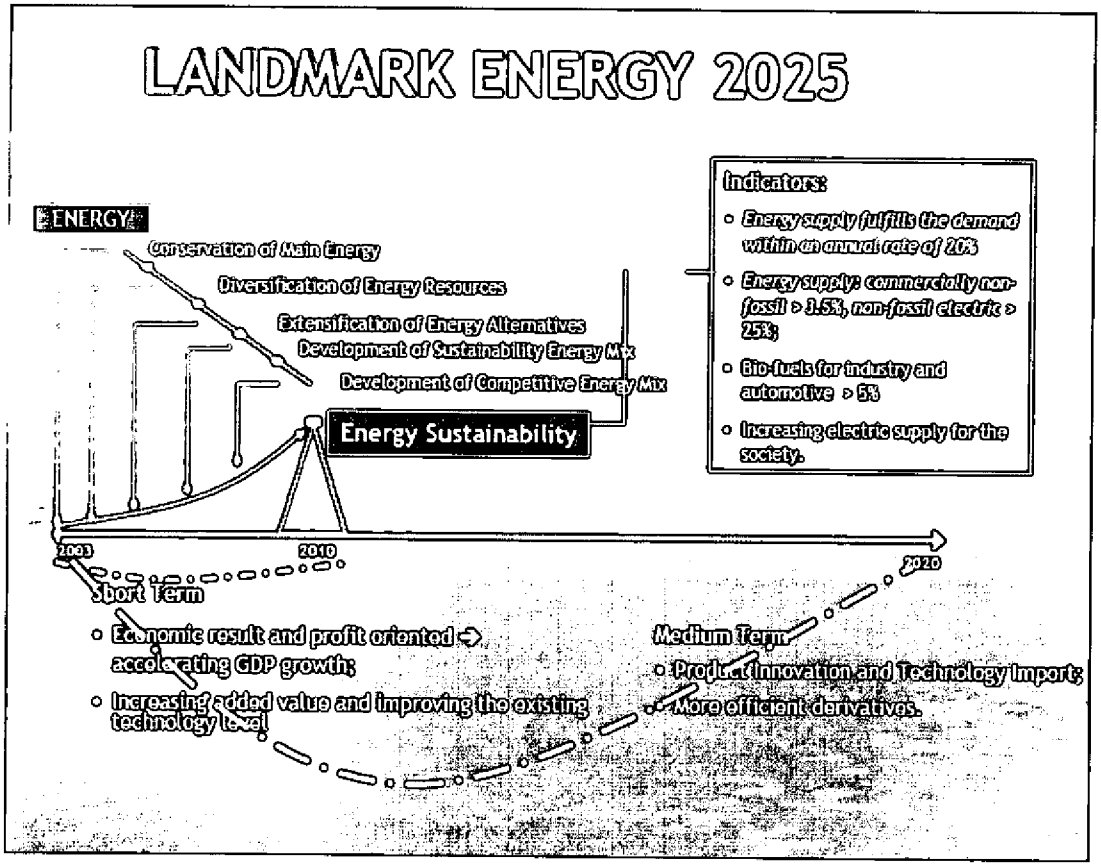
ENERGY CRISIS

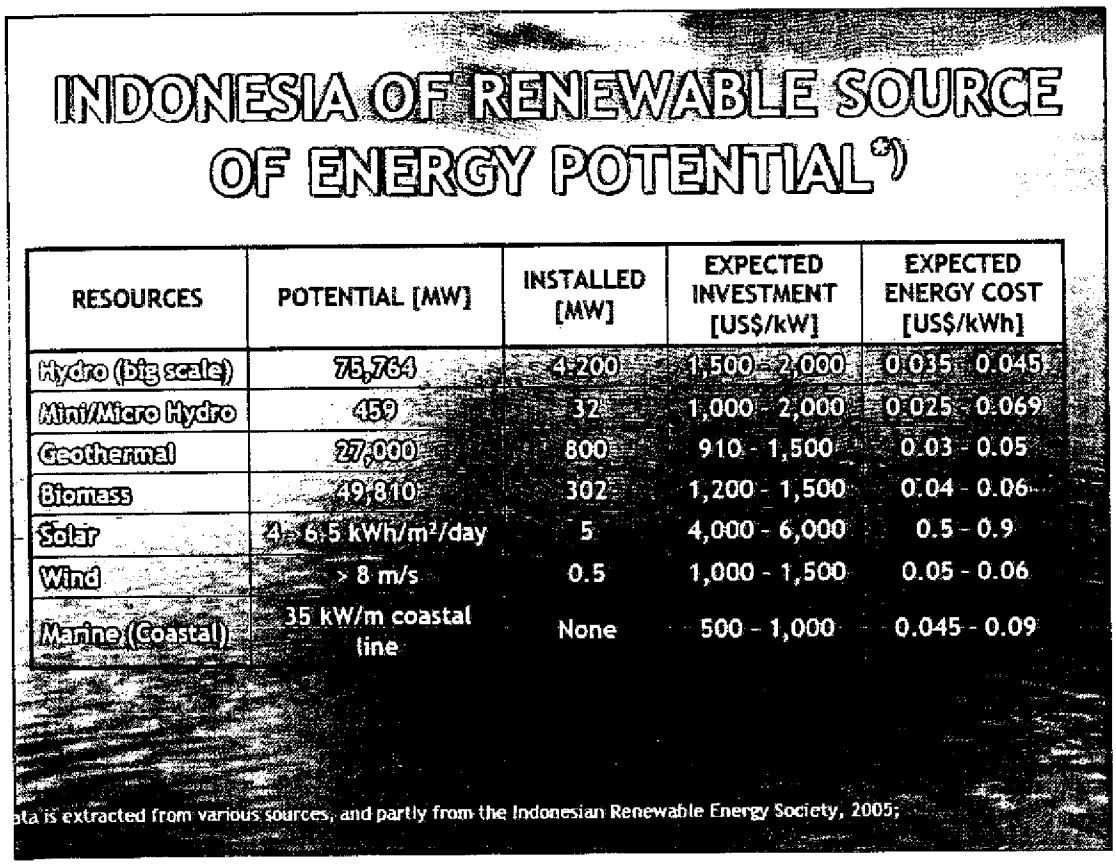



INVESTMENT NEEDED
Investment needed 2005 - 2015 → 28.072 MUSD:
- Power Plants USD 14.231,5 Million;
- Transmission USD 8.742,9 Million;
- Distribustion USD 5.097 Million
Government budget can only fulfill 10 ~ 20 % and remaining budget is from private entities.


TARGET 2020*)
By 2020, 90 % of housing electricity should be fulfilled;
Equivalence to the increment of 1 million house per year → 450 MW/year;
5 % of electricity demands is fulfilled by renewable source of electricity.
005 - 2020 Blue Print of National Energy Management, Department of Energy and Mineral Resource, Indonesia


ENERGY DEVELOPMENT
Human Resources
Technology/Process
Life Standard
Sustainable Development
Energy Resources
Fossil, Water, Winds, Solar, Natural Gas, Hydrogen, Nuclear, Bio-massa, Marine, Other Renewable Resources
General Policy on Energy:
Diversification;
Intensification;
Conservation;
Market Mechanism
Environment.


LANDMARK ENERGY 2025
ENERGY
Conservation of Main Energy
Diversification of Energy Resources
Extensification of Energy Alternatives
Development of Sustainability Energy Mix
Development of Competitive Energy Mix
Energy Sustainability
2003
2010
2020
Short Term
Economic result and profit oriented accelerating GDP growth;
Increasing added value and improving the existing technology level
Medium Term
Product innovation and Technology Import;
More efficient derivatives.
Indicators:
Energy supply fulfills the demand within an annual rate of 20%
Energy supply: commercially non-fossil > 3.5%, non-fossil electric > 25%;
Bio-fuels for industry and automotive > 5%
Increasing electric supply for the society.



RESOURCES	POTENTIAL [MW]	INSTALLED [MW]	EXPECTED INVESTMENT [US$/kW]	EXPECTED ENERGY COST [US$/kWh]
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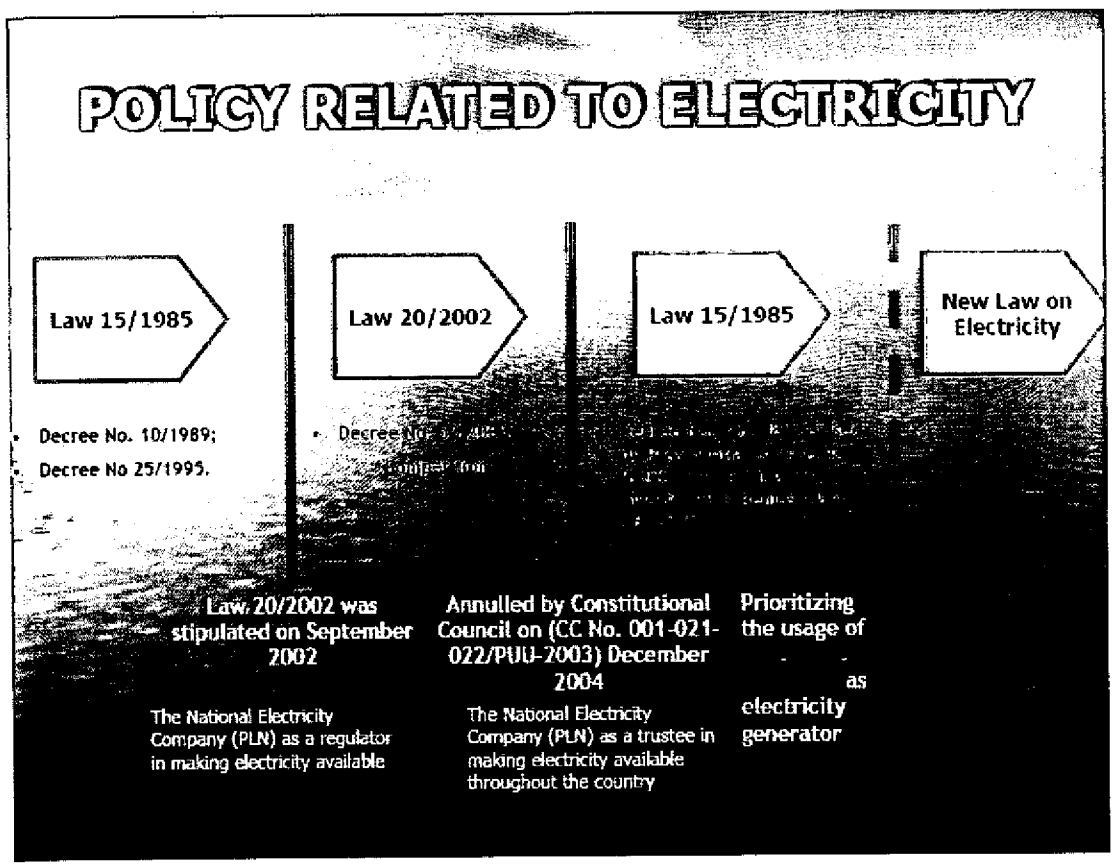
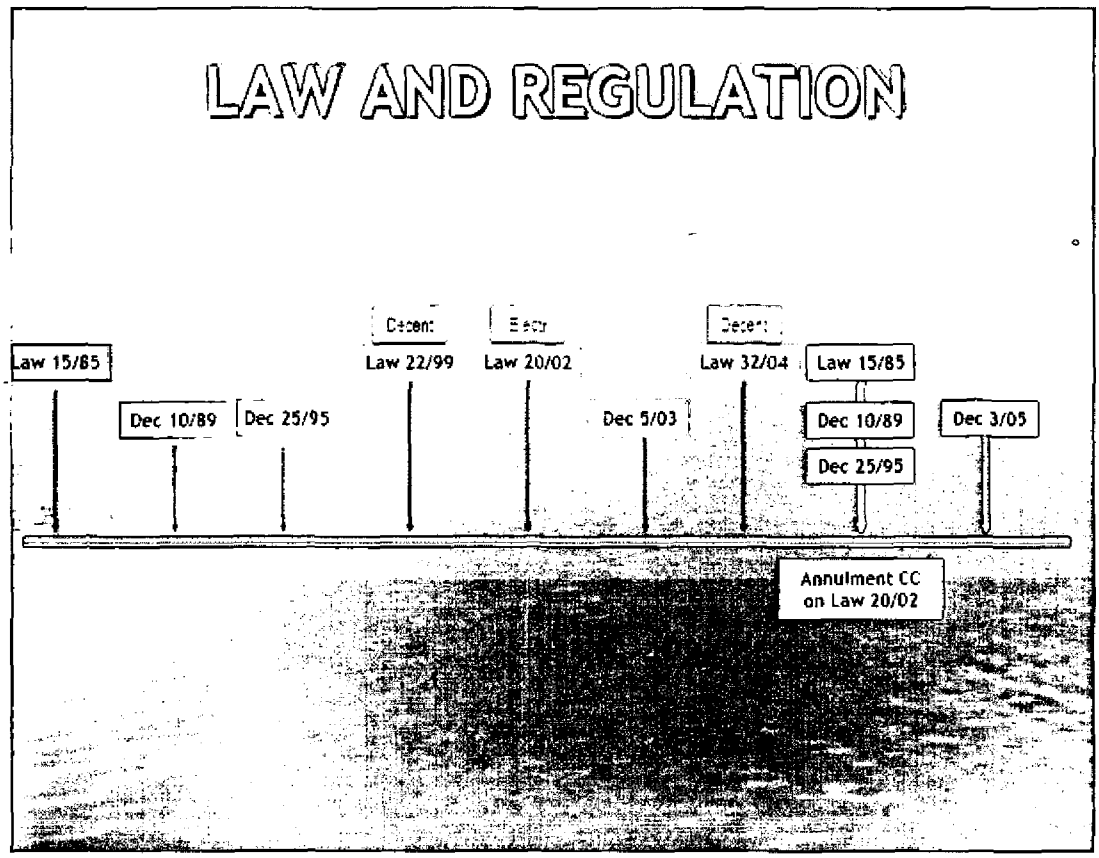
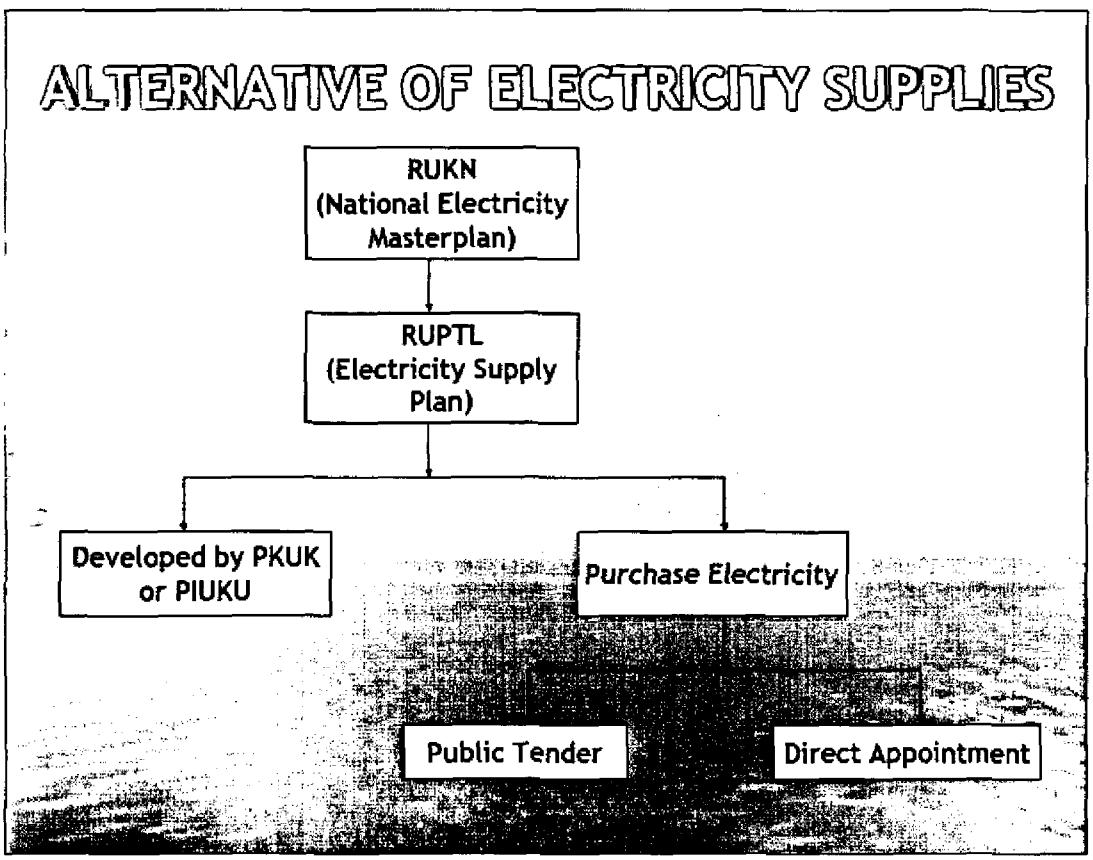
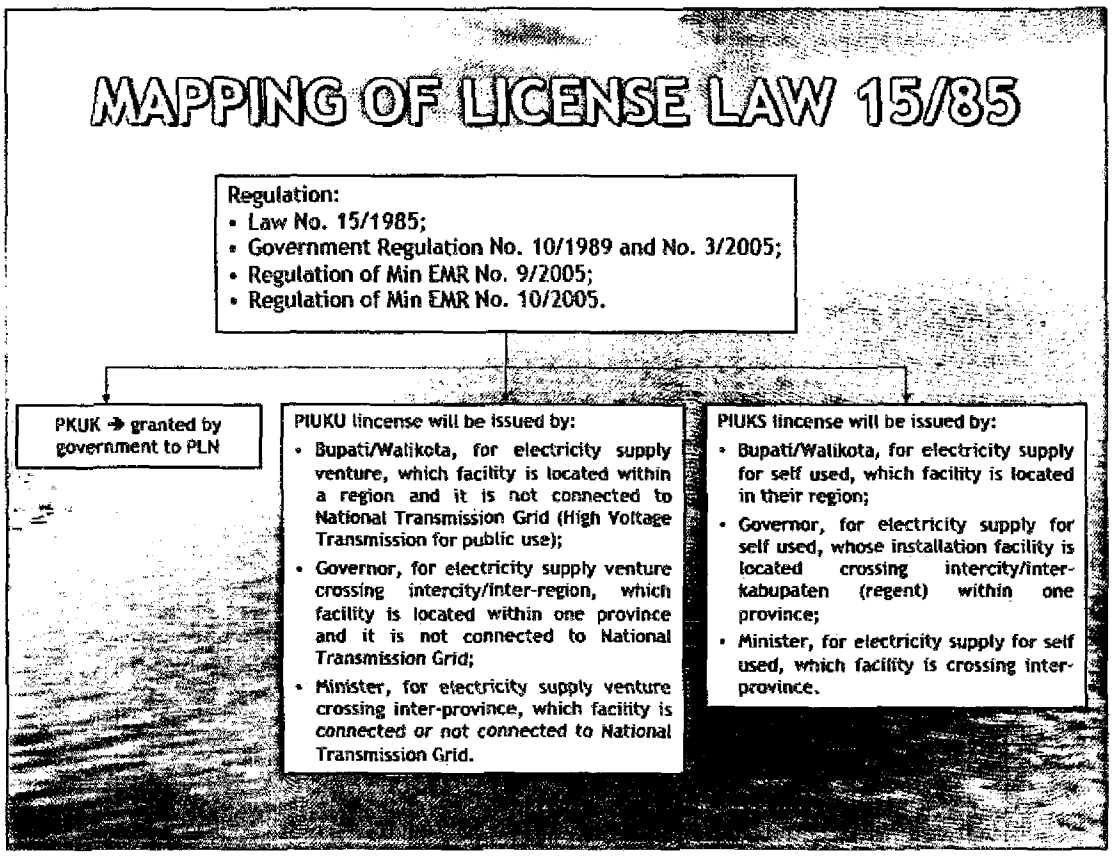
Marine (Coastal)	35 kW/m coastal line	None	500 - 1,000	0.045 - 0.09




LAW AND REGULATION
Law 15/85
Dec 10/89
Dec 25/95
Law 22/99
Law 20/02
Dec 5/03
Law 32/04
Law 15/85
Dec 10/89
Dec 25/95
Dec 3/05
Annulment CC on Law 20/02


ALTERNATIVE OF ELECTRICITY SUPPLIES
RUKN (National Electricity Masterplan)
RUPTL (Electricity Supply Plan)
Developed by PKUK or PIUKU
Purchase Electricity
Public Tender
Direct Appointment



CONCLUDING REMARKS

- Despite the abundant resources of energy, Indonesia faces a critical situation in fulfilling the electricity demand. The rate of growth of the demand cannot be met by the government. Accordingly, the new government regulation No. 3/2005 stipulates not only inviting the participation of cooperative and private entity in supplying electricity but also emphasizing the new look into the renewable resource of energy.
- Through Blueprint of National Energy Management, the government has targeted that the renewable resource of energy shares [illegible] installed capacity by the [illegible] upon which by the year 2010 the objective can be materialized within 2%, and 5% by 2020.
- The electricity supply provided by private entities has to fulfill the national electricity masterplan. The mechanism can be done through [illegible] or [illegible]. The participation of private entities, be it local or national; have to get an approval through the local/national authority (PKUK/PIUKU), according to the regulation, depending on the location of facility and the connection with national grid.

Alternative Locations of a Typical Prototype Kobold Patented Marine Energy in Indonesia

Andi Eka Sakya

Assistant to the Deputy for Priority and Strategic Research Program
The State Ministry of Research and Technology of Indonesia

ABSTRACT

Indonesian government has marked out a goal that by 2025, 6.24 % of energy demands will be fulfilled by renewable source of energy. The State Ministry of Research and Technology within the National Strategic Policy on the Development of Science and Technology 2005 - 2009 has also set out 6 priorities in which one of them is to sustain the creation and use of new and renewable source of energy.

There are a lot of alternative available for renewable source, namely solar, hydrogen, water, geothermal, wind, biomass and marine. The exploitation and the exploration of them is, however, hampered by the unpreparedness of available technology as well as energy industries.

As an archipelagic country, the potential of marine in Indonesia is, in fact, exceeding the potentialy of other sources. The Kobold patented marine current energy is one of power plants that utilizing inner current to drive the turbine. This will be the first time for Indonesia to implement such technology to provide electricity. The availability of such type of a marine current will serve as an alternative of renewable source of energy, especially for the people who live in the remote area or small islands.

This report discusses the alternative location to installing a prototype in Indonesia. Several factors have been taken into consideration, namely, acceptability, maintainability and operability, as well as sustainability of current.
Keywords : Kobold Patented, Marine Current, Power Plant, Stability, Current Speed.

PREFACE

The rate of electricity demand in Indonesia has arrived at 5 - 6 % annualy. The government of Indonesia can only fulfill 10 % of the demands. Through the Law No. 3/2005, the government has encouraged participation of private entities or cooperative to supply electricity. More over, the Law has also put a high priority on the generation of renewable energy. It has been targeted that by the year 2025, the share of renewable energy will reach 6.4 %.

Indonesia has abundant of renewable

sources of energy, among others: geothermal, solar, water, wind and marine. However, the marine is the least exploited. In fact, looking into the coastal lengthin Indonesia, the potential of the marine current reaches 2,800 GW. A typical marine current power plant has been developed by Ponte di Archimede of Italy. The plant is driven by patented Kobold turbine attached vertically. Three blades are provided to propel the turbine and transmitted to move the gear box to produce electricty. The cut-off speed of the prototype is 1.5 mps. The prototype is now moored in Messina Strait in the southern part of Italy.

Under the auspices of UNIDO HQ in Vienna, the prototype is offered to Indonesia. Potential locations are sought so as to guarantee that the observation of the prototype's performance can be done. If performed successfully, the power plant will surely enable to supply electricity especially in the area of the many small islands in Indonesia.

Representing the largest archipelagic country, Indonesia that is located between two big oceans, benefitted by its position. The flow through from the Pacific Ocean to the Indian Ocean passes the Indonesia bringing large amounts of mass flow. The Indonesian Flow Through create a potential site for not only prototype but also the mass produt of the plant, if it performs well.

The report discusses the potential location by considering not only the stability of the current speed and its variation, but also the absorptive capacity of the people and the possible logistical support so as to sustain the activity in the long term basis.

KOBOLD PATENTED MARINE CURRENT ENERGY

There are many alternatives choices of primary energy resources for electricity production that is available abundantly. The fossil fuel based seems to have been unpopular recently due to oil price hike. Global warming, carbon emission, climate change is the words that environmentalists often used to encourage researchers to find better alternative of energy sources.

The increasing oil price in the last decades grows concern on the conventional energy. Attention on the renewable source of energy is getting more and more intensifying. The government of Indonesia through the Department of Energy and Mineral Resource through the 2005 - 2020 Blue Print of National Energy Management has set out a goal to fulfill at least 5 % of the energy demands using the renewable source of energy in 2020. The State Ministry of Research and Technology synchonously has also defined the creation and use of renewable source of energy as one of the focuses of national research activity.

It has long been known there are many sources of renewable energy, among others: solar, geothermal, wind, biomass, hydro as well as marine. The solar energy has long been investigated. Solar based energy will remain expensive due to the state-of-the-art of the present technology. It is predicted that until 2013, the solar energy will not serve as the best alternative for the low-income people. Price is not the only constrained. The patterns of sun rise and sun set, as well as cloud pose other problems to store the energy produced. A better method to store the energy is needed.

To avoid the patterns of sunset, sunrise and cloud, the wind is selected. Basically, the wind arises caused by air warming. It can also be noted that this is another way to collect the solar power, but it can be done during the dark. The use of wind as the primary source has been widely investigated. The biggest one has recently been developed in Denmark. More than 18 ton of carbon fibre was used to construct propeller whose length is 61.3 m and turbine wose hight is 183 m, six times as high as the Liberty Statue in New York. In the northern part of German Coastal, a 5 MW prototype of wind energy will be constructed thal will light up more than 5000 houses. The construction of wind energy in Europe and USA depicted in MW per year installed capacity is shown in Fig - 813. The popular wind energy in Europe is encouraged by the incentive of carbon credit materialized through tax reduction policy.

Another alternative that is also popular is biodiesel. In fact, this type of energy has

been used through the years as old as the world age started when the people used wood to burn and warms their body. The biodiesel also presents the preliminary hydrogen era of energy. The hydrogen is still a mere challenge.

But, biodesel is just before the eyes. German and Brazilia are two countries that used biodiesel as the alternative fuel for transportation. In German, 3% of the diesel demand is fulfilled by biodiesel. Brazillia is famous for the Saudi of Ethanol. Asan alternative of fuel for air transportation, biodiesel has been commonly used instead of avtur. There are more 320 ethanol production factories in Brazillia.

Nuclear serves tho most efficient way to produce energy. However, the shadow of atomic bomb in Hiroshima, Nagasaki as well as the leak of Threemile Islands in the USA and the Chernobil of Rusia has raise up concern on the safety of nuclear power generation. The nuclear faces the problem of acceptance, at least in another 5 years to come.
Another alternative that has not been explored yet is the ocean. The marine serves as the potential resources of energy. The potentiality shows by the fact that its wave gives 10 - 35 kW/m coastal line, the thermal prospects more than 240 MW of energy, and the tide guarantee to serve more than 3000 MW. There have been several investigation worldwide, however, the structure of waves pose difficulties to construct power generators in the off-shore.
In the last 10 ten years, a type of renewable source of energy based on marine current has been developed. The Ocean Thermal Energy Conversion (OTEC) is one of the marine current power plants utilize the thermal characteristic of the wave as the source of energy. In Indonesia, this type of OTEC had been once investigated by BPPT . The prototype was installed at Bali Strait. The sustainability of the project was, however, brought to an end when the project was completed.

The BPPT has also initiated an ocean wave current, a typical of marine current power plant make use the impact of wave periodically to drive the turbine. Subscale prototype of the plant has been successfully tested at the Laboratory of Coastal Dynamic. At present, a real prototype has been planned to be erected in the southern part of Yogyakarta.

Among others is the so-called Enermar Project proposed by Ponte di Archimede in cooperation with Universita di Napoli "Frederico II". The model was developed base on the patented Kobold turbine . The plant is driven by a vertical axis hydro tubine that enable to convert the energy kinetic of the inner current into mechanical energy. The transmission of the system with the gear-box is facilitated that make possible to produce electricity. The Kobold has been designed to satisfy under high efficiency, sound environmental, low construction and maintenance characteristics. It has the following physical characteristics:

o its direction of rotation is independent of the marine current direction;
o It can spontaneously start due to high torque.

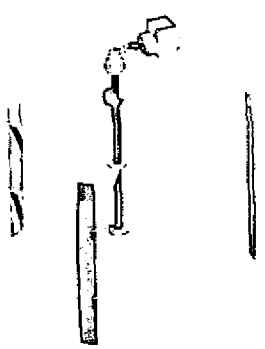


Fig - 1 Scheme of turbine rotor and electric generator

The Enermar Plant is constructed by a turbine and an electrical generator. The whole system is built up on a floating platform. The turbine consists of a transmission shaft, built with special steel, and three couples of radial arms, each of them holding a blade. Fig - 1 shows the scheme of turbine rotor as connected to the electrical generator. The dimension of the main plant is as depicted in Table - 1.

The generator is brushless, three phases, synchronous, 4 poles equipment, 128 kW

and it is connected to a control unit delivering energy to the net. The 3-blade turbine rotor mounted under the buoy and set on the clock, before installation in the sea.

MAIN PART	ITEM	UNIT
Turbine	Diameter	6 [m]
	Blade span	5 [m]
	Chord	0.4 [m]
	No. of Blade	3
Floating Platform	Diameter	10 [m]
	Depth	2.5 [m]
	Draft	1.5 [m]
Mooring	No. Anchoring Blocks	4
	Block Weight (Concrete)	350 kN each
	Chain	70 [mm]
	Water Depth	18 - 25 [m]

Table - 1 The dimension of Enermar Plant

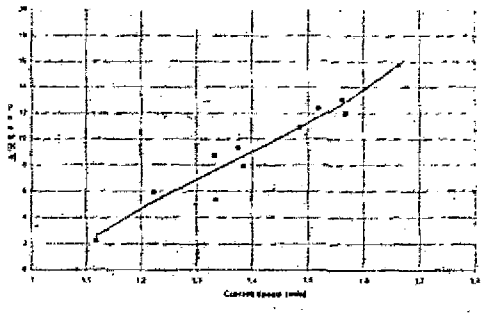


Fig - 2 The measured electrical power as function of current speed

The cut-off speed of the first tested system is 1.2 mps. The efficiency of the system is as the ratio between electrical produced and the theoretical power, as follows:

electrical

where, S is the diameter height (S=30 m2 in the case of Kobold), p is the density, and V is the current speed. The calculated efficiency is around p = 23%. The electrical power produced as measured versus the current speed is depicted in Fig - 2. Whereas, the calculated rotor power curves at different current speed is shown in Fig - 3.

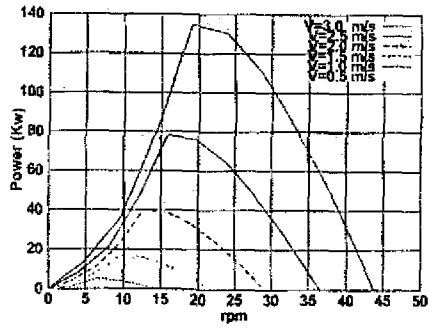


Fig - 3 Calculated rotor power at various current speed

A pilot plant has been moored in the Strait of Messina, close to the Sicilian shore, Italy. In this site, the current is expected to reach 2 mps (4 knots). The sea depth is 20 m, and the plant is moored at 150 m off-shore. The current in this site is never still. The period of inversion is 6 to 12 hours. The prototype has successfully produced approximately ~ 75 kW at the current speed of 2 mps. It is expected that by a continuous development takes part at Ponte di Archimede, the efficiency of the turbine will be better and can produce a higher power of electricity. Furthermore, the formula [1] also shows that the power will increase in cubic of speed of the current. The prototype is now moored in the Messina Strait and shows in Fig - 4, where the electrical power was used to pump the sea-water.

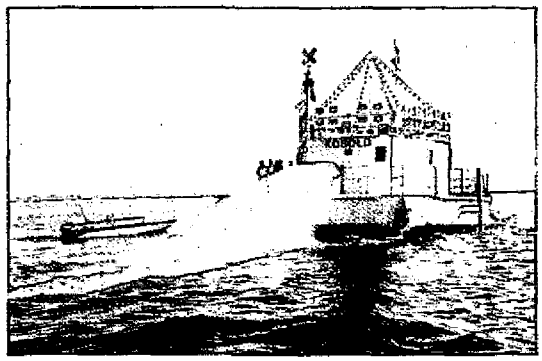


Fig - 4 A prototype of Enermar Plant within which Kobold patented turbine is installed

SUSTAINING A TYPICAL NEW TECHNOLOGY

Transfering a new technology from one place to another faces the question of whether the aforemetioned technology could sustain. In the case of renewable source of energy, the government of Indonesia encourages the community to be actively participated. The approach of Renewable Energy Small Scale Power Plant (RESSPP) is basically not only to provide energy but also to create a better social life. Having the community actively participates in electricity generation, it is expected that the supply would be more sustain in the long run. Vice versa, the activity will give a mutual benefit between local community and local government as well as investor. Therefore, the policy of the development RESSPP is put under the community based development concept. The concept emphasizes the participation of local community. The exposition of society to the new technology, if successfully adopted, guarantee that the system will, at least, live longer.

Beside the financial problem, for the technology is developed in another location, three main aspects are worth considering. Those are acceptability, maintainability and operability, and stability of energy production. The aspect of acceptability and sustainability is related with the people adjacent to the location where the technology is applied. Implementing a typical new technology, one has to take into consideration the people surrounding the site who will get the most of the benefit of the technology. Because Kobold Marine Current Energy (MCE) could produce not only electricity, their various products should, therefore, be linked to - as far as possible - the essential need of those people. The adoptabibility of Kobold MCE will also guarantee to sustain the program at a longer term.

This perspective is in line with the regulation applied. According to the Law No. 15/1989, the electricity produced by the plant, either used for it self or connected to the national grid, it has to be approved by local government. The Kobold MCE is classified as small RESSPP that produces less than 1 MW. Specifically, the project should appoint a venture as PIUKU/PIUKUS to get a license holder from the head of local government. By law, the development of the plant should also involve cooperative or private entity as part of the community development.

The basic of consideration of acceptability resides on the absortive capacity of the society. The Indonesian people, especially those who live in the rural area, is a paternalistic one so that the leader embraces a very important position in determining whether or not a new thing is good for them. In the perspective of introducing a new technology, this condition follows. In the region where the head of the region is propensity to the new idea, to make a breakthrough, to introduce acceptably innovation, the region will more advance than the one whose leader is not prone to innovative idea.

Moore reemphasizes the important of persuading the people who are prone to technology. The so-called early adopters will facilitate the dissemination of new technology to the remaining majority. Statistically, it is widely accepted that the number of population belongs to the early adopters are not more than 7.5 %, but ultimate important in determining the success of introducing technology. Once the process of introducing the new technology to the early adopters is success, the follow up is much easier.

The situation is the same in the case of Kobold. The selection of location should consider the level of adoptability that related to the absorptive capacity of the leader and the people surroundings.

The maintenance and operability closely related with the logistic support and manufacturing facility, that is available vicinity to the site. The turbine of the plant has been made as such that satisfy the low maintenance characteristics. However, the facility has been developed in the area that has four seasons. Indonesia is a tropical country, where hot and rainy season is periodically and regularly changed within 6 months period.

The tropicalization of the equipment either

under the sea or floating is of necessitates anticipating the extreme weather condition, especially in the hot season where humidity of the tropical area is different from that of the country in the subtropical area. More than that, the deliberation of the maintainability and operability will sustain the support of the plant if one or two spareparts fail to work. In this case, the involvement of local surroundings in the construction of either prototype or mass product will ensure not only the acceptance but also the support of the plant, and in turn, will guarantee the use of the equipment for the long term.

CHARACTERISTICS OF MARINE CURRENT

The stability of energy production is determined by marine and coastal characteristics of the site. Its current velocity and tidal variability will determine the energy stability production, and hence the first key success factor and very crucial for this project.

In Indonesia, with the projected of 4.5 percent gross domestic product (GDP) average annual growth rate, the average energy demand of the country increase 5-6% annually which equal to 1000 MW annually. The population of Indonesia is now over 200 million, increasing at an average of 2.3 % annually. Sixty per cent (60%) live in rural areas (about 180 sub-districts and 42,000 villages).

Indonesia is also the world's largest archipelago, which comprises more than 17,504 islands. Not all of them have been named. It is offcially noted that the named islands is approximately 9634. More than that, more than 10,000 islands are classified as small one, scattered around the western to the eastern part of Indonesia. The total land area of the country is approximately 2 million square kilometers, with more than 80,000 km length of coastal line.

Representing the largest archipelagic countries in the world, not all of her islands are "reachable" from the point of view infrastructure development, especially islands in the eastern part of Indonesia. More than 6,000 villages and around 20 million households in the country are still left not electrified. The electrification targets cannot be met since PLN (the Indonesian Electricity Company) is currently unable to expand its power generating and distribution capacity due to the financial difficulties using the traditional electrification approach of grid extension. It is expected that only 10 - 20% of demand that Government can fulfill. The remaining is left fulfilled by private entities. The electricity supplied for almost all of small islands, if any, is supported by diesel-based generator, which is not only environmentally damaging, but also - from the supply perspective - climate and weather dependent.

Therefore, as long as location is concerned, the power plant is aimed at facilitating the communities residing in coastal areas where no electricity is available. The pilot plants - if economically proven to be viable - will produce quite a substantial output of energy that will enable entire small communities to take advantage of the benefits of a regular supply of electricity. This project will also indirectly be benefited to the local governments.

Ocean current along the Indonesian Archipelago comprises of wind and monsoonal effect current, tidal current and Indonesian Through Flow (ITF) current . The current has been measured and the data collected are the combination of those currents at various depth and locations. Measured free surface current mostly generated by local or moonsonal wind, propagating wave and astronomical tide. Effect of tide, generally, dominates the shallow waters region and the effect of local or moonsonal wind induced current is identified or named as the residual current. The characteristic of Monsoonal current is a continuous one directional flow through a longer period in comparison to a daily tidal cycles. Indonesian Through Flow, on the other hand, has a much greater magnitude compare to the tide or wind induced current. Its potential has been subject to oceanographer and scientific community interest, millions of research budget had been allocated to deploy meta-ocean measurement devices.

JAMSTEC buoys have been collecting data around East and West of Pacific Ocean since 1978 and it is still kept updating the current conditions.

Baruna Jaya Research Vessels through its various Ocean Survey programs had taken ample of data between year 1990 to 1998. More advanced method using satellites and triangulated Accoustic Dopplet Current Profilers (ADCP) are also used and concentrated on the subject of Indonesian Through Flow current. The characteristic of Indonesian Through Flow is a continuous one direction flow from Pacific water masses through Makassar Strait, Lifamatola passage, Lombok and Ombai Strait and Timor passage to the Indonesian Ocean.

Wind induced free surface current with the prevailing average wind speed at 20 knot will generate water masses circulation at the average speed of 0.50 - 1.0 knot. Tidal generated current varies depending upon the astronomical tide characteristics, that is diurnal (one flood, one ebb in 24 hours), semi-diurnal (two floods and two ebbs in 24 hours) and mixed diurnal - semi diurnal depending upon its geographical location. For shallow water area, adjacent to deep open ocean with many island constellation at tidal range of 2.0 m, between High Water Spring (HWS) and Low Water Spring (LWS), generate ocean current with the speed 1.5 to 2.0 knot.

Indonesian Through Flow (ITF) is generated by warm Pacific water masses fluxing through Makassar Strait, Lombok Straits, Lifamatola Passage and Ombai Strait to the cooler Indonesian Ocean. Approximately 10 million m3/sec of Pacific Ocean water pass into the Indian Ocean through the Indonesian seas. ITF generated current has been measured at the average speed more than 5 knot. Observations indicate that the throughflow is composed mostly of North Pacific upper and intermediate warm water flowing through Makassar Strait (Gordon and Fine, 1996), which then passes into the Indian Ocean through the passages of Lesser Sunda Islands. East of Sulawesi South Pacific water infiltrates the lower warm water and dominates the deeper layers, including the Lifamatola Passage overflow into the deep Banda Sea (Fig - 5).

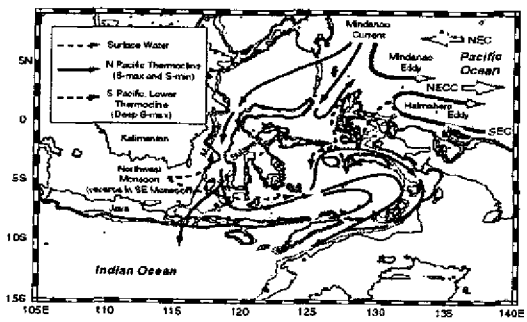


Fig-5 Overview of Indonesian Through Flow

Geographically eastern Indonesian displays complicated topography in which many large and small islands divided the area into different seas. Eastern Indonesian waters consists of a series of very deep basins with very limited interconnection. This complex topography makes the dynamic of water mass in the area complicated.

ITF is the only path which connects the two oceans (Pacific and Indian) in low latitude so it is believed it has an influence on water mass, heat and salt exchange between Pacific and Indian Oceans. ITF also has an important role in the chain of Thermohaline circulation and global climate phenomenon. ITF is not a passive path, which only flows the water from Pacific into Indian Oceans, but a lot of local variabilities influence the flow. Those variabilities, among other, are complex geographical structure, monsoon pattern, run off, evaporation and precipitation in the internal of Eastern Indonesian waters. All of these cause the physical and chemical properties of Pacific and Indian Oceans to be affected by the characteristic of the ITF.

Utilizing the data collected from early JAMSTEC mooring buoy deployment in 1978, Baruna Jaya Research Vessel survey programs from year 1990 to 1998 and the most recent INSTANT, CATS mooring buoys deployment program 2003-2006. Thousand of mooring locations, from the deep ocean to shallow sea have been selected throughout 1978-2004 period to collect current

velocity, salinity, temperature including water quality samples. Figure - 6 shows the schematic Maps of Indonesian Through Flow (ITF).

Excerpted from primary and secondary databases with majority mooring buoy data and monthly averaged for consecutive months in a year, Ontowirjo et all tabulated the following current intensity at various locations (Table-3).

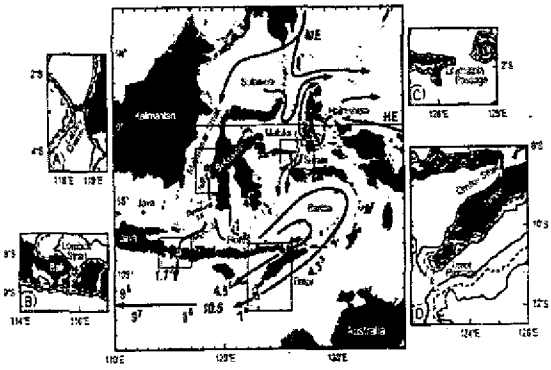


Fig - 6 The Schematic Maps of Indonesian Through Flow (ITF)

Note: Red Colored Number represent water mass movement in Sv unit (106 m3/sec). Smaller number in black colored data from other references.

Zoom images A-D show location of mooring buoy INSTANT Program. Figure A: 2 US Buoys for current measurement at Makassar Strait (red diamond) around Labani Strait. Figure C: The Netheriand Buoy within main channel of Lifamatola passage (yellow triangl). Figure B, D: Sunda Buoy at Ombai Strait, Lombok Strait ,and Timor passage:US (red diamond); French, (purple box); Australia green circle). Depth Transducesr Position (US,green crossed);

As mentioned that the sustainability of the supply determined by the stability of the current. There are various places that can be potential sites of the prototype. In the area of Papua whether in northern part (Biak - Papua) or in the southern part (Digul - Papua) as well as Ambon - Maluku the current speed may reach 12 knot (~ 6 mps), however the variation within a year vary so much. This type of area may serve as a potential places but not for the prototype one. Worth to mention is Biak - Papua that has a very interesting variation, for the current is always above 5 knot (2.5 mps).

Month / Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Des
Lhoksemawe, Aceh Utara	8	8	4	2	2	6	4	6	6	4	6	8
Belawan, Sumatra Utara	2	4	2	2	1	4	2	4	2	1	2	2
Tanjung Balai Karimun, Riau	1	4	4	6	4	1	1	2	1	1	4	4
Batam, Bintan Riau	4	4	4	4	6	6	8	8	6	2	4	6
Sumatra Selatan	6	6	4	2	5	6	4	4	8	2	5	6
Bangka, Belitung	8	4	4	2	4	1	2	2	4	2	4	4
Bengkulu	6	4	8	6	4	4	2	2	2	4	6	4
Lampung	4	4	2	4	4	6	4	4	4	2	4	4
Selat Sunda, Jawa Barat	4	4	2	4	4	8	8	4	8	2	4	5
Indramayu, Jawa Barat	6	5	6	2	2	5	4	2	1	2	4	8
Pontianak, Kalimantan Barat	6	5	8	4	4	2	2	4	4	3	4	6
Banjarmasin, Kalimantan Sel	4	5	4	1	4	4	4	4	5	5	2	4
[illegible]	4	5	5	5	4	4	4	4	5	4	4	4
Semarang, Jawa Tengah	8	2	5	2	2	4	4	4	3	2	6	4
Kuta,Bali	2	4	4	2	4	6	[illegible]	4	4	4	1	2
Selat Lombok NTB	6	8	4	[illegible]	2	7	10	10	[illegible]	4	2	5
Selat Makassar	5	2	4	[illegible]	5	8	[illegible]	8	6	8	4	4
[illegible]	4	5	5	5	4	4	4	4	[illegible]	4	4	4
[illegible]	5	5	4	4	5	4	4	7	8	5	6	4
Halmahera, Maluku Utara	5	5	8	2	5	[illegible]	11	8	8	2	11	5
Ambon, Maluku	4	8	5	2	4	2	2	[illegible]	4	2	[illegible]	7
Selat Flores, NTT	8	10	8	10	2	4	1	6	4	6	[illegible]	[illegible]
Selat Ombai, NTT	4	5	[illegible]	[illegible]	4	2	2	[illegible]	8	5	4	4
[illegible]	10	10	10	[illegible]	10	10	10	4	5	6	5	[illegible]
Sorong, Papua	8	8	[illegible]	6	4	5	4	4	4	5	2	8
Digul, Papua	[illegible]	8	4	8	4	[illegible]	[illegible]	8	8	4	2	6

Table - 3 Region with current speed [in knot] variation in term of the month

A power plant prototype should be explored in a very stable manner so that its performance can be observed detailly. In that case, other site that has more than 4 knot (cut-off speed) but characterises on small variation of speed will be the candidate. Upon examining the location, there are at least 3 areas that fulfill the criteria, these are: Gorontalo, Manado and Kalimantan Selatan. The minimum speed of the current is above the cut-off speed or the speed at the Strait of Messina. The variation within a year is not so-much, except in Manado in the month of August and September.

Three areas has been identfied due to their marine current characteristics, namely Manado, Gorontalo and East Kalimantan. However, the exact location has to be determined. The Kobold is a floating type power plant. The system is moored on 350 KN concreet sunk into the deep water. At Messina Strait, the length of mooring could reach 150 m.

In either one of the identified location, the characteristics of the coastal topography should, then, also be investigated apart from the wave characteristics. As mentioned that the ITF could effect the chemical and physical characteristics of the sea. Therefore, the

measurement should include the depthness, slope of the coast, as well as the physical and chemical properties of the sea.

Furthermore, this measurement will facilitate the project to decide whether a lab scale simulation is needed prior to floating the prototype in its exact position. The simulation testing will ensure the success of installing the prototype, for the testing will reduplicate the topography of the defined coast.

CHOICES OF LOCATION

Based on the measured current speed, it can be deduced that there are three potential locations. Those location provide a stable current with maximum variation of only 1 - 3 knot (0.5 ~ 1.5 mps). Figure 7 describes the precise locations of the potential sites.

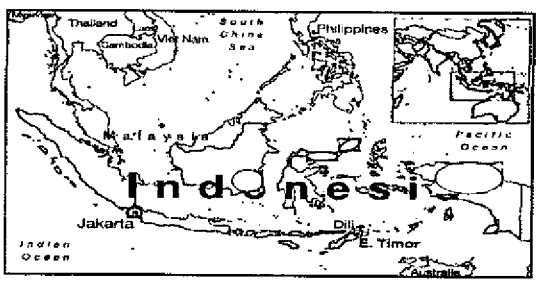


Fig - 7 The potential locations with small but stable current speed

The steady current is not the only - as explained above - consideration, the coastal topography, the absortive capacity of the people, the endorsement of the local government, local logistic support, among others, are also the factors that have to be taken into account.

In the East of Kalimantan, there is a complex of foreign oil company that is actively engaged on the community development. East Kalimantan is also famous with PT. PUPUK KALTIM - a vertilizer producer. Although it is not sustain anymore, its passed activity on manufacturing, especially in the automotive sector has made the company wellknown as one of the domestic truck maker. The infrastructure in Kalimantan especially surrounding Balikpapan and adjacent to the oil company area is suportive for installing the prototype. A prudent deliberation should be taken, for the area is also recognized as the wood floating path for forestry product.

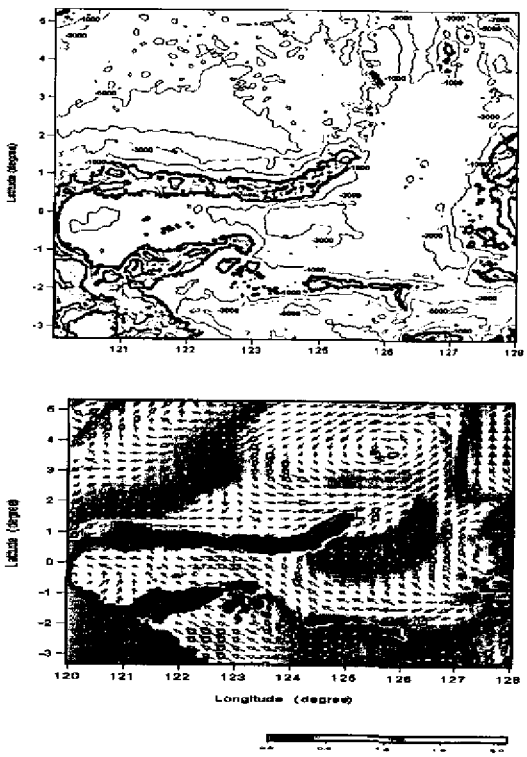


Fig - 8 Numerically simulated current speed in the area of the northern part of Sulawesi

Gorontalo area is one of the new born province in Indonesia. The Governor of

Gorontalo is formerly a businessman that actively engages on manufacturing sector. The area mentioned has been chosen as the pilot project under the Country Service Framework (CSF) that UNIDO Jakarta Office is active with. The visioner Governor convinces the State Ministry of Research and Technology to establish a pilot trial on Agrotechno Park within his region. The possibility of this region to be a candidate for the site is backed up by the fact that one of the CSF's Program is capacity building. The program concentrate on the creation of Business Development Services for the Eastern part of Indonesia, where Gorontalo serves as the pilot plant.

Manado rests in northern part of Gorontalo and southern part of the Philippine. Characteristically, the people of Manado is not much different from its neighbourhood Gorontalo. Bunaken is the famous place for its marine park due to the beautifulness of its coral-reef.

The numerical simulation of the current in the area of Gorontalo and Manado by Supangat depict approximately the same result as it shown by Ontowirjo et al5. Figures 8 describes the calculation by Supangat on the current speed at the area of Gorontalo and Manado.

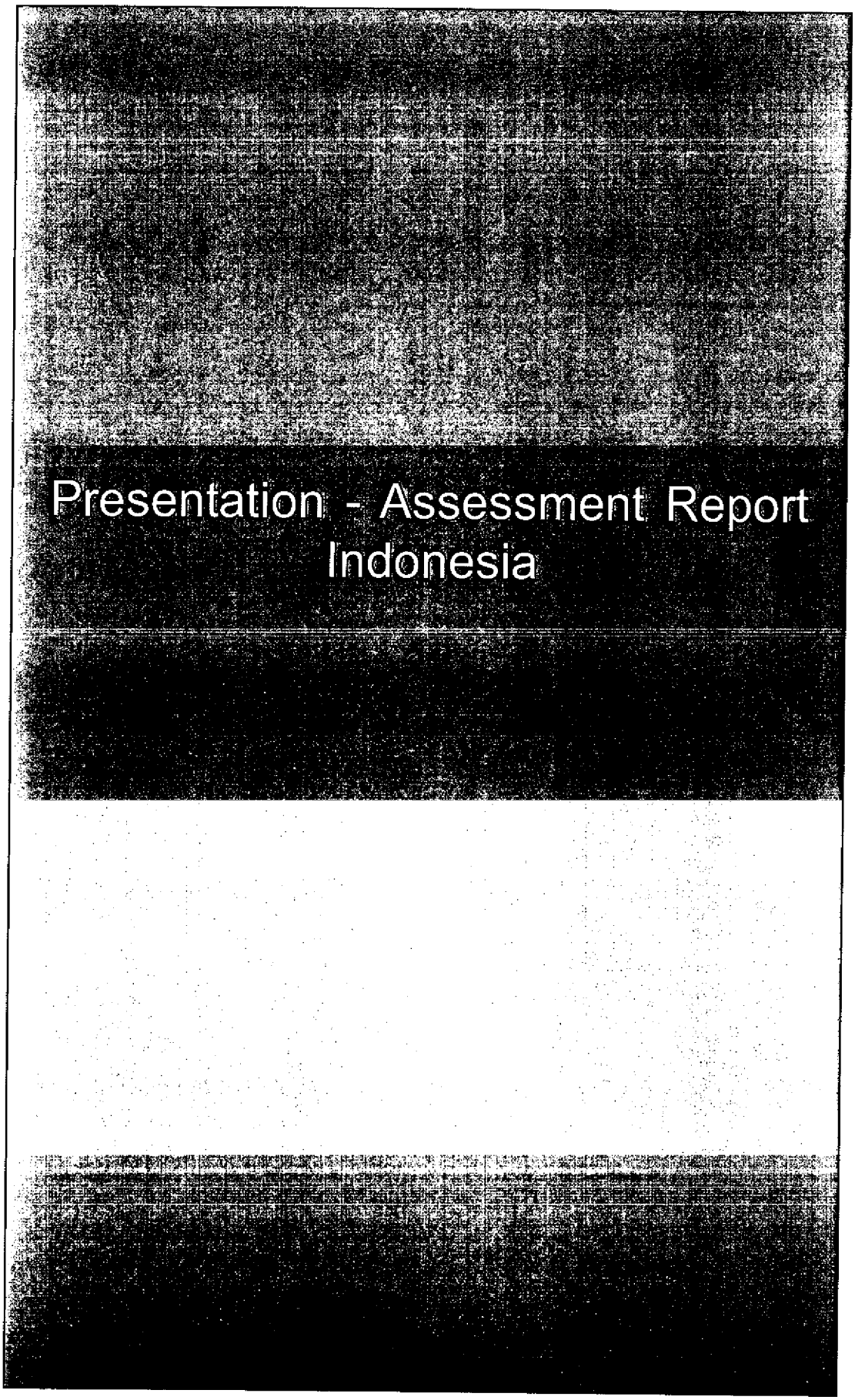
CONCLUDING REMARKS

Potential locations for installing a Kobold Patented power plant have been discussed. The candidate is not merely determined by the highest current speed. Consideration on the absorptive capacity of the people and hence their leader, logistic support as well as stability of the marine characteristics is taken into account. Three potential location are determined namely, Gorontalo, Manado and East Kalimantan.

The numerically calculation shown similar trend of speed as compared to the measured one. However, exact site for installing the prototype is worth investigating. Gorontalo is potentially promising within the perspective of the Country Service Framework run by UNDO Jakarta Office.

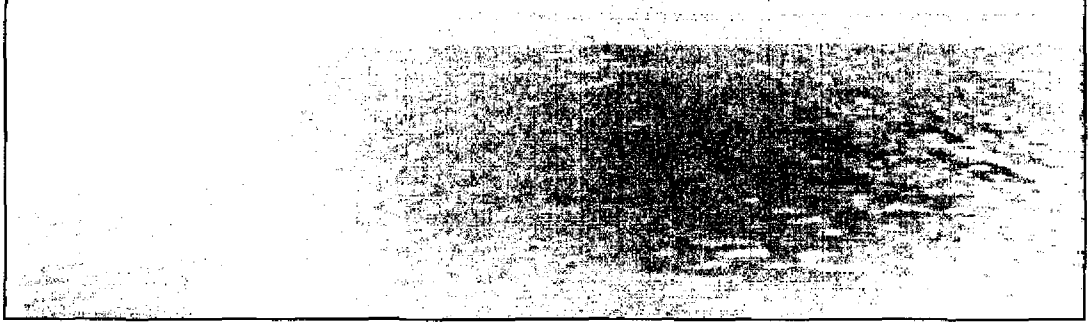
RECOMMENDATION

The marine current characteristic in Indonesia, affected by ITF, is different from that of in Messina. The coastal topography is of necessitate to be investigated. Furthermore, the mooring end that tighten up on the very heavy concretes insist on us to reconsider the process of putting the concrete onto the bottom of the sea. In that case, a simulation testong is worth considering prior to floating the system to its position.


Presentation - Assessment Report
Indonesia

THE ESTABLISHMENT OF KOBOLD TYPE MARINE ENERGY IN INDONESIA

Andi Eka Sakya



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1. Introduction;
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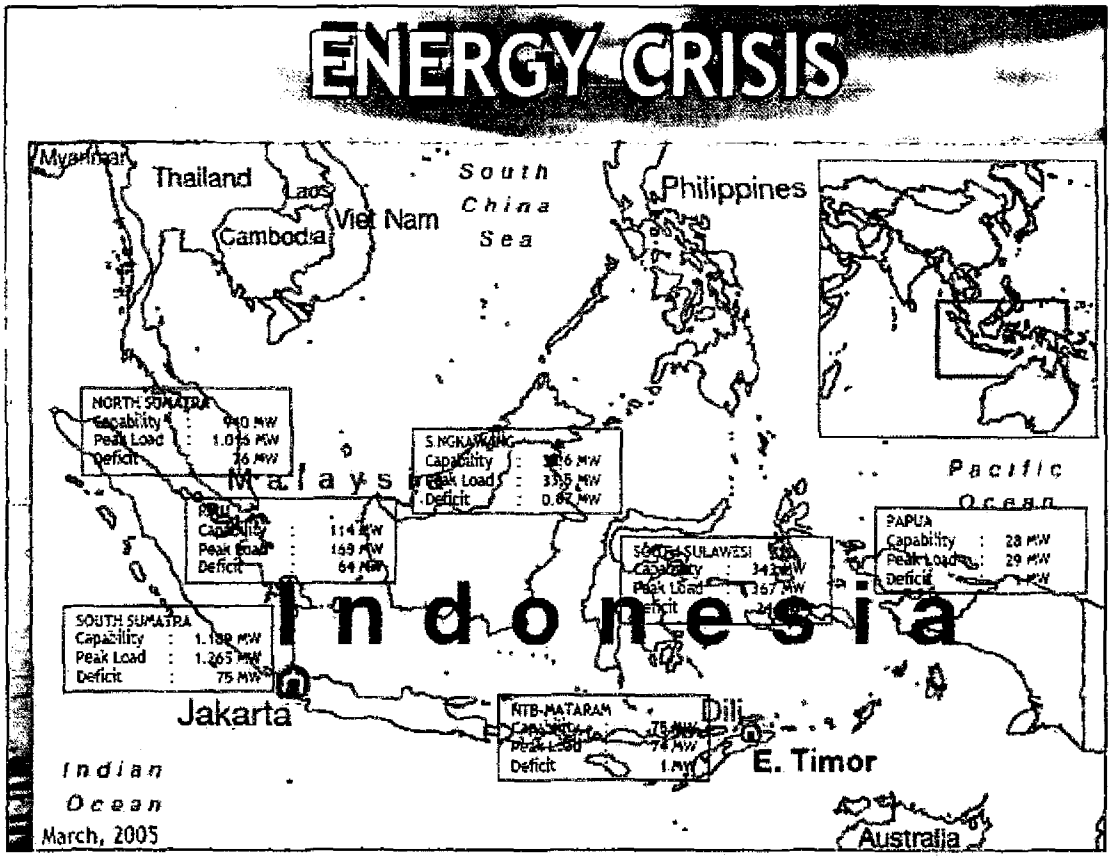
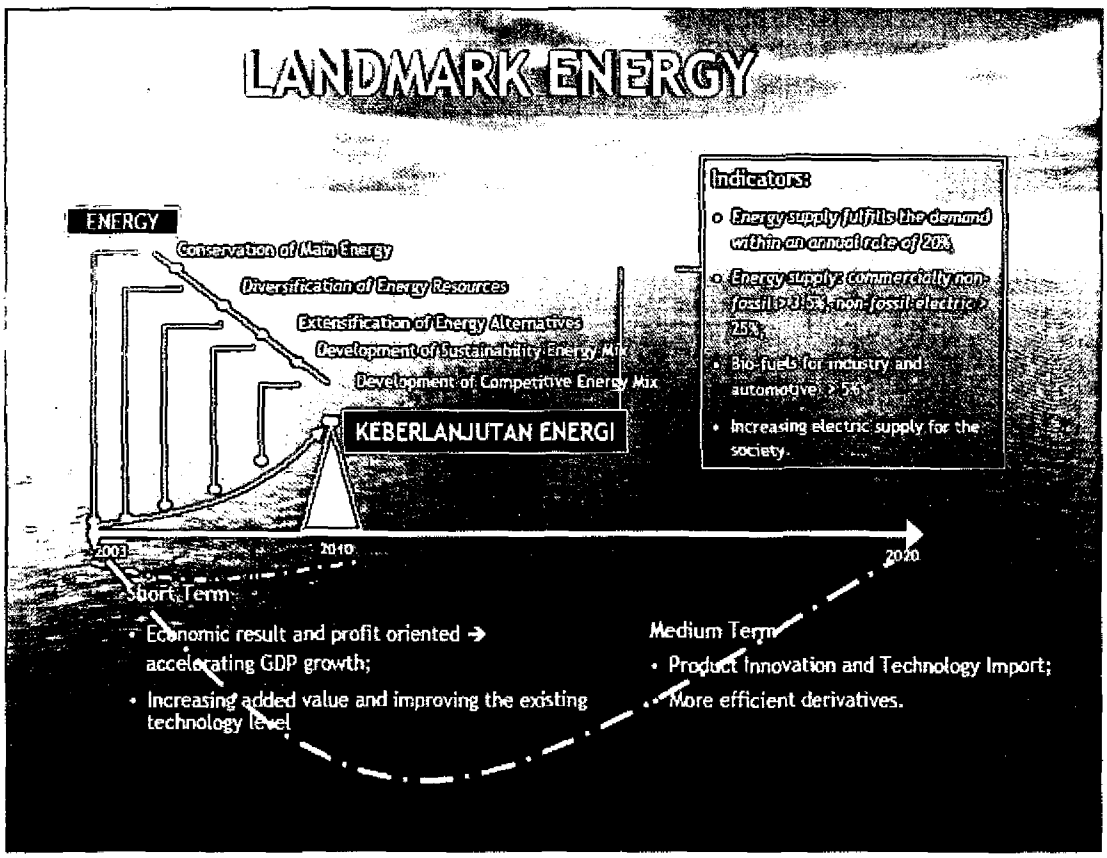
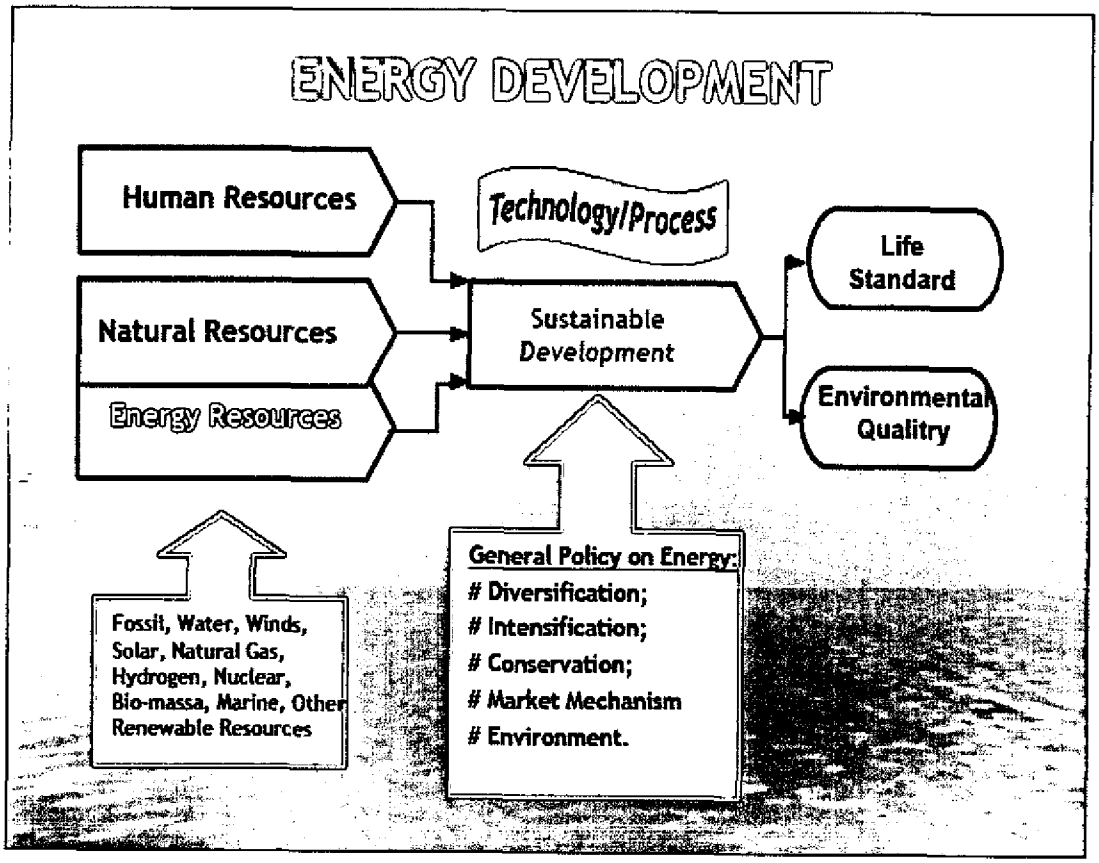
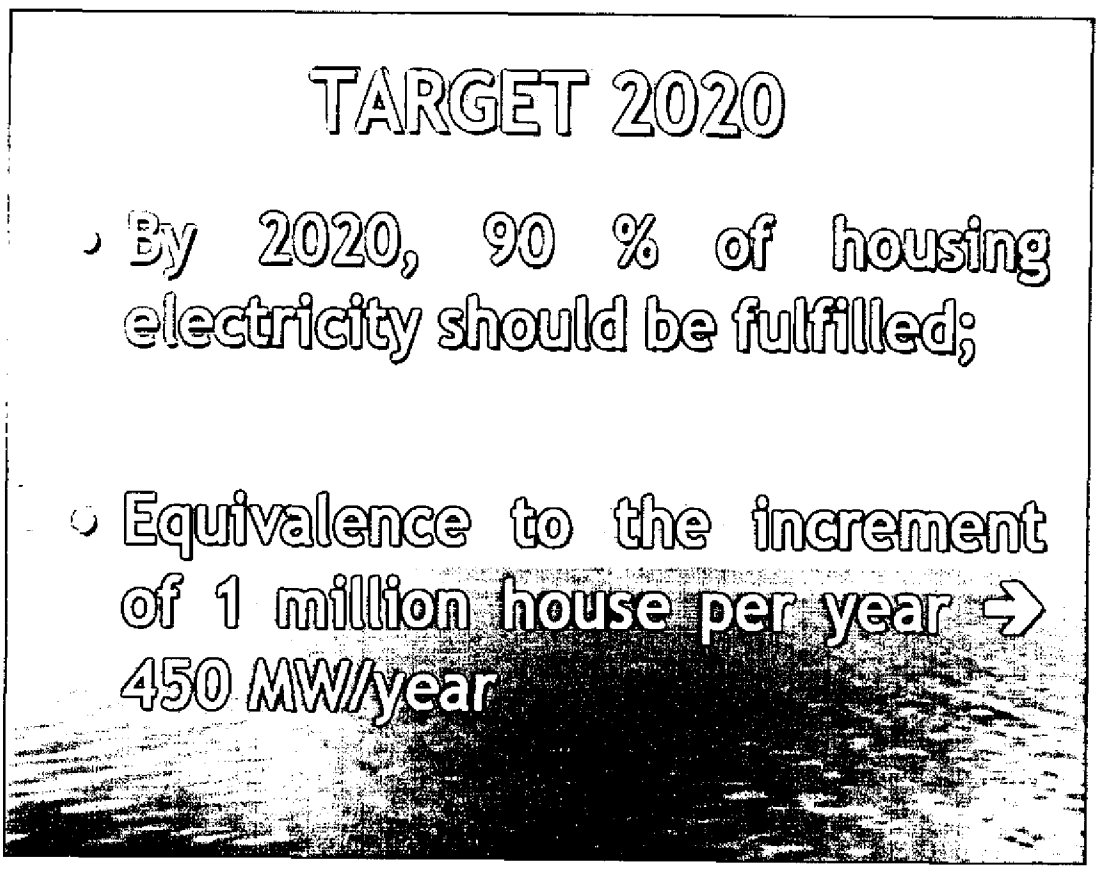

ENERGY CRISIS
Myanmar
Thailand
Laos
Cambodia
Viet Nam
South China Sea
Philippines
Malaysia
Indonesia
Pacific Ocean
Jakarta
Dili
E. Timor
Indian Ocean
Australia
March, 2005
NORTH SUMATRA
Capability : 940 MW
Peak Load : 1.016 MW
Deficit : 76 MW
SOUTH SUMATRA
Capability : 1.138 MW
Peak Load : 1.265 MW
Deficit : 75 MW
PAPUA
Capability : 28 MW
Peak Load : 29 MW
Deficit


LANDMARK ENERGY
ENERGY
Conservation of Main Energy
Diversification of Energy Resources
Intensification of Energy Alternatives
Development of Sustainability Energy Mix
Development of Competitive Energy Mix
KEBERLANJUTAN ENERGI
2003
2010
2020
Indicators:
Energy supply fulfills the demand within an annual rate of 20%
Energy supply commercially non-fossil > 15% non-fossil-electric > 25%
Bio-fuels for industry and automotive > 5%
Increasing electric supply for the society.
Short Term
Economic result and profit oriented → accelerating GDP growth;
Increasing added value and improving the existing technology level
Medium Term
Product Innovation and Technology Import;
More efficient derivatives.


ENERGY DEVELOPMENT
Human Resources
Natural Resources
Energy Resources
Technology/Process
Sustainable Development
Life Standard
Environmental Qualitry
Fossil, Water, Winds, Solar, Natural Gas, Hydrogen, Nuclear, Bio-massa, Marine, Other Renewable Resources
General Policy on Energy:
Diversification;
Intensification;
Conservation;
Market Mechanism
Environment.

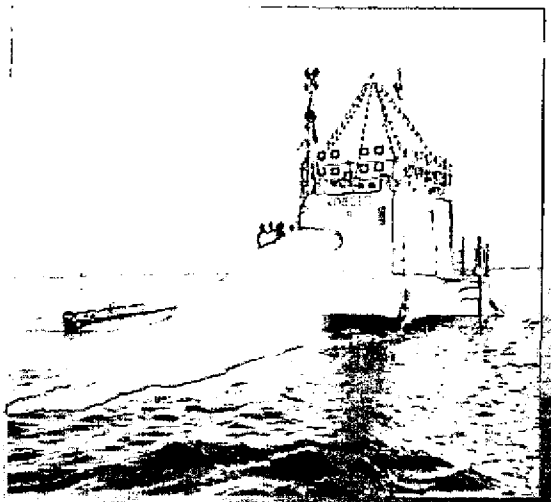

TARGET 2020
By 2020, 90 % of housing electricity should be fulfilled;
Equivalence to the increment of 1 million house per year
450 MW/year

INVESTMENT NEEDED

- Investment needed 2005 - 2015 → 28.072 MUSD:
  - Power Plants USD 14.231,5 Million;
  - Transmission USD 8.742,9 Million;
  - Distribustion USD 5.097 Million
- Government budget can only fulfill 10 - 20 % and remaining budget is from private entities.

INDONESIA ARCHIPELAGO

KOBOLD TYPE MCE



Characteristics:

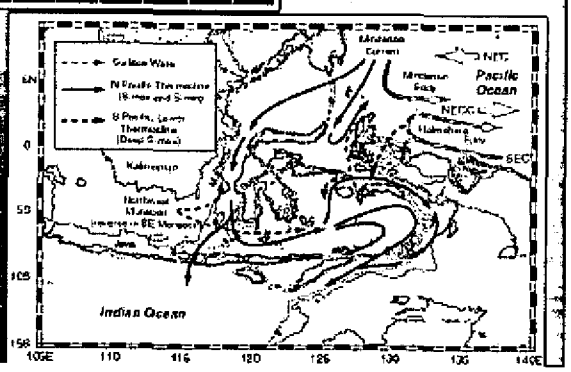
- Cut-off Speed (Inner Current) : 2 m/s;
- Energy Resulted: 75 kW;
- Hexagone "Buoyant" type generator;
- Rpm speed: 8;
- Environmentally sound.

CURRENT FLOW VELOCITY CARACTERISTICS

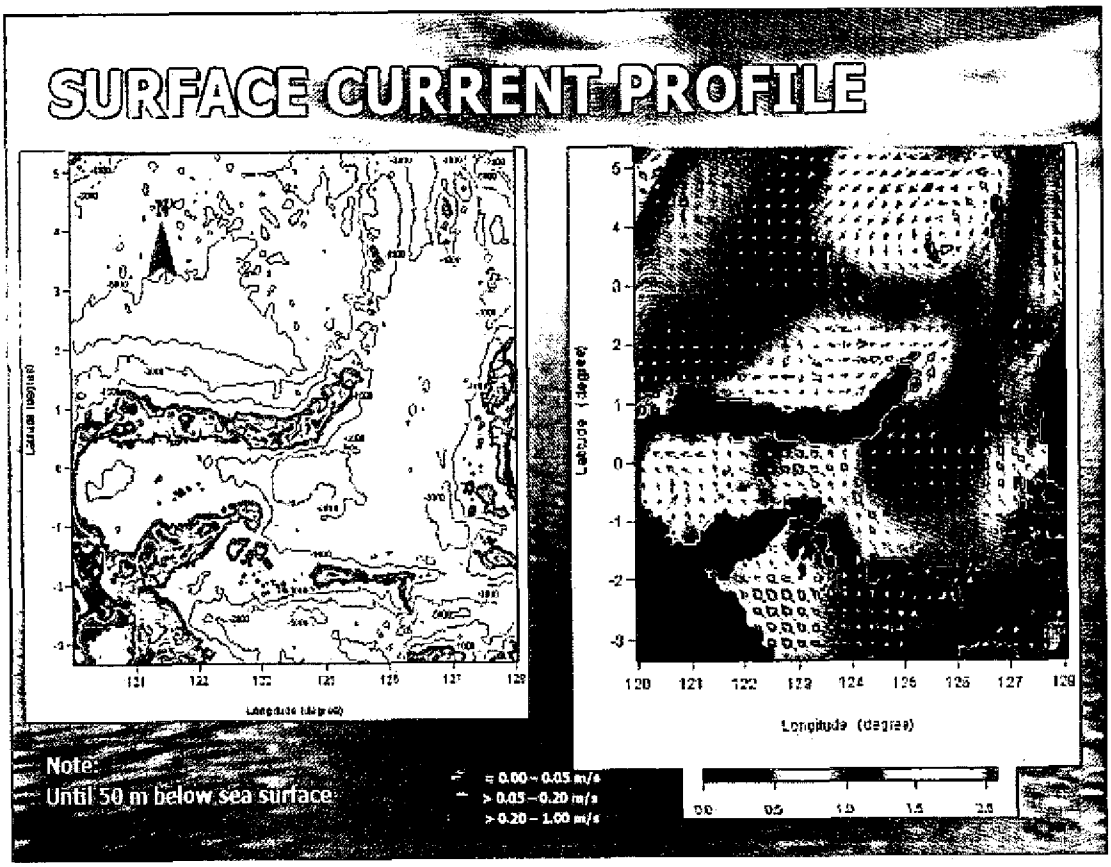
LOCATION	MONTHS AVG VELOCITY [KNOT]											
	J	F	M	A	M	J	J	A	S	O	N	D
Lhoksemawe - ACEH	8	8	4	2	2	6	4	5	5	4	6	6
Batam - RIAU	4	4	4	4	5	5	6	8	6	2	4	6
SOUTH SUMATRA	6	6	4	2	5	6	4	4	6	2	5	6
LOMBOK STRAIT	8	8	4	6	2	7	10	10	6	4	2	5
NORTH MALUKU	5	5	8	2	5	12	11	8	8	2	11	5
Biak - PAPUA	10	10	10	6	10	10	10	4	5	5	5	6
GORONTALO	**4**	**5**	**5**	**5**	**4**	**4**	**4**	**4**	**6**	**4**	**4**	**4**

Measured by buoys deployed 2003 – 2006.

- Highest flow velocity appx 12 knot at North papua;
- Steadiest flow → Gorontalo (~ 4 Knot);

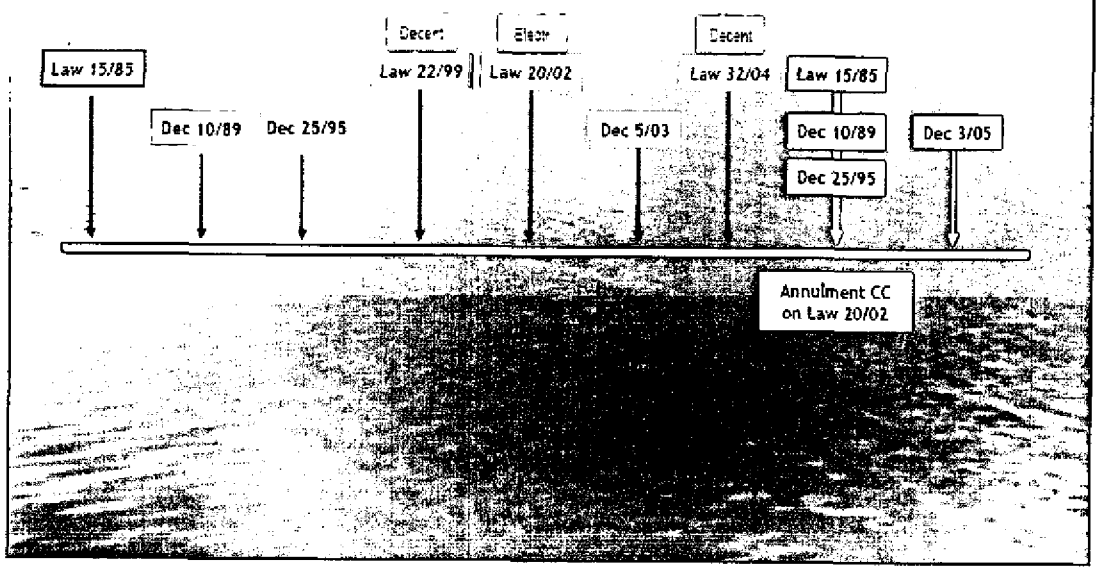


Ontowirjo, B., Purwandani, A., Lukijanto, Indonesian Current Report, 2004.

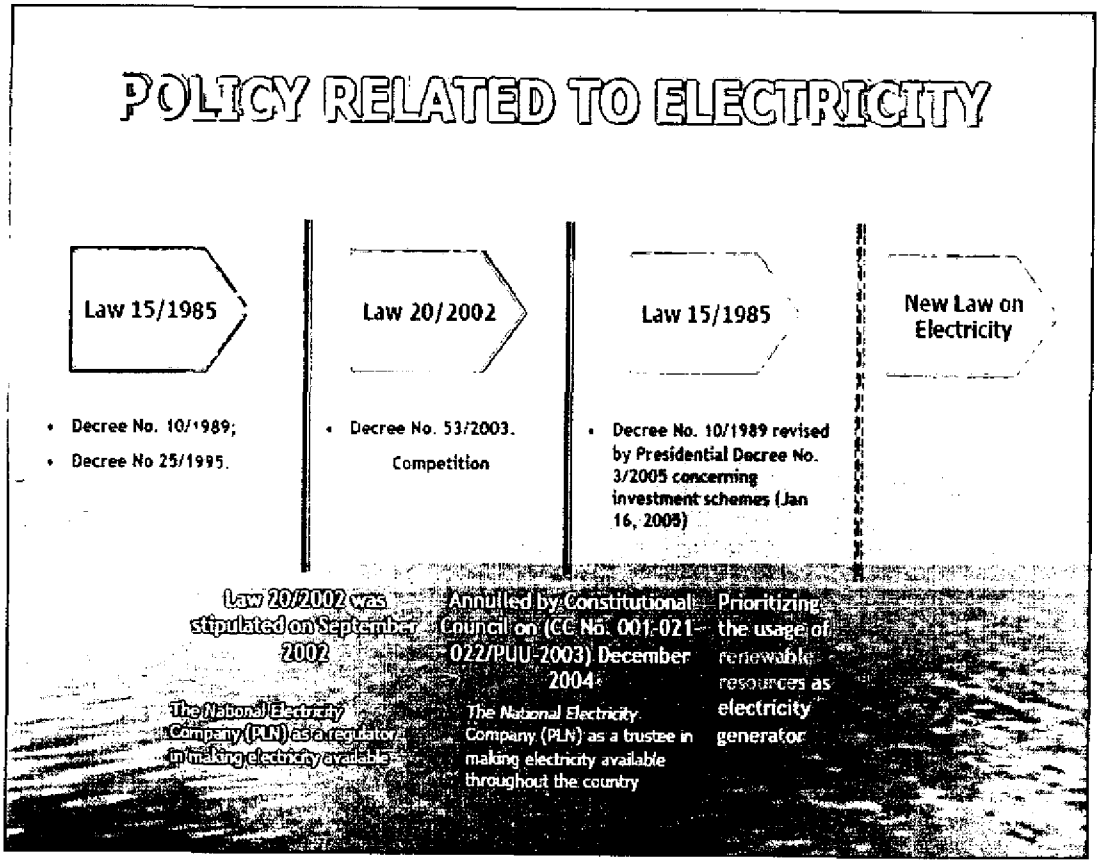

SURFACE CURRENT PROFILE
Latitude (degree)
Longitude (degree)
Note:
Until 50 m below sea surface
= 0.00 ~ 0.05 m/s
> 0.05 – 0.20 m/s
> 0.20 – 1.00 m/s


POTENTIAL LOCATION
Myanmar
Thailand
Laos
Cambodia
Viet Nam
South China Sea
Philippines
Malaysia
Indonesia
Jakarta
E. Timor
Indian Ocean
Australia
Pacific

LAW AND REGULATION



POLICY RELATED TO ELECTRICITY



The Outlook of Renewable Energy in the Philippines

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Taguig City, Philippines

INTRODUCTION

The objectives of the energy sector have been formulated to support the macroeconomic agenda of the national government who's focus has been on job creation. Its goals take into account the timing, allocation of responsibility, funding needs and other resources in a manner that allows for the monitoring and evaluation of progress. Consequently, strategies or specific action plans have been identified as a means to achieve the statement of objectives and targeted goals.

One of the government's critical objectives in the energy sector is to ensure a sufficient, stable, secure, accessible and a reasonably priced energy supply. This translates to a targeted 50.0 percent average energy self-sufficiency level within the next ten years culminating in a 55.0 level percent by the end of 2013. Wider access to reliable energy supply on the other hand, especially in the countryside, shall result from programs to be implemented in the power and downstream oil and gas sub-sectors. Considering the intensive capital requirements to achieve these goals, policy directions that will ensure fair business practices shall be introduced to encourage and sustain private sector participation.

The stated self-sufficiency levels should be brought about by the intensified and efficient exploration, development and utilization of indigenous energy resources. In addition, efforts will be accelerated to develop and promote the use of renewable energy and alternative fuels.

In terms of providing wider access to energy supply, the completion of barangay energization by 2006 shall be vigorously pursued and further expanded to reach 90.0 percent of the country's estimated number of households by 2017. This will be undertaken by an aggressive campaign to electrify both grid and off-grid barangays through a com-

bination of the accelerated application of renewable energy systems, maximum utilization of available electrification funds and other innovative measures.

For the downstream oil industry, the 2004 Plan Update is targeting a 50.0 percent increase in the number of petroleum product outlets outside Metro Manila. This will occur through the diversification of supply sources and modes, petroleum supply as well as the rationalization and enhancement of storage and distribution facilities. In addition to this the capability and utilization of local refineries shall be enhanced. The development and commercial use of alternative fuels including compressed natural gas (CNG) for non-power purposes and the transport sector shall be promoted.

Towards the realization of these goals, the government shall encourage private sector investment and participation by formulating policies that will build on the gains achieved in power sector restructuring, downstream oil deregulation and the establishment of a Philippine Natural Gas Industry. Meanwhile, the Department of Energy (DOE) shall institute the necessary measures to strengthen vigilance in monitoring market abuse and other trade malpractices in these sectors.

Consistent with our national and international commitments to promote sustainable development, the government shall promote the cleaner and more efficient use of energy as well the application of clean energy technologies. Along this line, the government is aiming for an emission avoidance level of 32,000 Gg C02 by 2013 and shall also work to generate energy savings in the amount of 82.6 million barrels of fuel oil equivalent (MMBFOE) in the next ten years. Apart from aggressively promoting renewable energy resources in the sector, the other critical strategies identified to achieve this emission avoidance level include the prioritization of converting old and retiring oil and coal-fired power plants to natural gas and the stricter implementation of R.A. 8974 or the Philippine Clean Air Act (CAA) provisions in terms of fuel quality standards.

Finally, the expanded coverage of energy standards and labeling programs as well as the enhanced implementation of energy efficiency and conservation measures are likewise seen to contribute to the achievement of the emission and energy savings levels. The establishment of mechanisms to enhance and sustain private sector support, participation and cooperation in energy projects shall also be pursued. Investments in the various energy sub-sectors and activities shall be promoted, particularly in the areas of exploration and development of indigenous resources, power generation, transmission and distribution facilities, downstream oil and gas activities and renewable energy systems.

The proposed Renewable Energy Law that will provide fiscal and non-fiscal tax incentives to prospective partners on renewable energy development. In tandem with this the DOE will strengthen similar efforts in respect of its other legislative initiatives, namely the Natural Gas Bill, which shall institutionalize the regulatory mechanisms to govern the Philippine natural gas industry, and the Liquified Petroleum Gas (LPG) Bill which proposes to streamline policy and enforcement measures in the LPG sector.
The formulation and implementation of energy policies shall involve the participative and pro-active undertaking of the public and private sectors. Linkages and advocacies within the Executive and Legislative branches of government, national government agencies and other sectors including the

academe, non-government organizations, local government units, regional development councils and other stakeholders shall be fortified.

The promotion of consumer welfare and protection shall be a continuing thrust of the government. Thus, programs to enhance awareness and involvement of the general public in energy issues and safeguard consumer interest shall be implemented including innovative information, education and communication campaigns and other similar advocacy programs as well as the establishment and implementation of appropriate consumer feedback and monitoring mechanisms.

The government shall also ensure the strict compliance of the industry players with fuel quality, safety, health and environmental standards and practices as prescribed in the Clean Air Act and other laws and issuances. In safeguarding consumer interest, the government shall also enjoin the participation of the different energy stakeholders.

ENERGY DEMAND AND SUPPLY

The country's primary energy supply grew by 2.2% from 255.4 MMBFOE in 2002 to 260.9 MMBFOE in 2003. Oil remained the major source of energy for the country, despite its reduced share in the total energy mix from 42.7% (109.0 MMBFOE) in 2002 to 40.1% (104.7 MMBFOE) in 2003. The total indigenous energy production in 2003 increased by 8.5% reaching 139.1 MMBFOE as compared to its 2002 aggregate of 128.1 MMBFOE. The bulk of the increase may be attributed to the improved production of natural gas resulting from the continuous operation of the Malampaya gas field. This enabled the country to increase its self-sufficiency level from 50.2 % in 2002 to 53.3 % in 2003.

Geothermal energy remains a significant source of power comprising 18.6% of the country's power requirements in 2003. Power generated from this source amounted to 16.9 MMBFOE. Hydropower increased its generating capacity by 348 MW in 2003 from its 2002 level of 2,519 MW. As a result, hydropower contributed 13.6 MMBFOE to the country's total energy supply, posting an 11.9 % increase from the previous year level. Likewise, renewable energy sources from biomass, solar and wind continued to play a major role in the gross energy requirements of the country. The total from these resources posted a moderate growth of 4.6 % from 76.8 MMBFOE in 2002 to 80.3 MMBFOE in 2003.
In terms of energy consumption, the country recorded a 3.2% growth from 189.7 MMBFOE in 2002 to 195.9 MMBFOE in 2003. Energy use in the residential sector is mainly for lighting and cooking. The residential sector consumed 74.7 MMBFOE in 2003 compared to 71.5 MMBFOE in 2002The demand of the residential sector constituted 38.1 % of the total energy consumption.

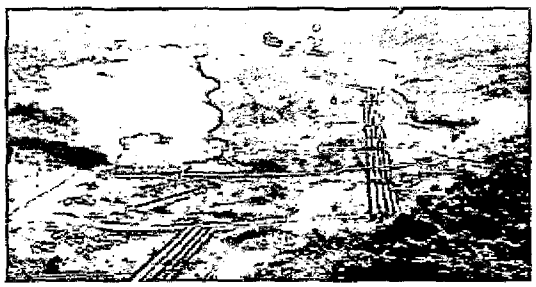
The total energy consumption in the transport sector rose to 55.9MMBFOE in 2003 from 54.4 MMBFOE in 2002. Diesel continues to be the dominant fuel used in the transport sector constituting 54.2% of the total oil consumption or 30 MMBFOE, increasing by 2.6% from the previous year. In 2003, the industry sector composed of the manufacturing, mining and construction accounted for 33.5 % of the overall GDP of the country. Energy consumption of the sector registered an increase of 1.9% from 46.8 MMBFOE in 2002 to 47.7 MMBFOE in 2003. The manufacturing sector took up the biggest share at 96.4%. The commercial or

services sector accounted for 46.7% of the country's total GDP. Energy used by this sector grew by 3.1% from 14.7 MMBFOE in 2002 to 15.1 MMBFOE in 2003.

Despite the occurrence of typhoons, the agriculture sector posted a contribution of 19.6% to the total GDP of the country. Although its contribution to the GDP was quite high, its energy consumption was the lowest among the sectors of the economy posting only 2.5 MMBFOE representing 1.3 % of the total energy consumption in 2003.

RENEWABLE ENERGY SOURCES

GEOTHERMAL



The Philippines is situated in the Pacific Ring of Fire and as such, geothermal energy resource abounds in the country. Potential reserve is conservatively estimated at 4000 MW. Installed generating capacity is 1,930 MW, securing the country's position as the world's second largest producer of geothermal energy next to the United States. In 2003, the Philippines generated 9,822 GWh from geothermal energy displacing about 16.9 MMBFOE.

HYDROPOWER

The country is endowed with abundant water resources from small river and stream systems to irrigation networks, sufficient to support installation of micro-hydro systems (<100 kW). Micro-hydro is becoming increasingly important and usually well suited to village level development and local self-help project. Micro-hydro can thus play an important role in promoting rural development in remote areas. These systems have been used both for mechanical applications, to generate power for lighting and to run electrical machines.

The share of power generation from micro hydro power plants accounted for 0.3 percent from the share of hydropower of 14.9 percent of the country's energy mix in 2003 (PEP 2005 update, Vol.1). The government has been tapping this resource to energize off-grid barangays under the government rural electrification program. Report also shows that there are still a lot of potential micro-hydro resources that remain untapped.

BIOMASS, SOLAR AND WIND

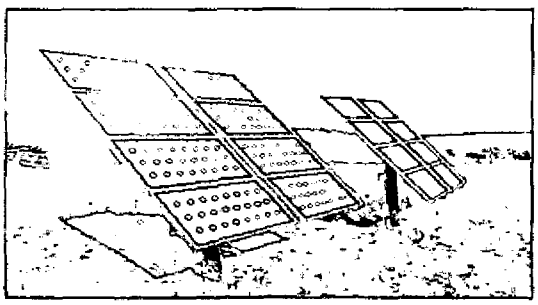
As the country grapples with the soaring oil prices and its adverse impact on the economy, environmentally friendly fuels such as biomass, solar and wind address a high import dependency. As of December 2003, installation of biomass, solar and wind energy technologies reached 46,061 units which have been utilized to meet the barangay electrification targets of the government.

BIOMASS

The Philippines, being an agricultural country can generate a substantial volume of agricultural residues or biomass that can be used as energy fuel. Available biomass energy resources in the country are waste materials from crops and livestock production, and the crops themselves from which fuels may be produced. Utilization of biomass by direct combustion ranges from wood stoves in households to steam boiler application in industry. Current usage of wood and agricultural residues (primarily bagasse, coconut shell and rice husks) are in use in the wood industry, sugar and a number of food and/or consumable manufacturing plants. There is an existing 8-MW

power plant in Mindanao that uses bagasse as its fuel.

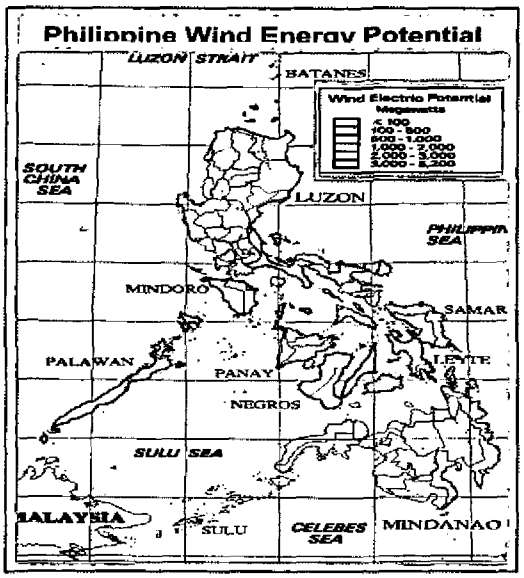
SOLAR ENERGY



Solar energy has a big potential in the country. Being situated near the equator, the Philippines have very good solar isolation with an annual average daily exposure of 3.0-4.75 kWh/sq.m. and annual average sunshine duration of more than 1,825 hours. The photovoltaic (PV) technology has emerged as one of the most promising renewable energy technologies. Energy from the sun has become a popular source of electricity especially in areas where the cost of extending power lines and the difficulty of transporting generator fuel is a limitation. International funding agencies are now focusing on solar energy as a low cost option in providing energy to off-grid areas. There are several PV demonstration systems installed in different areas of the country to stimulate and generate public interest in the use of PV systems. These schemes that range from 50 watt off peak (Wp) to 75 watt peak in capacity have been tested for various applications such as repeater systems, telemetry, water pumping, lighting and refrigeration.

Photovoltaics (PV) is considered to be a commercial technology in the Philippines. PV modules are imported while other components are locally manufactured. The success and potential of this technology in the Philippines is demonstrated with the establishment of a solar wafer manufacturing plant in Laguna. The plant manufactures high-efficiency PV cells and is expected to produce enough solar wafers to supply six (6) percent of the world's total available market for photovoltaic industry and boost the country's bid to become a solar manufacturing hub for Southeast Asia

WIND ENERGY



With a good wind potential, the country aims to become the leader in wind energy in South East Asia within the next ten years. A study conducted by the US New and Renewable Energy Laboratory (NREL) in collaboration with the Philippine National Oil Corporation and the Department of Science and Technology showed that the Philippines has a total wind potential of 70,000 MW. The Northern Luzon region, in particular, showed very good wind potential. To date, this region hosts the first wind power project in the country.

OCEAN ENERGY

The oceans and seas are viewed as vast reservoirs of energy. However, technological barriers have hampered tapping of these resources. Substantial development is still required for this energy source to be economically feasible. Initial assessments and studies conducted by the National Power Corporation (NPC) on some potential sites indicated favorable results to warrant further studies. Ocean current profiles were conducted in San Bernardino Strait, Basiao and Gaboc Channels. However, it is still necessary to collect more data in order to accurately determine the recoverable energy and the most appropriate design of the technology.

CONCLUSION

The growth of renewable energy in the Philippines is primarily driven by the country's need to realize its energy goals, that is, to increase the country's level of independence in energy terms. Additionally there is also the creation of demand for renewable energy technologies due to the increasing concern on cleaner environment and the global climate change due to the growing concentration of greenhouse gases (GHGs) from fossil fuel consumption.

Presentation - Policy Philippines

The Outlook of Renewable Energy in the Philippines

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Introduction

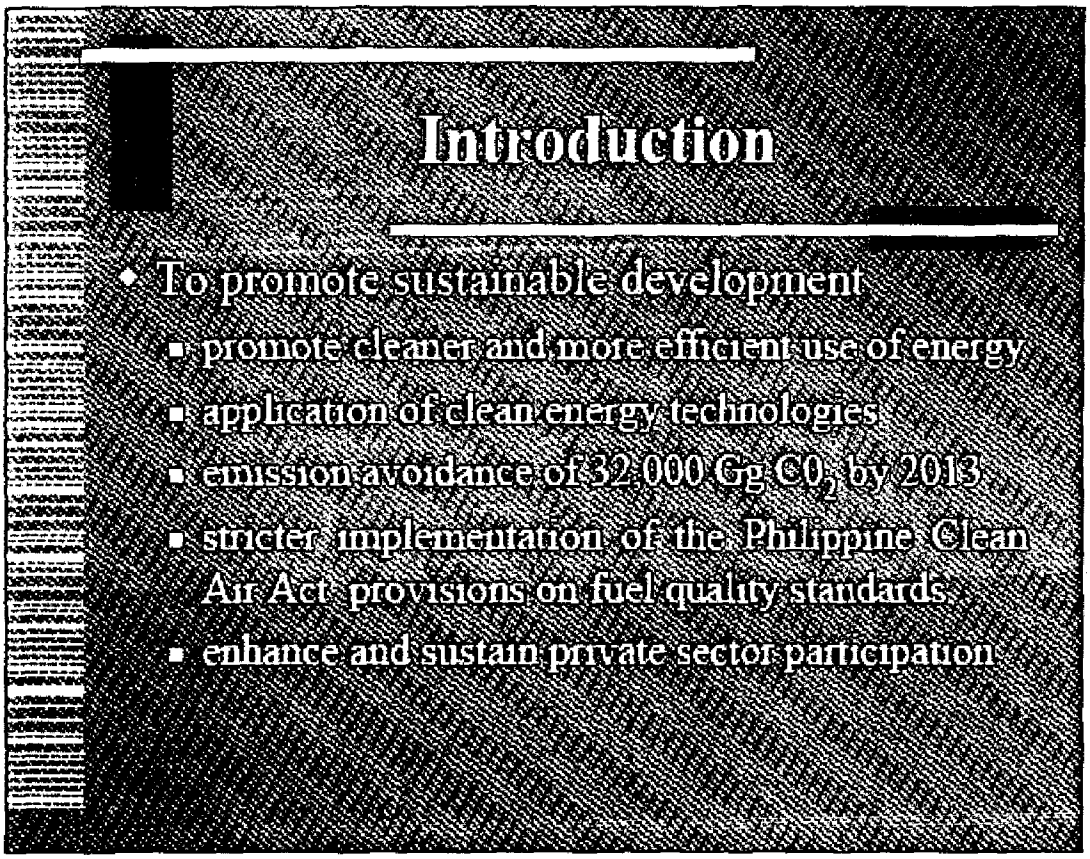
- the objective of the energy sector is to support the macroeconomic agenda of the national government which focuses on job creation
- to ensure a sufficient, stable, secure, accessible and reasonably-priced energy supply
- translates to 50.0% average energy self-sufficiency within the next ten years

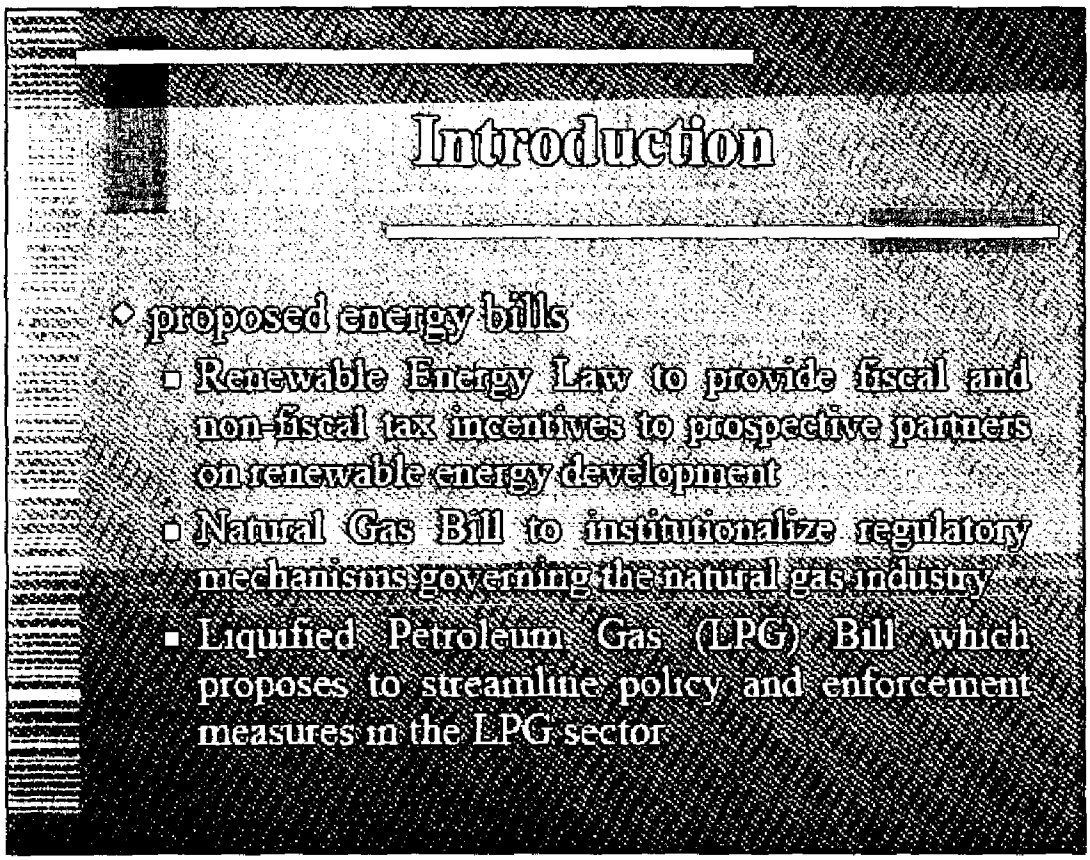
Introduction

- self-sufficiency
  - intensified and efficient exploration, development and utilization of indigenous energy resources
  - development and promotion of renewable energy and alternative fuels.
- wider access to energy supply
  - the completion of barangay energization by 2006
  - application of renewable energy systems

Introduction

- development and commercial use of alternative fuels including compressed natural gas (CNG) for non-power purposes and the transport sector


Introduction
To promote sustainable development
promote cleaner and more efficient use of energy
application of clean energy technologies
emission avoidance of 32,000 Gg CO_2 by 2013
stricter implementation of the Philippine Clean Air Act provisions on fuel quality standards
enhance and sustain private sector participation


Introduction
proposed energy bills
Renewable Energy Law to provide fiscal and non-fiscal tax incentives to prospective partners on renewable energy development
Natural Gas Bill to institutionalize regulatory mechanisms governing the natural gas industry
Liquified Petroleum Gas (LPG) Bill which proposes to streamline policy and enforcement measures in the LPG sector

Energy Demand and Supply 2002-2003

- Primary energy supply grew by 2.2%
- Oil remained the major source of energy
- Total indigenous energy production increased by 8.5%
- Geothermal contributed 18.6% to the country's power requirements
- Hydropower increased capacity by 11.9%
- Renewable energy posted 4.6 % growth

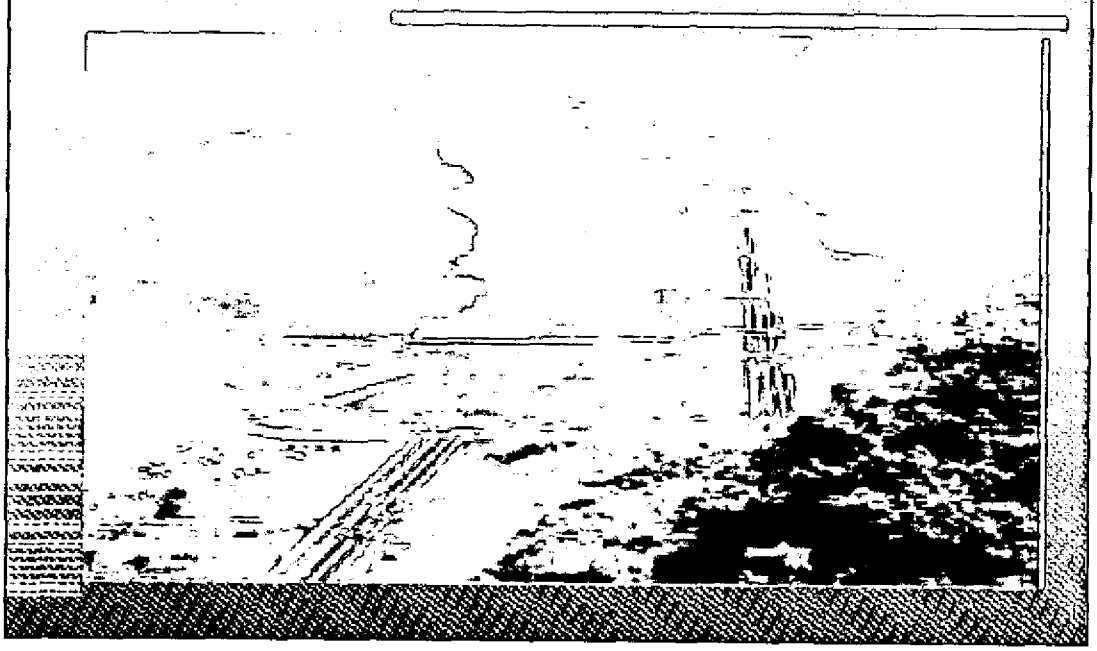
Energy Consumption 2002-2003

- energy consumption grew by 3.2%
- residential sector accounted for 38.1 % of the total
- transport sector increased by 2.6 %
  - diesel constituted 54.2% of the total oil consumption
- industry sector registered an increase of 1.9%
  - manufacturing sector took up 96.4% of the total
- commercial or services sector energy consumption grew by 3.1%
- the agriculture sector posted 1.3 % of the total

Geothermal

- Location in the Pacific Ring of Fire endowed Philippines with geothermal energy resource
- Potential reserve is estimated at 4,000 MW
- Installed generating capacity is 1,930 MW
  - world's second largest producer, next to US
- In 2003, the Philippines generated 9,822 GWh from geothermal energy displacing about 169 MMBFOE

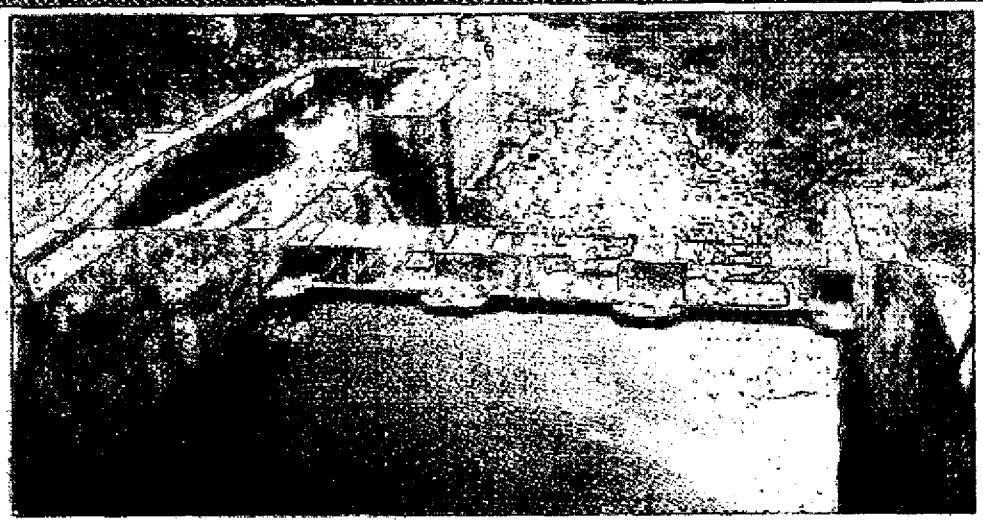
Geothermal



Hydropower

- abundant water resources from small river and stream systems to irrigation networks
- micro-hydro is well suited to village level development and local self-help project
- used to generate power for lighting and to run electrical machines
- government is tapping this resource to energize off grid barangays

Hydropower



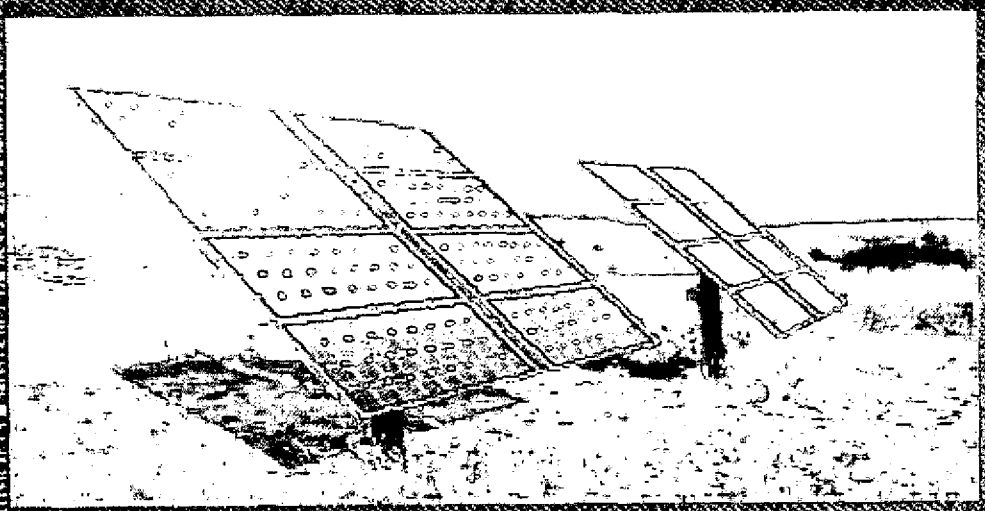
Biomass, Solar and Wind

- As of December 2003, installation of biomass, solar and wind energy technologies reached 46,061 units
- utilized to meet the barangay electrification targets of the government

Biomass

- country generates substantial volume of agricultural residues for energy use
- utilization of biomass by direct combustion ranges from wood stoves in households to steam boiler application in industry
- there is an existing 8-MW power plant in Mindanao that uses bagasse as its fuel

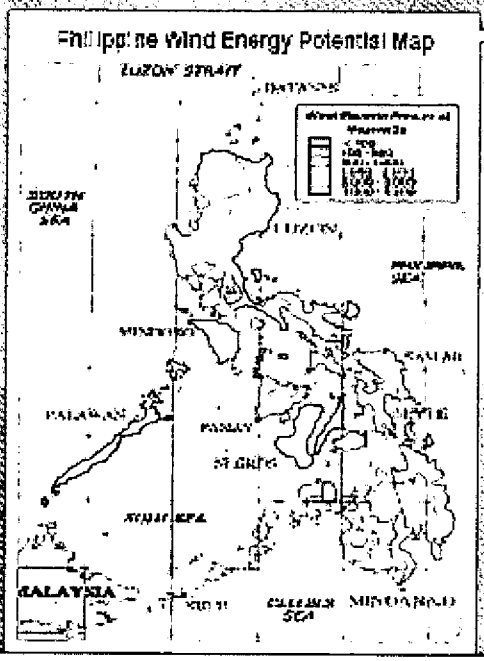
Solar



Solar

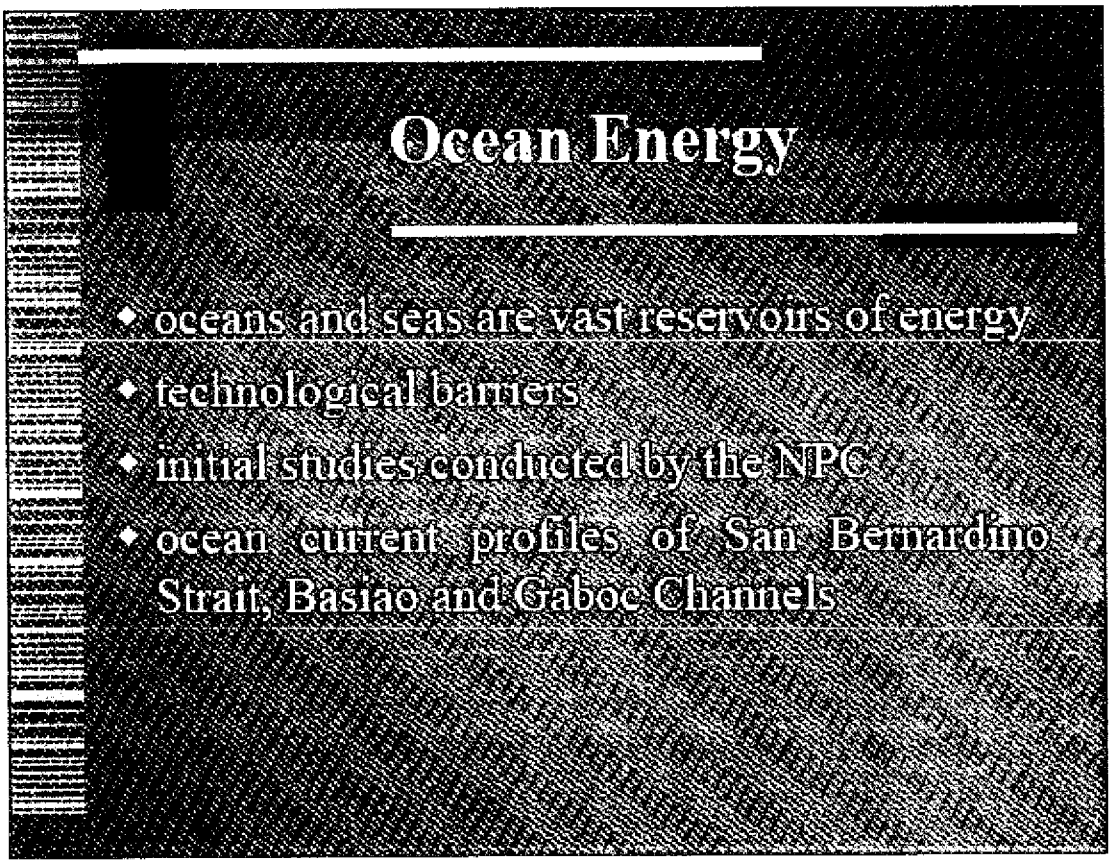
- average daily insolation is 3.0-4.75 kWh/sq.m.
- annual sunshine duration of more than 1,825 hours
- popular source of electricity in off-grid areas
- tested for repeater systems, telemetry, water pumping, lighting and refrigeration
- solar wafer plant in Laguna to supply 6% of the world market

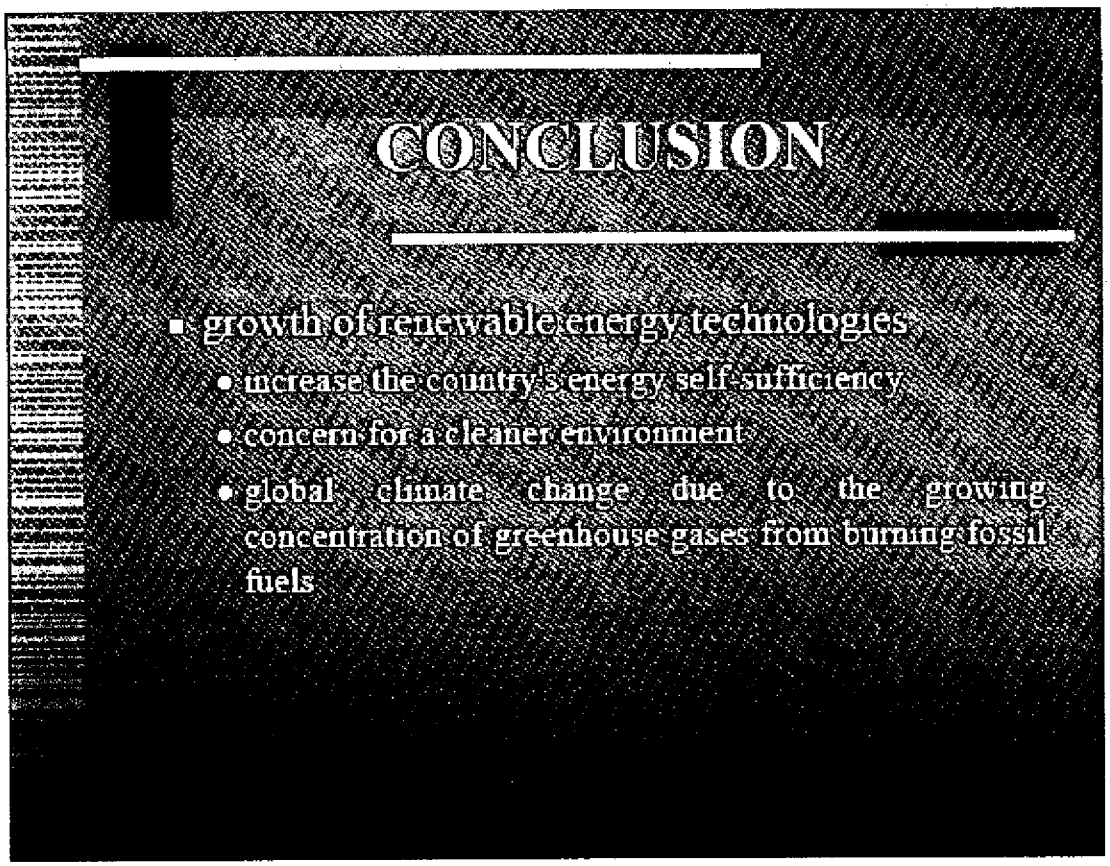
Wind



Wind

- good wind potential
- country aims to become the leader in wind energy in South East Asia within the next ten years
- study by US-NREL in collaboration with the DOST showed a wind potential of 70,000 MW
- The Northern Luzon region hosts the first wind power project in the country


Ocean Energy
oceans and seas are vast reservoirs of energy
technological barriers
initial studies conducted by the NPC
ocean current profiles of San Bernardino Strait, Basiao and Gaboc Channels


CONCLUSION
growth of renewable energy technologies
increase the country's energy self sufficiency
concern for a cleaner environment
global climate change due to the growing concentration of greenhouse gases from burning fossil fuels

Assessment of Selected Sites for Ocean Current Potential

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INTRODUCTION

BACKGROUND

In 1996, the National Power Corporation (NPC) with the funding support from the Department of Science and Technology (DOST) through the Philippine Council for Industry and Energy Research and Development (PCIERD) conducted preliminary marine current resource assessment using an Acoustic Doppler Current Meter in selected Philippine water channels and passages, namely: the San Bernardino Strait, the Basiao Channel and the Gaboc Channel/Hinatuan Passage.

METHODOLOGY OF MEASUREMENT

The Acoustic Doppler Current Meter (ADCM), Model DCM 12, was used primarily in the study to measure the ocean current speeds and direction on the surface and at various depths in shallow waters, up to about 30 meters deep. The ADCM is an instrument that can transmit and receive sound waves under water. As the sound waves travel through the water, some part of it are reflected or scattered by small particles in the water such as plankton, organisms and other particles resulting from natural and human activities. This back-scattered energy is received by the instrument and analyzed to find any changes in the frequency. An upward shift in frequency means that the particles are moving towards the instrument while a downward shift means that the particles are moving away from the instrument. The degree of shift indicates the rate of movement. The direction of the flow of current is determined by the instrument by the use of measurements along two orthogonal axes and linking them to the true North using an internal compass. The usefulness of the instrument depends on the presence of sufficient scatterers which vary from place to place. Seasonal variations are also common especially in less polluted waters.

The DCM 12 can also be used to determine water level by measuring the hydrostatic pressure in the water column above the instrument. The water level is calculated internally based on the pressure measurements. By getting measurements once every second over a period of time, significant wave height can also be calculated based on the variations in the pressure

measurements.
The instrument is usually placed in a fixed position on the seabed with the aid of commercial SCUBA divers.

For each of the site that was studied, the following information were gathered: Site location and description, including visibility under water and degree of encrustation, water level, significant wave height, direction of current and the ocean current profile.

SAN BERNARDINO STRAIT

San Bernardino is situated between Samar Island and Southern Luzon. The monitoring site was located in Sacalagayan Point, Northern Samar, approximately 12o 33.9'N, 124o 15.7'E. The instrument was deployed on the seabed, about 30 meters deep. The site is about 200 meters from the shoreline.

The seabed is composed of sand and coral rubbles. The visibility under water was tolerable up to 6 meters. Monthly retrieval of the DCM 12 instrument was done to replace the battery and data storage unit. It was observed that the rate of encrustation in the area was very fast due to the presence of macro algae (seaweeds) and some barnacles.

The water level variations at the monitoring site were minimal. The minimum water level was recorded at 26.5 meters and the maximum at 27.4 meters. Tide variation is normally greater during full moon and new moon. In contrast, tide variation during first quarter is very minimal as well as during the last quarter of the moon. The current speeds are usually at the highest during high tide.

Surface currents were observed to be strong. However, only few scatterers were found near the surface which resulted to low data recovery rate. In contrast, scatterers generated by strong currents near the seabed were sufficient to measure current speeds and direction. The average current measured ranged from 74 cm/sec to 105cm/sec.

Though the DCM 12 instrument was deployed on the sea bed at 30 meters below mean sea level, no measurements were done near the seabed. The nearest sampling level to the instrument was located at 19.02 meters below mean sea level. The current speeds obtained at 7.6 meters and 11.41 meters below mean sea level were more stable and persistent.

The current moves South-West during high tide and North-North-East during low tide.

The significant wave height in the monitoring area varied from a minimum of 0.2 meters to a maximum of 0.6 meters. The usual significant wave height variation is between 0.2 to 0.4 meters.

BASIAO CHANNEL

Basiao Channel is situated between Bohol Island and C.P. Garcia Island (formerly Lapinig Island), about 150 kilometers northeast of Tagbilaran City. The mooring site is about 10 meters deep situated at 10o 4'N, 124o 25'E. It is about 300 meters from the Bohol mainland.

The underwater visibility was observed to be low (about 1 meter) due to the murky conditions of the seabed. The rate of encrustation in the area is fast due to the presence of barnacles and oysters.

The water levels at the monitoring site varied from 8.0 meters minimum to 9.9 meters maximum. Depending on the lunar period, the water level changes almost of the same magnitude.

Surface currents were generally observed to be much stronger than those observed below the surface. However, the current speeds below the surface were more persistent. The measured current speeds ranged from 47 cm/sec. to 61 cm/sec.

The currents were moving South-East during high tide and North-West during low tide. The ocean current at 2.8 meters and 4.1 meters below mean sea level were traveling more frequently in Southeast and Northwest directions as compared with the surface currents

The water in the area is generally calm. The Channel is shielded by the C. P. Garcia Island during the North-East monsoon and by the Bohol Island during the South-West monsoon. However, there were some short periods of peak waves recorded probably generated by winds, strong currents, and by small motorized boats passing over the mooring site.

GABOC CHANNEL

Gaboc Channel is situated between Nonoc Island and Dinagat Island in Surigao del Norte. The Gaboc Channel is about 80-120 meters wide and 8 kilometers long. The instrument was deployed on the seabed, about 30 meters deep, at 9o 52.25'N, 125 o 38.9'E.

The seabed is composed mostly of sand. The water was observed to be less polluted and visibility under water was tolerable up to 10 meters. The rate of encrustation is very slow. Sponges and hydrozoa were the main source of encrustation at the site.

The water level at the mid-water during the sampling period registered a minimum of 30.8 meters and a maximum of 32.8 meters. The tide usually reaches its peak during full moon.

Currents at the surface up to about 4 meters below mean sea level were observed to be strong but flowing intermittently. The current speeds at 8.6 meters to 22.9 meters below mean sea level were noted to be more consistent although there were some short peak events recorded. The short peak events recorded particularly during the first sampling periods may have been caused by the obstruction created by the wall of the channel. During the second sampling period, only few short peak events were recorded because the instrument was moved in mid-water.

The current speeds below the water surface were slower as compared with those on the surface. Considering the current speeds between 9.17 meters and 18.3 meters below mean sea level, the maximum average current was computed at 110 cm/sec. A maximum current speed of 199 cm/sec was recorded at 9.17 meters below mean sea level.

The current at the sampling site moves in northwesterly direction during low tide and southeasterly direction during high tide. The ocean current on the surface and below appear to be moving in one direction.

The water in Gaboc Channel is generally calm. This was expected since the Channel is shielded by the Dinagat Island on the northeast and by the Nonoc Island on the southwest. There were some short periods of peak waves recorded. However, these were attributed to the strong currents moving through the channel and also to small motorboats occasionally passing over the mooring site.

SUMMARY AND CONCLUSION

The data collected by DCM 12 instrument at shallow waters or near the coast has proven the availability of strong currents at San Bernardino Strait, Basiao Channel and Hinatuan Passage/Gaboc Channel. The strongest period, which persisted for 16 days per lunar cycle, is during full moon and new moon. The current intensity generally declines with water depth.

Among the three selected water channels/passages, San Bernardino Strait is perceived to have the great potential for future large marine current power stations. Gaboc Channel/Hinatuan Passage, on the other hand, could be an ideal site for a small pilot tidal power plant because of its shallow water and the proximity of the grid presently supplying the electricity needs of the municipalities of the Dinagat Island through the existing small diesel power plants.

RECOMMENDATION

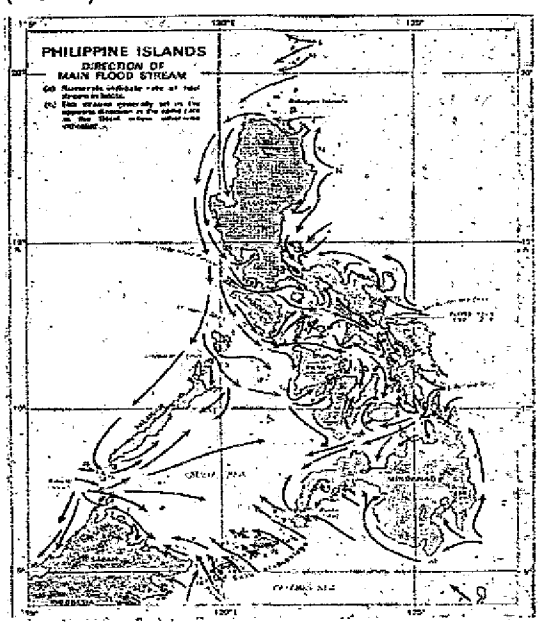
Based on the preliminary findings, it is recommended to collect more data to further assess the monthly and seasonal variability of ocean current in selected sites. The current measurements using the DCM 12 were conducted at short periods and do not show

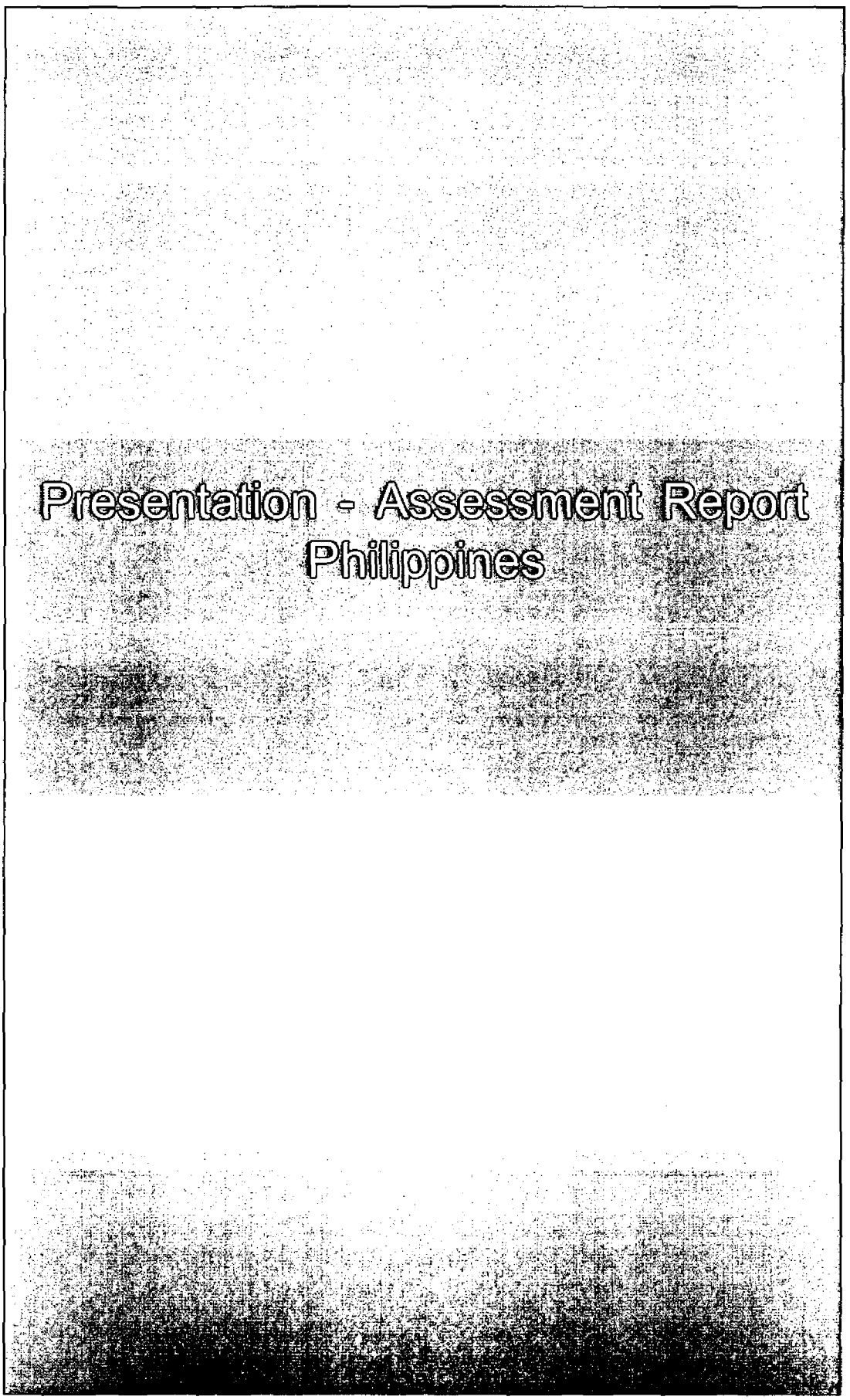
seasonal variations. Further study must include surface to seabed current profile, tide variations, wave motions, wind speed and seabed conditions. These information are needed in order to determine the recoverable energy at the potential site and the most appropriate technology to harness the energy including the design of the support structure.

It is also recommended not to collect further data from the Basiao Channel due to weak currents. The Channel is also too shallow for a current turbine.

ACKNOWLEDGEMENT

This paper is excerpted from the 1997 Terminal Report on Preliminary Tidal/Ocean Current Energy Resource Assessment prepared by the Strategic Power Utilities Group (SPUG) of the National Power Corporation (NPC) in cooperation with the Philippine Council for Industry and Energy Research and Development (PCIERD) of the Department of Science and Technology (DOST).




Presentation - Assessment Report
Philippines

Assessment of Selected Sites for Ocean Current Potential

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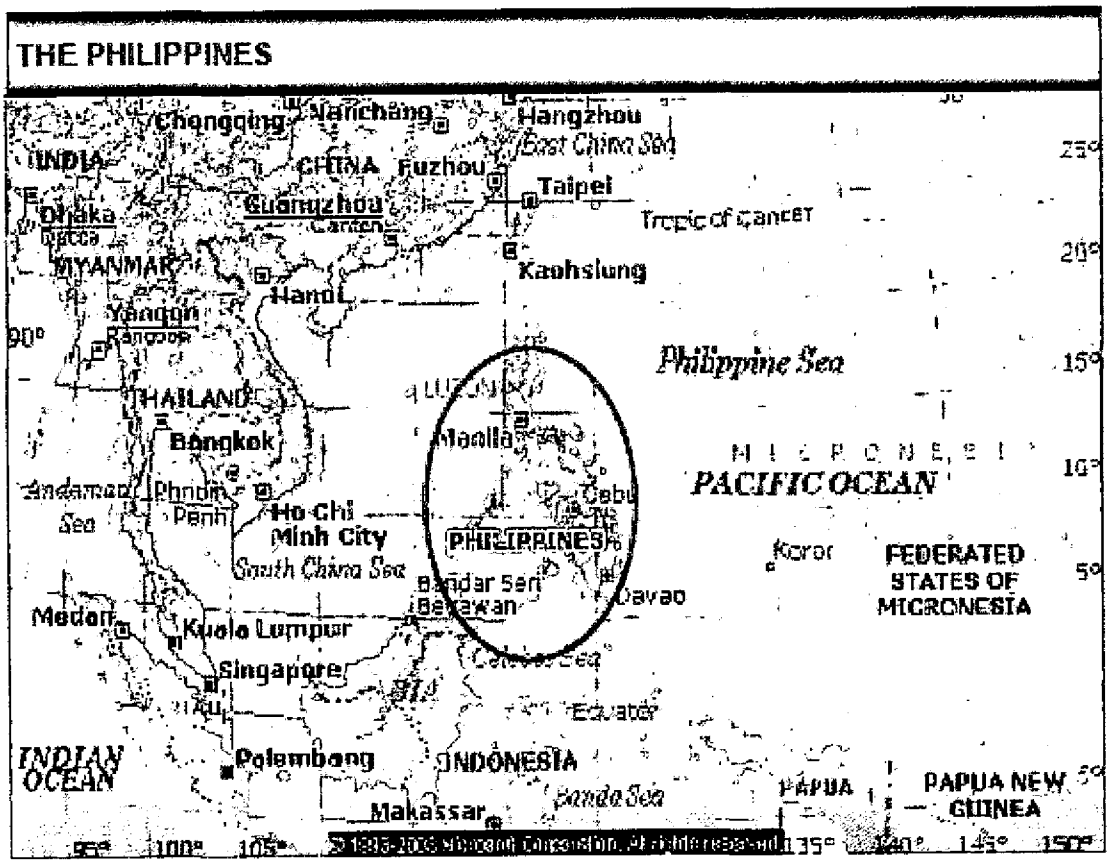
Introduction

- Development of renewable energy sources
  - biomass, geothermal, solar, wind and ocean
- Main drivers
  - diminishing supply of fossil fuel
  - need to mitigate global warming
- Unlimited energy from the ocean
  - does not produce harmful emission

Introduction

- Philippine archipelago
  - China Sea on its left, Pacific Ocean on its right
  - more than 7,100 islands
- NAMRIA reported potential areas
  - Verde Island Passage, Mindoro and Balabac Strait
  - San Bernardino Strait, Surigao, Basilan and Sulo Group of Islands
  - Batanes and Babuyan Islands
- 1996 DOST-PCIERD NPC study
  - San Bernardino Strait, Basiao Channel and Gaboc Channel/Hinatuan Passage



Methodology

- Use of Acoustic Doppler Current Meter (ADCM), Model DCM 12
- ADCM is an instrument that can transmit and receive sound waves under water
  - as sound waves travel, some of them are reflected by small particles in the water
  - reflected or back-scattered energy is received by the instrument and analyzed
  - shift in frequency means particles are moving either towards or away from the instrument
  - usefulness of the instrument depends on the presence of sufficient scatterers

Methodology

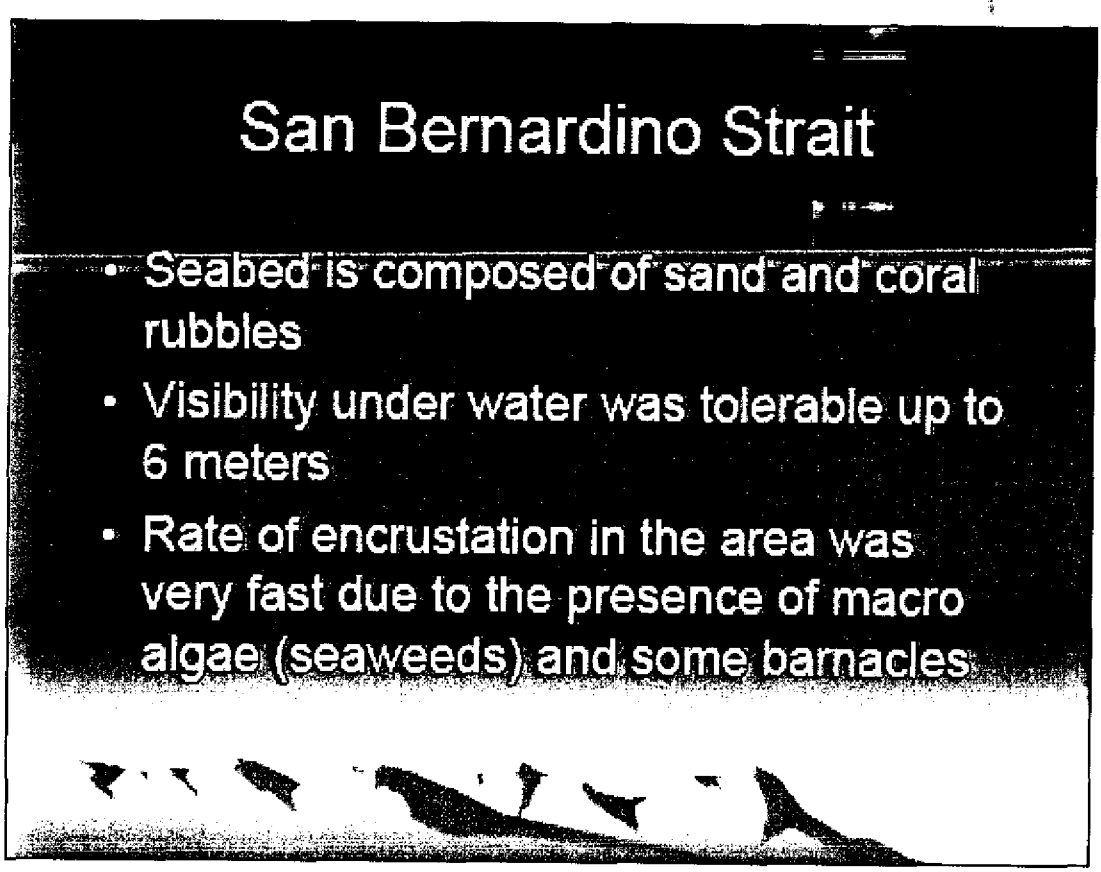
- DCM 12 can also determine water level
  - measures hydrostatic pressure in the water column above the instrument
  - water level is calculated based on the pressure measurements
  - significant wave height is also calculated based on the variations in the pressure measurements
- Instrument is fixed on the seabed by SCUBA divers

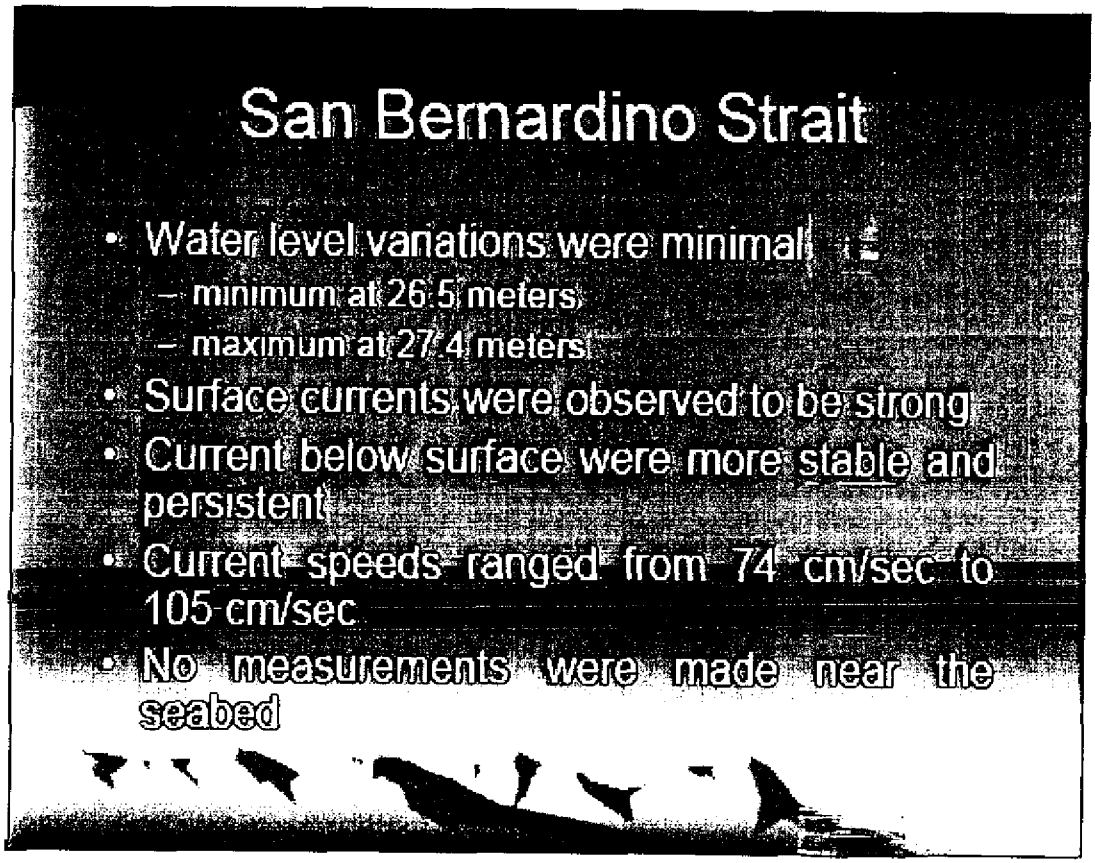
Methodology

- Following information were gathered for each site:
  - site location and description
  - visibility under water
  - degree of encrustation
  - water level
  - significant wave height
  - direction of current
  - ocean current profile

San Bernardino Strait

- Between Samar Island and Southern Luzon
- Site is in Sacalagayan Point, Northern Samar
- Coordinates: 12º 33.9' N, 124º 15.7' E
- Instrument was deployed on the seabed, about 30 meters deep.
- Site is located about 200 meters from the shoreline


San Bernardino Strait
• Seabed is composed of sand and coral rubbles
• Visibility under water was tolerable up to 6 meters
• Rate of encrustation in the area was very fast due to the presence of macro algae (seaweeds) and some barnacles

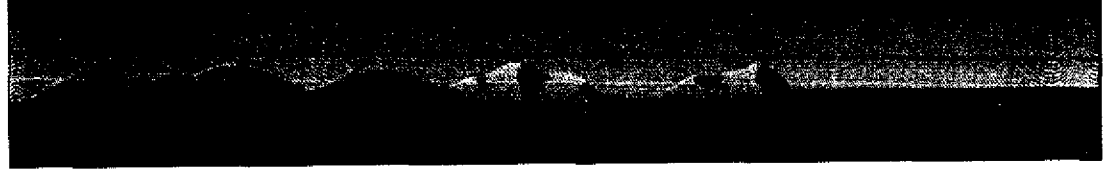

San Bernardino Strait
• Water level variations were minimal
– minimum at 26.5 meters
– maximum at 27.4 meters
• Surface currents were observed to be strong
• Current below surface were more stable and persistent
• Current speeds ranged from 74 cm/sec to 105 cm/sec
• No measurements were made near the seabed

San Bernardino Strait

- Current generally moves South-West during high tide and North-North-East during low tide
- Usual significant wave height variation is between 0.2 to 0.4 meters
  - minimum 0.2 meters
  - maximum 0.6 meters

Basiao Channel

- Situated between Bohol Island and Carlos P. Garcia Island (formerly Lapinig Island)
- About 150 kilometers northeast of Tagbilaran City
- Site is about 10 meters deep
- Coordinates: 10° 4' N, 124° 25' E
- About 300 meters from the Bohol mainland



Basiao Channel

- Low underwater visibility (about 1 meter)
- Murky conditions of the seabed
- Rate of encrustation in the area is fast due to the presence of barnacles and oysters

Basiao Channel

- Water levels
  - 8.0 meters minimum
  - 9.9 meters maximum
- Water level changes almost of the same magnitude

Basiao Channel

- Surface currents were observed to be stronger than those below
- Currents below surface were more persistent
- Speed ranged from 47 cm/sec to 61 cm/sec
- Currents were moving South-East during high tide and North-West during low tide
- Water in the area is generally calm
  - shielded by the Carlos P. Garcia Island and by Bohol Island

Gaboc Channel

- Situated between Nonoc Island and Dinagat Island in Surigao del Norte
- About 80 to120 meters wide and 8 kilometers long
- Instrument was deployed on the seabed, about 30 meters deep
- Coordinates: 9º 52.25' N, 125 º 38.9' E

Gaboc Channel

- Seabed is composed mostly of sand
- Water was observed to be less polluted
- Visibility under water was tolerable up to 10 meters
- Rate of encrustation is very slow
  - Sponges and hydrozoa were the main sources of encrustation at the site

Gaboc Channel

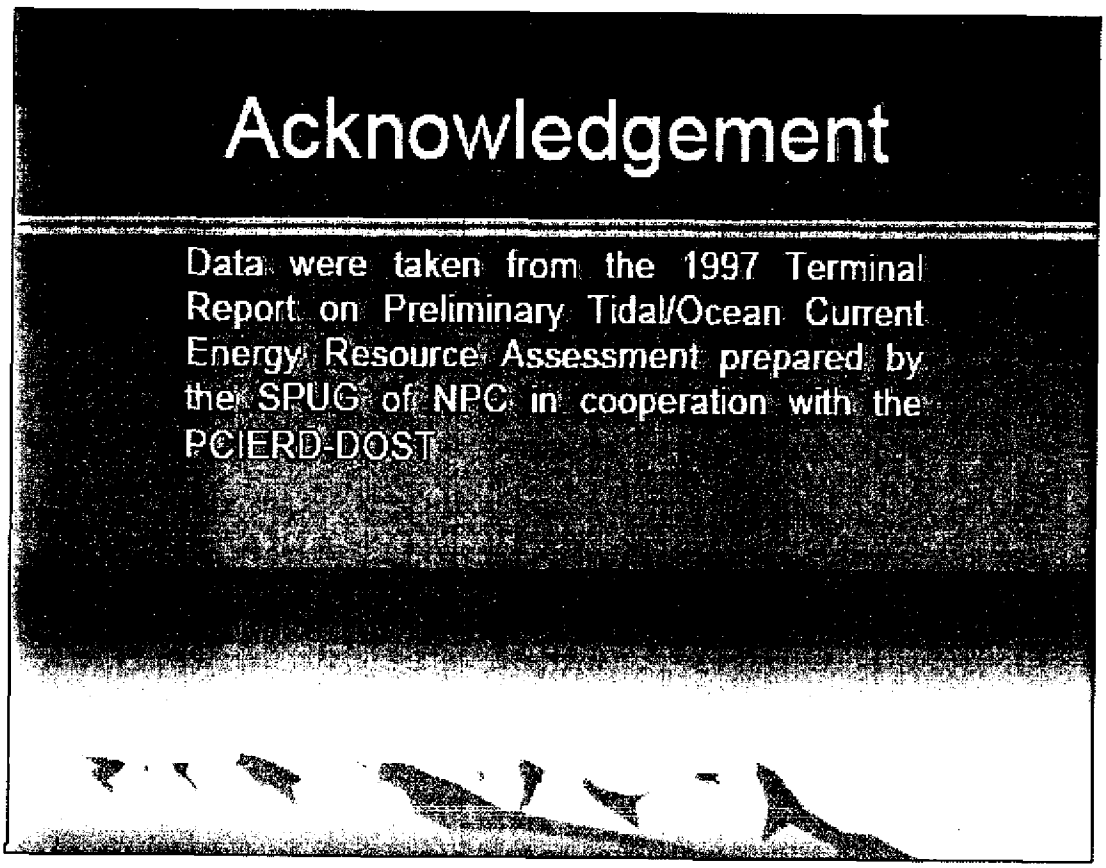
- Water level is 30.8 to 32.8 meters
- Surface current is strong but intermittent
- Current below surface are more consistent
- Average speed 110 cm/sec
  - maximum speed of 199 cm/sec was recorded
- Current moves northwest during low tide and southeast during high tide
- Water is generally calm
  - shielded by Dinagat Island and Nonoc Island

Summary and Conclusion

- Study proved the presence of strong currents
- Current intensity declines with water depth
- San Bernardino Strait has the best potential for marine current power station.
- Gaboc Channel/Hinatuan Passage could be ideal for a small pilot power plant

Recommendations

- Collect more data
  - assess monthly and seasonal variability of the ocean currents
  - include surface to seabed current profile, tide variations, wave motions, wind speed and seabed conditions
  - accurately determine the recoverable energy
  - determine best technology to harness the energy
  - design of the support structure


Acknowledgement
Data were taken from the 1997 Terminal Report on Preliminary Tidal/Ocean Current Energy Resource Assessment prepared by the SPUG of NPC in cooperation with the PCIERD-DOST

SECTION III - Associated Networks

Development of Hydrodynamic Design Tools for High-Performance Kobold Turbines

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ABSTRACT

The aim of this section is to address basic concepts related to the hydrodynamic analysis of a Kobold turbine and to discuss the relationships between single blade forces and turbine performance.

The development of computational and experimental tools to assist design of power generation plants based on the Kobold concept is described. In particular, the research activity performed by INSEAN, The Italian Ship Model Basin, in collaboration with Ponte di Archimede S.p.A. is presented and preliminary results are illustrated.

INTRODUCTION

The successful design of a hydroturbine plant necessarily stems from a multi-disciplinary work in which hydrodynamics, mechanics, structural dynamics, electric plant assembly play together a major role.

Here the emphasis is on hydrodynamics issues. Studying the hydrodynamics involved in the Kobold turbine aims to understand, predict and control the physical mechanisms ruling the transfer of energy from water to the turbine blades. Simply, the origin of power generation capability is addressed.

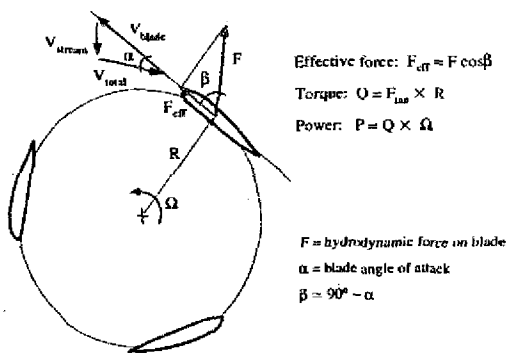
The possibility to extract power from both air and water currents is well known to human kind since thousands of years. Windmills and water pumps of different types witness 'ancient-concept' plants that, due to technology limitations, are characterized by a poor efficiency, *i.e.*, ratio between generated power and available power. The exploitation of such devices is thus limited to sites where intense water or air currents are available and the produced power is modest.

Nowadays, modern technology makes feasible a totally new approach with the capability to extract relevant amounts of power from low-intensity currents.

This yields the possibility to include sea currents and tides among natural power generation sources, with inherent advantages related to the fact that these types of currents are largely available worldwide in coastal regions.

The Kobold turbine represents one of the most appealing concepts of this type. Its working principle is described in detail in other sections of this book and hence it will be only briefly outlined here.

The term Kobold turbine is used to denote a vertical-axis multi-bladed rotor that is fully submerged and subject to an incoming flow originated by a sea current. Each blade has a rectangular, high-span planform and is linked to the rotor shaft by one or more arms. The hydrodynamic force acted by water on the blades generates a torque that puts the blades, and hence the rotor, in rotation around its shaft. Using an electric generator, shaft mechanical power can be converted into electric power. The relationships among hydrodynamic force on blade, F, torque, Q, and power, P, are sketched in Fig. 1.



IG. 1: Sketch of a three-bladed turbine section in a horizontal plane; definition of main parameters and physical quantities.

The successful design of a Kobold power generation plant is then necessarily related to maximizing the energy transfer from water to the shaft through the turbine blades.

Hydrodynamics studies are thus aiming to investigate energy transfer mechanisms and to provide related knowledge. This makes possible to develop design tools to determine turbine shape and working conditions that ensure an optimal performance with respect to the existing water currents.

In view of the complexity of fluid-dynamic features affecting the turbine performance, it is most appropriate to conduct a joint experimental and theoretical activity.
Three distinct investigation phases can be identified:

o understanding the physics involved through experiments on small-scale turbine models
o developing theoretical models and computational tools to predict turbine performance
o assess computational tools against experimental knowledge

The work structure outlined above largely reflects a research program that INSEAN, The Italian Ship Model Basin, is carrying out in order to assist Ponte di Archimede S.p.A. efforts to design a new generation of high-performance Kobold turbines.

In the following sections, an overview of INSEAN activity on both theoretical and experimental studies of Kobold turbines is given.

THEORETICAL MODELLING AND DESIGN SOFTWARE DEVELOPMENT

The development of a computational tool to predict the hydrodynamic performance of a Kobold turbine represents a real challenge for theoreticists. The turbine performance is the result of several different features interacting each other in a very complex way. Trying to classifying all these features, one should include:

o unsteady, three-dimensional blade flow
o turbine rotational speed (unknown a priori)
o blade-to-blade interactions
o number of blades, blade and assembly geometry
o flow viscosity, turbulence and cavitation
o non-uniformity of incoming flow

In spite of the problem complexity, a typical approach is to consider simple hydrodynamic models based on approximated representations (blade-element theory, blade cascades, etc.) where relevant physical aspects are missing. In fact, the simplified approach is largely used for the preliminary design of hydroturbines. Nevertheless, it is apparent that a careful prediction methodology can be developed only if all the hydrodynamic features involved are taken into proper account.

The research activity by INSEAN is thus aiming to develop a theoretical methodology in which most of the physics affecting the hydrodynamic performance of a Kobold turbine is included through suitable modelling.

The core of the theoretical model is a formulation to describe bodies of arbitrary three-dimensional shape in non-uniform flow. The methodology is known as Boundary Element Method (BEM) and is widely recognized as a powerful mean to study hydrodynamics and aerodynamics of rotorcraft systems as well as seacraft and aircraft. A description of the methodology is beyond the scope of the present paper and is only briefly summarized here. Details may be found in Morino (1993), whereas recent applications to marine rotor hydrodynamics are illustrated by Salvatore, Testa and Greco (2003), Pereira, Salvatore and Di Felice (2004), Greco, Salvatore and Di Felice (2004).

Under incompressible and inviscid flow assumptions, a three-dimensional representation of the flowfield around a multi-bladed rotor is determined by solving equations that are derived by mass and momentum conservation principles for the fluid mass surrounding the solid blades. Once the turbine rotational speed and the onset sea current speed are given, the intensity and direction of water speed induced by the blade motion is evaluated and the pressure distribution over the blade surface can be determined. Thus, the hydrodynamic torque and power is obtained as a function of rotational speed and sea current speed. Viscous-flow effects on torque and power are taken into account combining the BEM for inviscid flows with a boundary-layer solver by means of a viscous/inviscid coupling technique. The occurrence of cavitation on the blade surface can also be described including a sheet cavitation model in the BEM formulation.

The development of the fully three-dimensional rotor model using the Boundary Element Methodology above is underway. In parallel, BEM is applied to investigate isolated blade flow. This study is necessary to assess the capability of the proposed theoretical methodology to predict those features that primarily affect the hydrodynamic behaviour of rotor blades. To this aim, numerical solutions of the flowfield around isolated blades of various shapes in uniform

and non-uniform flow have been performed and are fully documented in a technical report by Salvatore and Greco (2005).

As an example of uniform flow calculations, predictions of lift coefficient versus angle of attack of rectangular blades with varying aspect ratio are considered here. The blade lift coefficient is defined as , where L is the hydrodynamic force F component orthogonal to the blade motion (cfr. Fig. 1), r is the water density and V0 is the blade speed with respect to calm water; the aspect ratio is defined as AR = b/c where b and c denote, respectively, blade span and mean chord. Left Fig. 2 depicts lift coefficient curves of blades with varying aspect ratio and sectional profiles identical to those designed for the Kobold turbine prototype recently tested in the Messina strait (prototype blade aspect ratio is AR = 12).

Numerical results by the present three-dimensional BEM approach for inviscid flows are compared with numerical results by a theoretical model valid only for infinite-span blades in viscous flow. At low angles of attack, the force curves have an almost constant slope that depends on the blade aspect ratio, and the importance to take into account three-dimensional effects to study finite span blades is apparent. At higher values of the angle of attack, viscous-flow effects are dominating and inviscid-flow simulations tend to overestimate the force.

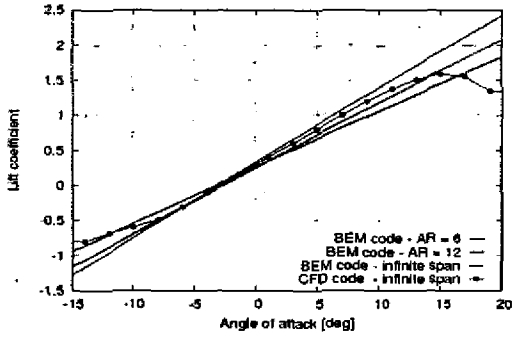


FIG. 2: Numerical study of flow around isolated Kobold turbine blade in uniform flow. Left: lift coefficient as a function of blade angle of attack. Right: three-dimensional view of vortical wake downstream the blade

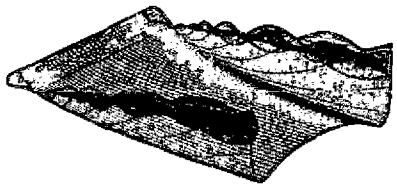


Fig. 2a shows a three-dimensional view of the vortical wake shed downstream the blade as a result of fluid-body interactions responsible for generating hydrodynamic forces on the blade. The typical rolled-up structure of the wake tips is the result of the numerical calculations by BEM and correctly describes the vorticity evolution downstream a lifting body in uniform flow.

Dealing with turbine blades, non-uniform flow conditions are necessary to describe cyclic variations of the blade angle of attack during a revolution. Two non-uniform flow conditions have been considered: (i) blade in horizontal translation plus a vertical oscillating translation (plunging motion), and (ii) blade in horizontal translation plus a cyclic oscillation around a mid-chord point (pitching motion). Such motions are closely representative of angle of attack variations occurring on Kobold turbine blades during a revolution, and reference numerical results are available from the literature.

Left Fig. 3 shows lift and moment coefficient amplitude versus oscillation reduced frequency k of a rectangular blade of aspect ratio AR = 2 in plunging motion. The reduced frequency is defined as , where f is the frequency of oscillations. Present results are compared with numerical and experimental results in Laschka (1963). In

particular, the comparison with numerical results using a methodology where non-uniform flow effects are only approximated ('quasi-steady' approach) highligths the importance to use a fully unsteady-flow theoretical formulation.

In addition, right Fig. 3 depicts three-dimensional views of the vortical wake shed downstream the blade at four different time steps during a blade oscillation. A comparison with right Fig. 2, referring to a blade in uniform motion, stresses the dramatic influence of unsteady motion conditions on the vortical path downstream the blade. This is a primary importance issue for Kobold turbines where each blade interacts with the vortical wake of the preceding blades. Such interaction has a strong impact on the hydrodynamic forces generated on the blades and hence is carefully studied in the present work.

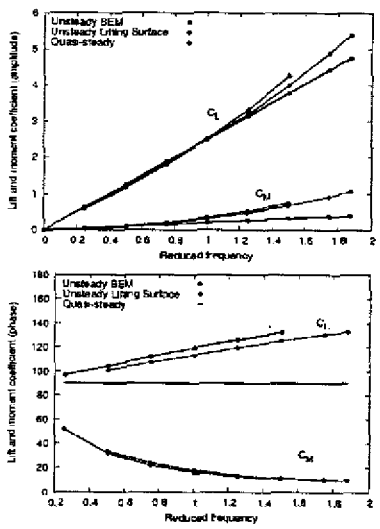
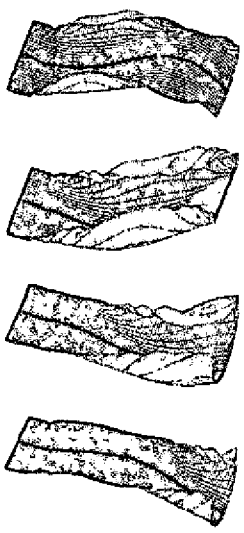


FIG. 3: Numerical study of flow around isolated Kobold turbine blade in non-uniform plunging motion. Left: lift and moment coefficients as a function of (reduced) oscillation frequency. Right: three-dimensional views of vortical wake downstream the blade (four time-steps during a complete oscillation).

The theoretical methodology above is implemented into a hydrodynamics prediction software that represents a practical design-oriented tool. Specifically, special attention is paid to realize low-computational effort software. This means that many different configurations can be rapidly simulated and an optimal choice of major turbine parameters can be achieved during the design phase. Such development procedure allows a dramatic reduction of both design times and costs, making possible to realize power generation plants that are carefully adapted to the real working conditions characterizing the selected installation sites.

EXPERIMENTAL TESTING

Although theoretical and computational tools are becoming more and more reliable design tools, the importance of experimental tests is undoubted. Sea trials as well as model-scale tests in confined water provide a unique and thorough insight of the flow-field around any object moving in water. This is especially true for objects of complex shape and motion as in the case of the Kobold turbine.



Dealing with experimental activity, the advantages to conduct model tests in facilities as towing tanks as well as circulating water channels rather than in open sea are apparent. All the parameters defining testing conditions can be accurately measured and controlled. Test setting-up is relatively fast and inexpensive and high-quality measurements can be conducted.

Once model tests are conducted, measured

data are transferred to full-scale by means of well-known correlation laws. In order to increase data quality, model scale-testing of large models in large facilities are necessary. Related to this aspect, INSEAN can provide among the largest facilities worldwide and hence the quality of tests is guaranteed. A sketch of INSEAN's towing tanks and circulating water channel facts is given in Figs. 4 and 5.

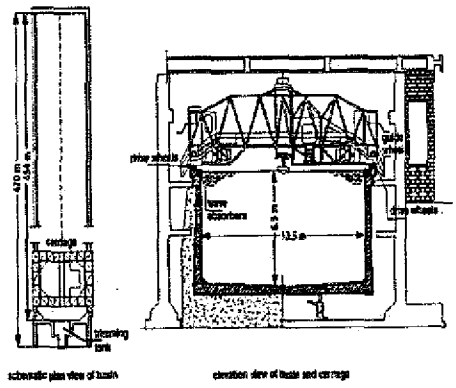


FIG. 4: INSEAN water basin no. 1

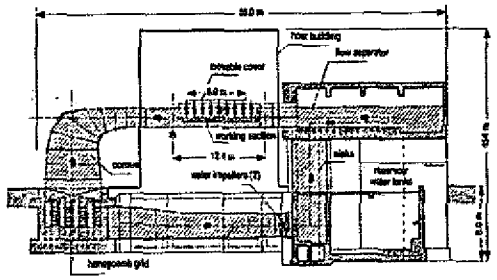


FIG. 5: INSEAN circulating water channel

In the present phase of the research on the Kobold turbine, testing is being conducted on models having a scale-factor . This means that the model is only 5 times smaller than the real prototype, whose height is 5 m and diameter 6 m. Such scale-factor is a compromise in order to have a high enough model size (height = 1 m and diameter 1.2 m), which guarantees flow similarity with the real prototype, but still being sufficiently compact, it can be easily managed and it has almost no-interferences with the limited size of the facility (wall-effects).

Model tests are being performed in the INSEAN towing tank. Although it would seem more realistic to put the model at a fix location in a flow stream, likewise real operating conditions, and therefore conducting tests in the INSEAN Circulating Water Channel, the choice of a model towed by a carriage in the tank offers considerable advantages in terms of current speed accuracy. The speed of the towing carriage, which is equivalent to the current speed investing the model, can be selected with a greater accuracy compared to the current speed of a circulating channel. Moreover, the fact that the water is at rest while the carriage is passing, implies that the turbulence of the incoming flow is practically zero. This allows focusing the experiment on the relation between the most relevant variables, which are current speed, i.e. the input variable, and angular velocity and relative torque and power, i.e. the output variables, without introducing uncertainties related to the flow turbulence.

Two turbine configurations are of interest: three-bladed and four-bladed models. Comparison of results will give designers experimental evidence of the best strategy in order to maximize the available power at different current speeds and rotational velocities. Specifically, a four-bladed turbine should have in principle a higher output power, nevertheless the hydro-dynamic interference of the wake shed from each blade with the other blades can cause negative interactions and finally reduce the delivered power.

Planned testing activity includes torque and rotational speed measurements during towing tests at different carriage velocities, thus simulating different sea current speeds.

The experimental measurement chain includes a torque-meter, an electro-mechanical brake, a rotational velocimeter, a set of pitot tubes, a load cell for the towing resistance and the carriage speed control system. The electro-mechanical brake allows to simulate the effect of an electric current generator whose effect is to yield a resistant torque. The torque-meter provides a feedback for the actual value of the torque measured on the shaft.

In addition to torque measurements, the turbine rotational interference can be measured using Pitot tubes placed upstream of the turbine. Furthermore, the towing resistance of the entire turbine at each current and power condition is evaluated in order to estimate mooring requirements.

CONCLUDING REMARKS

The development of computational and experimental tools for the hydrodynamic analysis of a Kobold turbine has been addressed.

The activity is under progress at INSEAN, the Italian Ship Model Basin, in the framework of a research program aiming to provide practical tools to assist the design of high-performance power generation plants based on this concept of hydroturbine.

An overview of both theoretical and experimental activity has been given and preliminary results have been presented and preliminary results of the research activity have been discussed.

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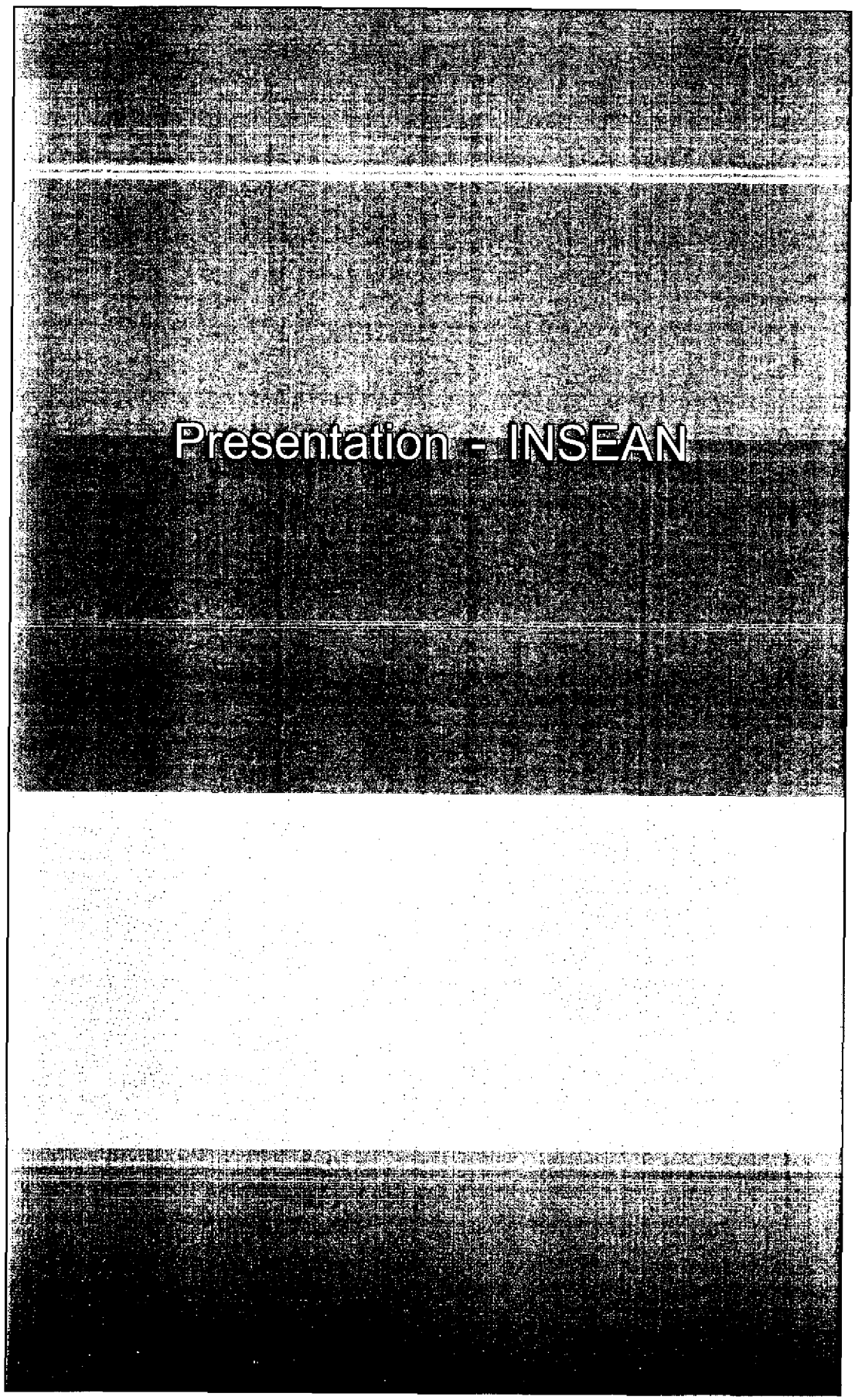

Presentation - INSEAN

INSEAN
Italian Ship Model Basin

United Nations Industrial Development Organization (UNIDO)
Conference on Exploitation of Marine Currents for Energy Production

Developing Hydrodynamic Design Tools for High-Performance Kobold Turbines

Francesco Salvatore, Guido Calcagno, Luca Greco
INSEAN – Italian Ship Model Basin
Roma (Italy)

Presentation of INSEAN

INSEAN
Italian Ship Model Basin

- Established in 1927 in Rome as a navy ship model testing facility
- Nowadays, the largest Italian Research Center on naval architecture
- Its mission includes:
  - ✓ promote and perform research in several fields of marine hydrodynamics
  - ✓ provide consultancy and services to national and international shipbuilders and shipowners (naval and civil applications)
- Distinguishing features:
  - ✓ 5 'scientific departments' for experimental and theoretical activity
  - ✓ 150 employees with academic staff of about 50 persons
  - ✓ World-class facilities (2 towing tanks, a circulating water channel)
  - ✓ In-house development of computational models and codes
  - ✓ Vast scientific/technological production (software, papers, patents, ...)

KOBOLD Turbine
UNIDO Conference on Marine Currents for Energy Production - Messina, Italy, Sept. 15-16, 2005

Role in the project

INSEAN Italian Ship Model Basin

- The successful design of a hydroturbine plant involves a multi-disciplinary work addressing:
  - ✓ hydrodynamics
  - ✓ Mechanic
  - ✓ structural dynamics and materials
  - ✓ electric plant assembly
  - ✓ operating conditions (site definition, moorings, ...)

- INSEAN contributes to research on the Kobold turbine by means of hydrodynamics studies

Overview of activity

INSEAN Italian Ship Model Basin

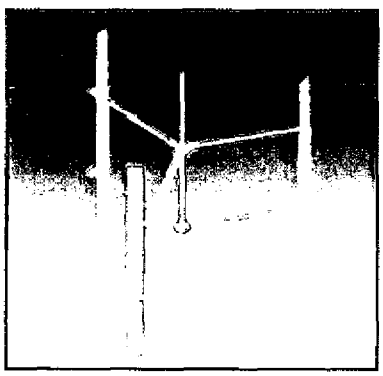
- Develop computational and experimental tools to assist design of new high-performance turbines
- Combine theoretical studies and experimental activity

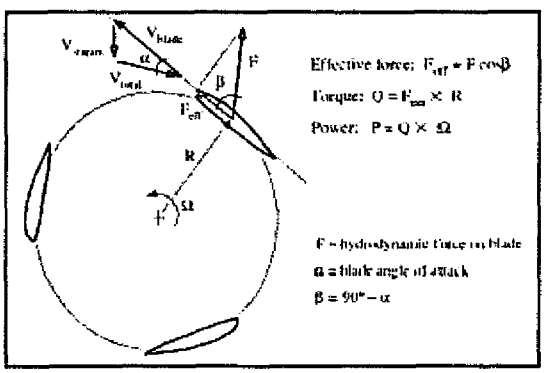
- Theory: turbine performance prediction tools
  - ✓ simulations of turbine behaviour under real working conditions
  - ✓ fast and effective design of site-taylored plants
- Experiments: model testing in large-scale facilities
  - ✓ better understanding of physics involved
  - ✓ provide data for validation of performance prediction tools

Kobold turbine: power generation

INSEAN Italian Ship Model Basin

- Kobold turbine:
  a vertical-axis multi-bladed rotor
- High efficiency: estimated 23%





- Sea current flow generates hydrodynamic force on blades
- Blade force into torque and hence into shaft power
- Electric generator converts mechanical into electric power

Theoretical modelling

INSEAN Italian Ship Model Basin

- Kobold-turbine hydrodynamics: a challenge for theoreticists!
  - ✓ unsteady, three-dimensional flow on blades
  - ✓ turbine rotational speed unknown a priori
  - ✓ blade-to-blade interactions
  - ✓ flow viscosity, turbulence and cavitation
  - ✓ non-uniformity of incoming flow

- Typical approach: consider simple hydrodynamic models based on
- approximated theories (blade-element theory, blade cascades, ...)

- Present approach: develop theoretical/computational methodology taking into account major features affecting the turbine performance

Performance prediction: two steps

INSEAN Italian Ship Model Basin

- The analysis of blade force generation is fundamental to predict turbine performance
- In view of problem complexity, two steps:
  1) isolated blade model
  2) complete multi-bladed assembly model
- Here, review of results from step (1); step (2) under progress

Isolated blade: uniform flow

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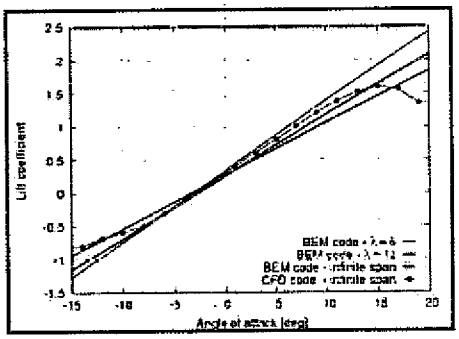
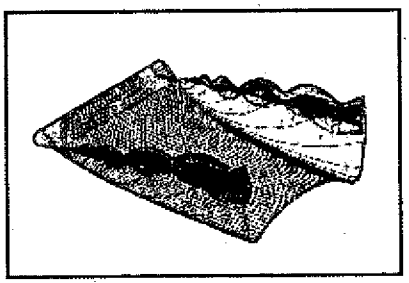
- Test case: rectangular blade identical to design used for Kobold-turbine prototype tested in the Messina strait
- Left: blade force vs. angle of attack (present results and CFD data compared)
- Right: calculated vortical wake downstream the blade



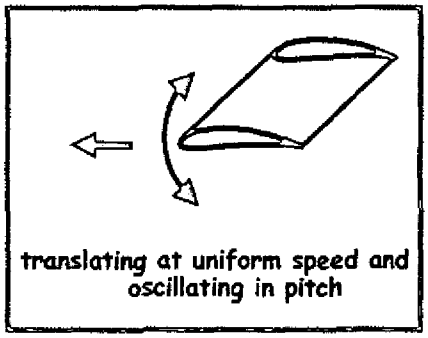


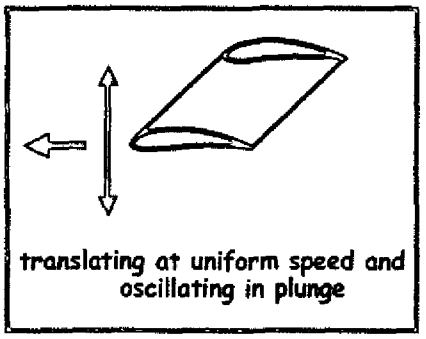
- Comment: importance of three-dimensional flow effects and viscosity effects

Isolated blade: non-uniform flow

Italian Ship Model Basin

- Rectangular blade (NACA 0005 profile, aspect ratio = 2)
- Two test-cases representative of Kobold turbine blade motion



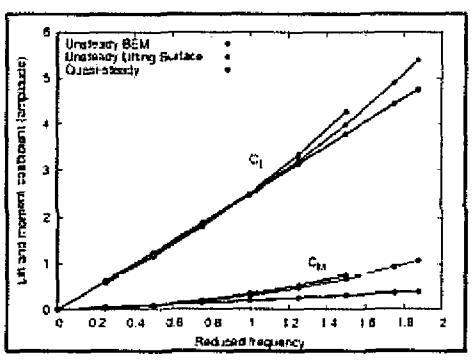


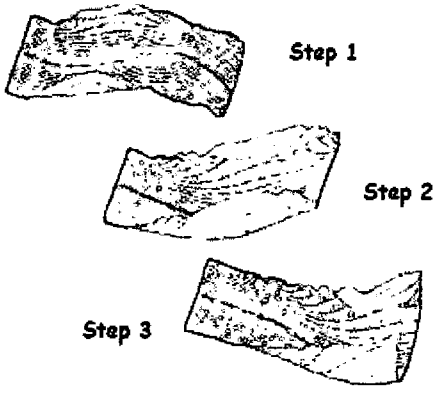
- Benchmark tests: experimental and theoretical data available for comparisons and validation of present results

Example: Plunging motion

Italian Ship Model Basin

- Left: Blade forces (lift and moment) as a function of oscillation frequency
  - ➔ Comparisons between present results and reference data (Laschka)
- Right: calculated vortical wake downstream the oscillating blade



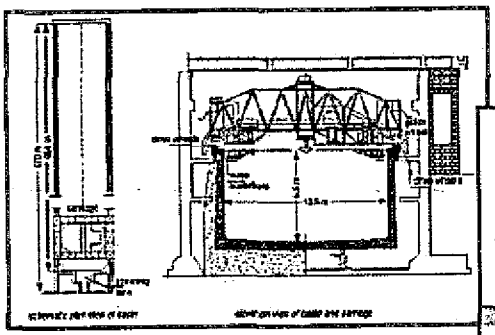


- Comment: present approach is fully adequate to describe non-uniform flow

Model testing: facilities

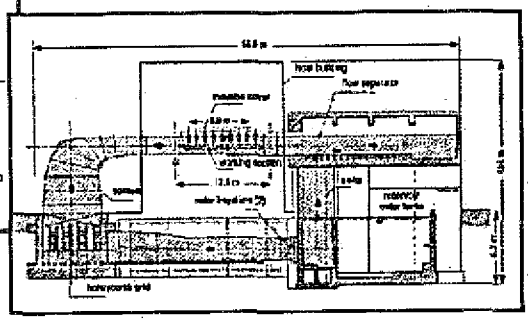
INSEAN Italian Ship Model Basin

- Experimental activity complementary to theoretical studies
- Model testing in confined water ⇒ flow parameters accurately measured and controlled
- Large-scale facilities to increase quality of measurements



INSEAN towing tank no. 1

INSEAN circulating water channel



Model testing: set-up

INSEAN Italian Ship Model Basin

- Present analysis: towing tank tests
- A 1:5 scale model of the Kobold turbine realized (≈1 m diam.)
- Two configurations: three-bladed and four-bladed
- Testing activity includes torque and rotational speed measurements during towing runs at different carriage velocities
- Electro-mechanical brake allows to simulate the effect of an electric current generator
- Result: charts of delivered power as a function of sea current speed and turbine rotational speed
- Additional measurements: blades rotational interference and turbine resistance (*mooring force*)

Concluding remarks

INSEAN
Italian Ship Model Basin

- INSEAN contributions to research on the Kobold turbine hydrodynamics has been presented
- Basic aim is to develop computational and experimental tools for the hydrodynamic analysis and design of Kobold turbines
- Combined experimental and theoretical activity
- Theoretical models are developed to provide fast and reliable tools for the automated design of new high-performance Kobold turbine
- Model tests in large-scale facilities are performed to achieve a better understanding of turbine flow features and to collect data for validation of theoretical models

The European Commission's Activities in Support of Renewable Energies, in particular Ocean Energy

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Despite attempts to decouple economic growth from energy consumption (in progress to some extent in industrialised countries) energy is currently an important component of growth. As events have recently demonstrated, increase in the cost of energy immediately translates in a decrease of GNP growth and in the well being of the European citizens. Energy price volatility of the kind currently being experienced also has a determining effect on economic growth and investment decisions. Europe therefore requires a stable, secure and affordable energy supply.

Growth of energy consumption at world level is due to increase sharply in the years to come especially with the somewhat unforeseen economic boom of demographic giants such as China and India (conservative figures indicate a progression from 10 000 Mtoe in 2001 to 16 300 Mtoe in 2030, with the share of OECD countries going down from more than 50% to about 44%).

Energy is therefore at the core of global concerns, as exemplified by the Climate Change Convention and Kyoto Protocol aiming to reduce greenhouse gas emissions through cleaner and more efficient use of traditional energies, and introducing Renewable Energy Sources (RES) as alternatives to fossil fuels, and the Johannesburg Renewable Energy Coalition Joint Declaration "The Way Forward on Renewable Energy", and in a more general

context the Göteborg and Lisbon Strategies on Sustainable Development.

I will therefore present the major energy research policies in place and will refer to the research activities in the field of renewable energies with emphasis in the sector of ocean energy, a short summary of which follows.

Over the last twenty years, the European Union financed ocean, wave and tidal energy research and developers. In total, twenty nine projects have been awarded to the research and development of the three main areas, of which four projects under FP5, one under FP6, while three are under still negotiation. In FP5 the EC contribution was 4.54 M , and in FP6 to date 1.5 M , while 5.7 M are in contract preparation phase. The cumulated EC contribution during the last fifteen years sums to more than 22 M with a total eligible cost of the order of 48 M .

Increasing R&D funding is critical to advancing the development of ocean energy systems. Ocean energy technologies must solve two major problems concurrently: proving the energy conversion potential and overcoming a very high technical risk from a harsh environment. No other energy technology has had to face such demands. When deploying their prototype, device developers are confronted with the possibility of losing five years of development and investment in few hours time. Furthermore, the majority of the developers are SMEs for whom such a loss can be overwhelming. Additional R&D funding would help to mitigate the substantial technical risk faced by device developers daring to harness the energy of the marine environment.

Ocean energy systems cover a wide range of applications that can be deployed on the shoreline and offshore. Technology is emerging to allow large scale demonstration projects. Therefore, very few demonstration prototypes exist and they are mainly all in Europe. The research activities covered the areas of shoreline and offshore wave energy devices, of tidal current turbines and of salinity gradient systems. Salinity gradient systems are a recent development and could be deployed in many European river estuaries.
The flagship prototypes developed with EU financial support are:
o Shoreline Wave Energy: two demonstrators of 400kWe each, one on the island of PICO, Azores, and one on the island of Islay, Scotland (FP4 projects)
o Tidal current turbine: one prototype of 300kWe (FP4 project)
o Kobold marine currents turbine: one prototype of 12 kW (FP4 project), and
o Offshore Wave Energy: one 1:4 prototype of 20kWe - known as Wave Dragon (FP5 project)

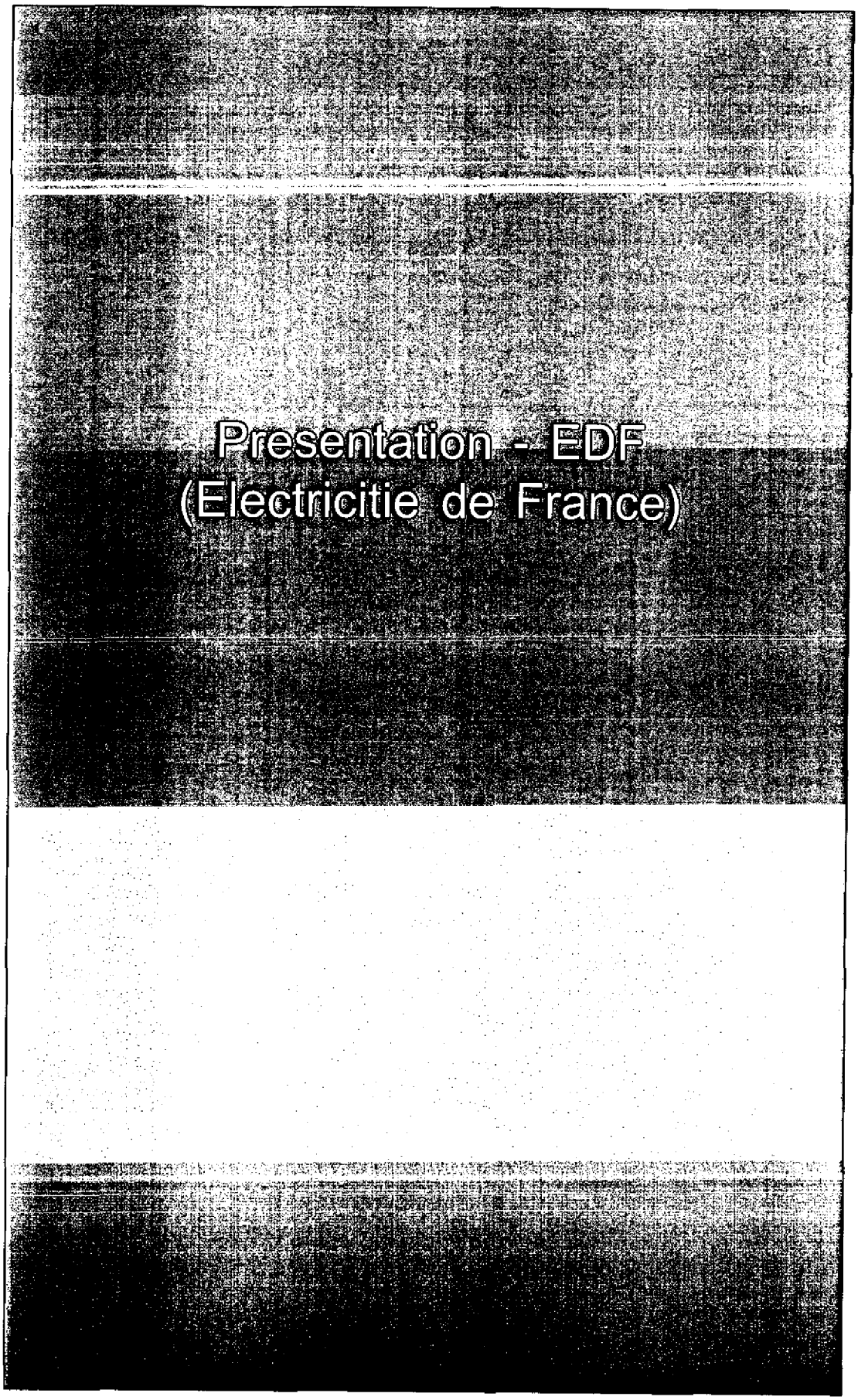
It is also worth noting that since October 2001 the European Commission participates and follows through the Implementing Agreement on Ocean Energy Systems the latest developments at international level while promoting the research, development, information exchange and demonstration of the Ocean Energy Technologies.

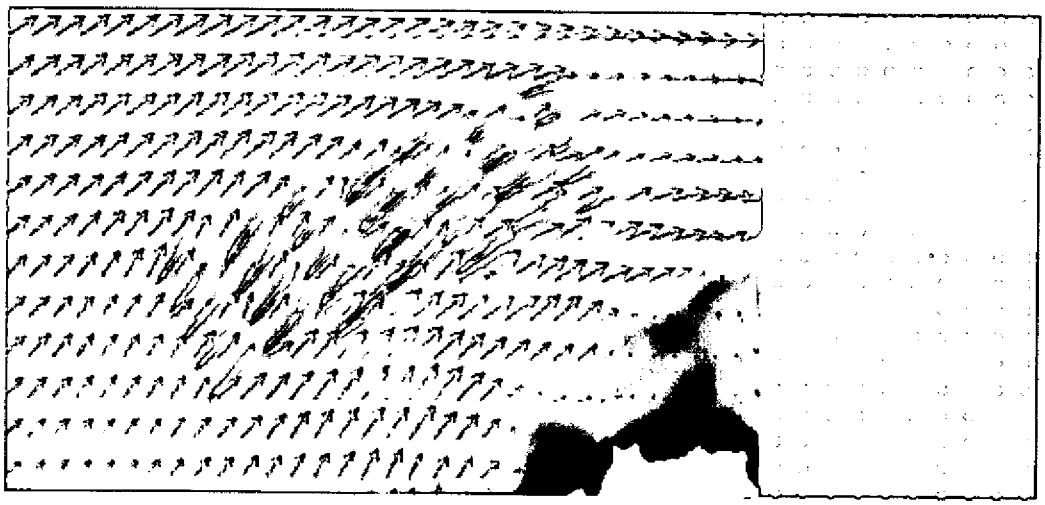
For additional information the reader can also check at the following web-sites:
a) related to Ocean Energy:
European Wave Energy Atlas:
http://www.ineti.pt/proj/weratlas/
Coordinated Action on Ocean Energy:
http://www.ca-oe.net
Wave-Net:
http://www.wave-energy.net/index3.htm
Wave Energy Centre (P):
http://www.wave-energy-centre.org/

WAVE DRAGON
: http://www.wavedragon.net/
LIMPET (Islay, Scotland):
http://www.wavegen.co.uk/what_we_offer_limpet_islay.htm
International Energy Agency:
http://www.iea-oceans.org/index1.htm
WAVETRAIN (Marie Curie Actions, FP6):
http://www.wavetrain.info/

b) related to European Commission's activities and events :
EUROPA:
http://europa.eu.int/comm/dgs/research/index_en.html
http://europa.eu.int/comm/research/energy/index_en.html
http://europa.eu.int/comm/energy/index_en.html
INCO and Marie Curie
http://www.cordis.lu/inco/home.html
http://europa.eu.int/comm/research/fp6/mariecurie-actions/indexhtm_en.html
CORDIS:
http://www.cordis.lu/fp6/
RENEWS newsletter :
http://europa.eu.int/comm/research/energy/pdf/renews3.pdf
Information days and similar events, conferences
http://europa.eu.int/comm/research/energy/gp/gp_events/action/article_2790_en.htm

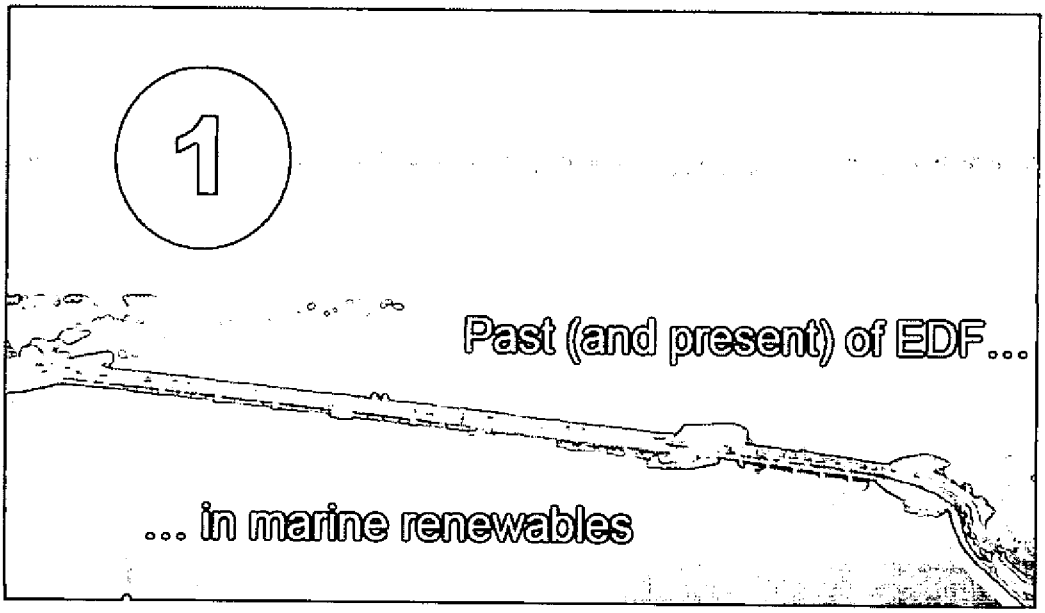
Renewable Energies in Europe - Research in Action, Conference organised in Brussels from 21 to 22 November 2005: The conference aims to present the important role that renewable energy research plays in Europe, and to enhance awareness among stakeholders of the opportunities ahead. Key European success stories will be analysed, and the existing and planned European renewable energy technology platforms on PV, biofuels, and wind will be presented. A particular emphasis will be placed on learning from national research programmes and examining possibilities to stimulate coordination. The potential of the different renewable energies will be put in the wider context of the renewable energy portfolio and market conditions.


Presentation - EDF
(Electricitie de France)



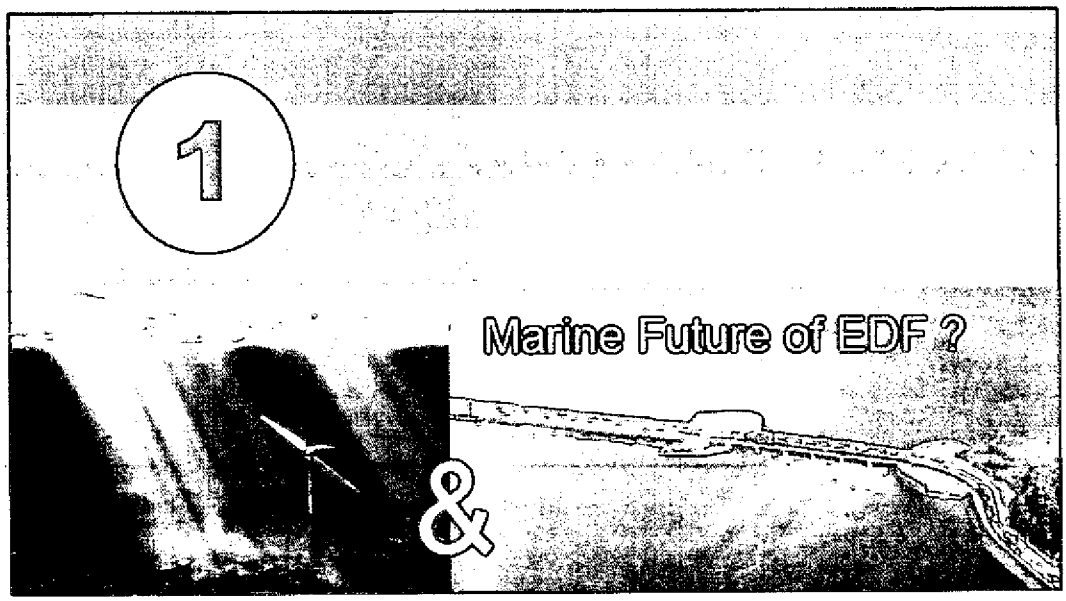
Marine Current Energy as part of an Utility (EDF) strategy

Cyrille ABONNEL
Marine Current Energy Project Manager
National Hydraulics and Environment Laboratory
EDF R&D, Paris, France



The LA RANCE tidal power plant, in France, operated since 1966

An installed capacity of 240 MW
A production close to 500 GWh/year



The LA RANCE tidal power plant
&
Marine Current Energy Converters

EDF

3 Conference on Exploitation of Marine Currents for Energy Production, organized by UNIDO – 16-18 September, Messina, Italy

The Marine Current Energy Project – an overview

The EDF R&D Marine Current Energy Project

Objective : to gather, in the years to come, the techno-economic elements to decide whether EDF takes part in an industrial demonstration site within the French waters, in order to diversify its sources of production.

- Watching the technological on-going developments
- Improving the resource knowledge in the French waters
  - Matching various criteria to identify the "tidal zones"
  - Measuring and modelling the hydrodynamics
- Exploring the environmental impact and acceptability issues
  - Pre-diagnosis realised in 2005
- Exploring the economic and administrative issues

Relying on strategic partnerships !

EDF

4 Conference on Exploitation of Marine Currents for Energy Production, organized by UNIDO – 16-18 September, Messina, Italy

2

French 'Marine Current Energy' Resource

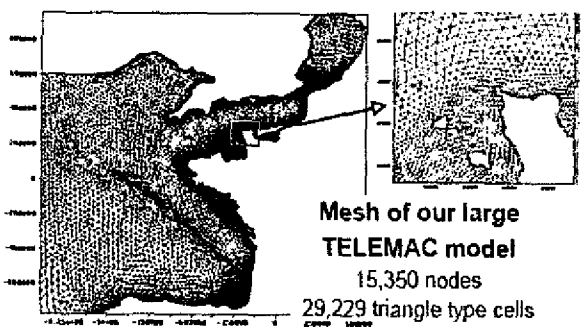
?

EDF

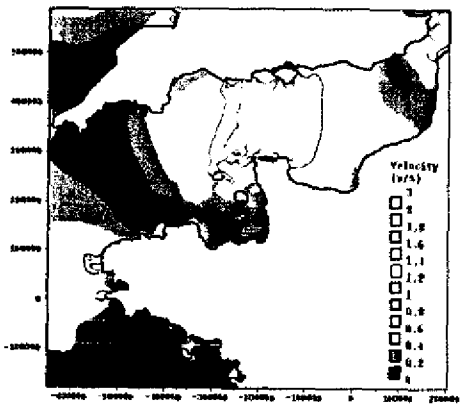
The 'large' picture : modelling tidal currents

1. Numerical model with the TELEMAC system

Finite element formalism using the 2-D shallow water equations



Mesh of our large TELEMAC model
15,350 nodes
29,229 triangle type cells



Field of max. velocities in the Channel (max for Normandy)

Betz approach to get started...

$$E_{extractible} = \frac{16}{27}\frac{1}{2}\rho \int_{0}^{1\text{ year}} V^3 .dt$$

EDF

The 'regional' picture : evaluating potential environmental impact

2. Pre-diagnosis realised early 2005

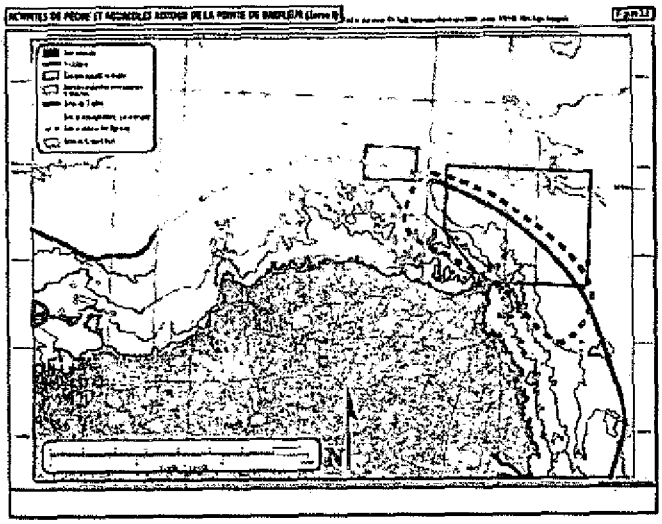
On several coastal zones in the Channel

First analysis of

- Physical environment
- Existing activities (fishermen...)
- administrative context

To share onwards and afterwards with various stakeholders

Dialogue is a key-factor !



Example of the map of fishing activities around the Barfleur Head

EDF

The 'local' picture : measuring tidal currents

3. Experimental measurements at sea

Two campaigns in the first half of 2005, on 1 tidal cycle

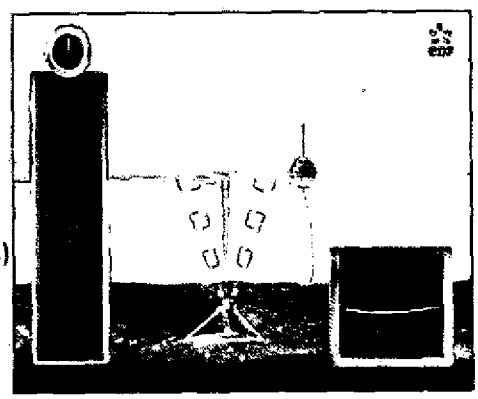
Normandy in January and Brittany in April

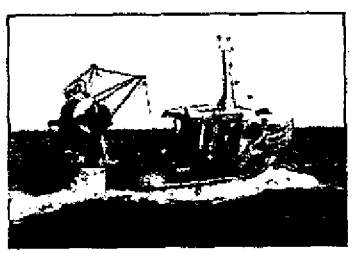
Scientific objective

To improve our knowledge on currents, waves, and their interactions

Non-technical objective

To initiate information-share and dialogue with the various stakeholders (fishermen...)





Vertical profilers and wave buoys

EDF

The 'farm-size' picture : modelling current-structure interactions (1)

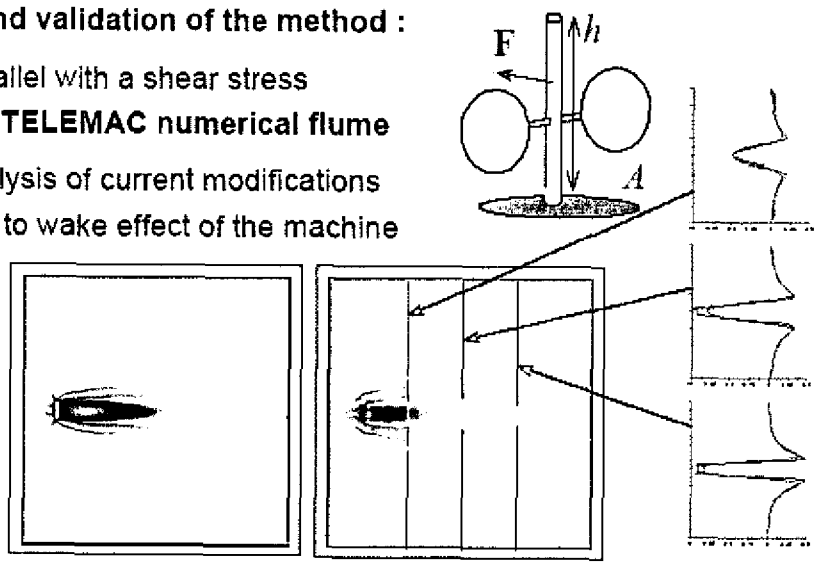
Modelling the wake effect of marine current energy converters

Set-up and validation of the method :

Parallel with a shear stress

Test in a TELEMAC numerical flume

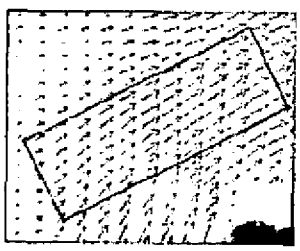
Analysis of current modifications due to wake effect of the machine



EDF

The 'farm-size' picture : modelling current-structure interactions (2)

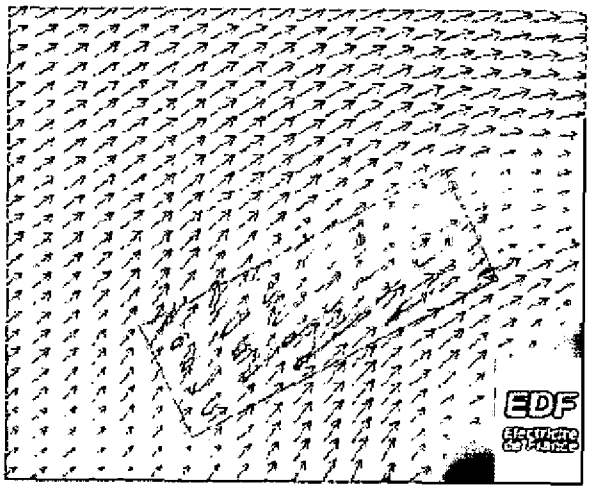
First applications to a theoretical farm



⇧

Tidal currents alone

Tidal currents + converters ⇨



⇨ Optimisation of the farm spacing

EDF

3

Vertical-axis turbines : a collaborative evaluation between EDF and the LEGI co-financed by ADEME

LEGI
LABORATOIRE DES ECOULEMENTS GEOPHYSIQUES ET INDUSTRIELS

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

The LEGI is a French laboratory specialist in hydraulics and turbo machinery, based in Grenoble.

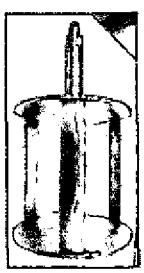
It is the leader of the HARVEST project, aiming at the development of the "ACHARD" system

EDF

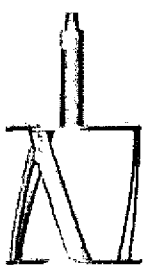
11 Conference on Exploitation of Marine Currents for Energy Production, organised by UNIDO – 15-16 September, Messina, Italy

Objective of the EDF-LEGI collaboration

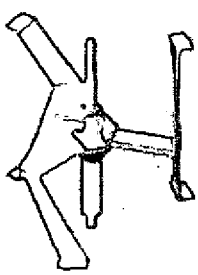
As an alternative to horizontal devices, several concepts of vertical axis turbines are being developed around the world, like



Darrieus type (Darrieus, 1926)



Gorlov type (Gorlov, 2001)



Achard type (LEGI, 2004)

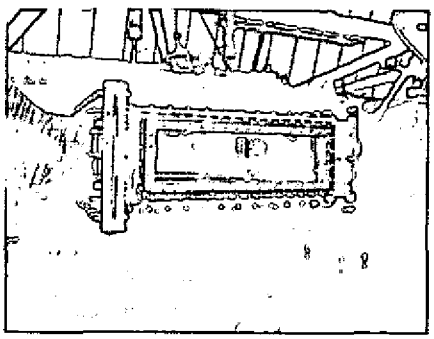
Objective of EDF as an end-user : to strengthen its own point of view on them, through a series of tests and comparisons of some of these different technologies, thanks to the work done at the LEGI.

LEGI EDF

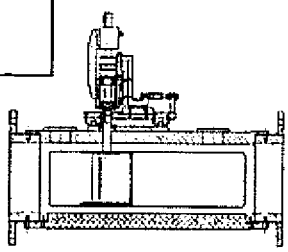
12 Conference on Exploitation of Marine Currents for Energy Production, organised by UNIDO – 15-16 September, Messina, Italy

The LEGI experiment

The hydrodynamic tunnel of the LEGI has been modified for this experiment



Section : 250 * 700 mm
3 faces in plexiglas
Sensors on top



Hydrodynamic tunnel main features

- Flow speed : 0 to 2.85 m/s (0 to 500 l/s)
- Pressure : Pv to 2 bars

Dimensions of the turbines

- Length and diameter : 175 mm
- Chord of blades : 30 mm

Manufacturers

- Collet-Amblard, Grenoble for the tunnel
- SERAS, CNRS Grenoble, for the turbines

Programme of the EDF-LEGI collaboration

Experimental comparison of three different turbines

Tests on different turbine types → Technologies comparison

Performances → Technologies comparison

Instability → Results to study fatigue of blades and axes

Forces → Results to study fatigue of blades and axes

Forces → Anchoring calculations

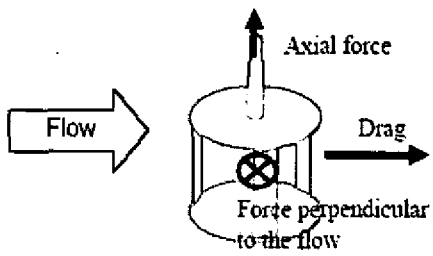
Complementary numerical analysis

Development of a little code to estimate global performance of the turbines

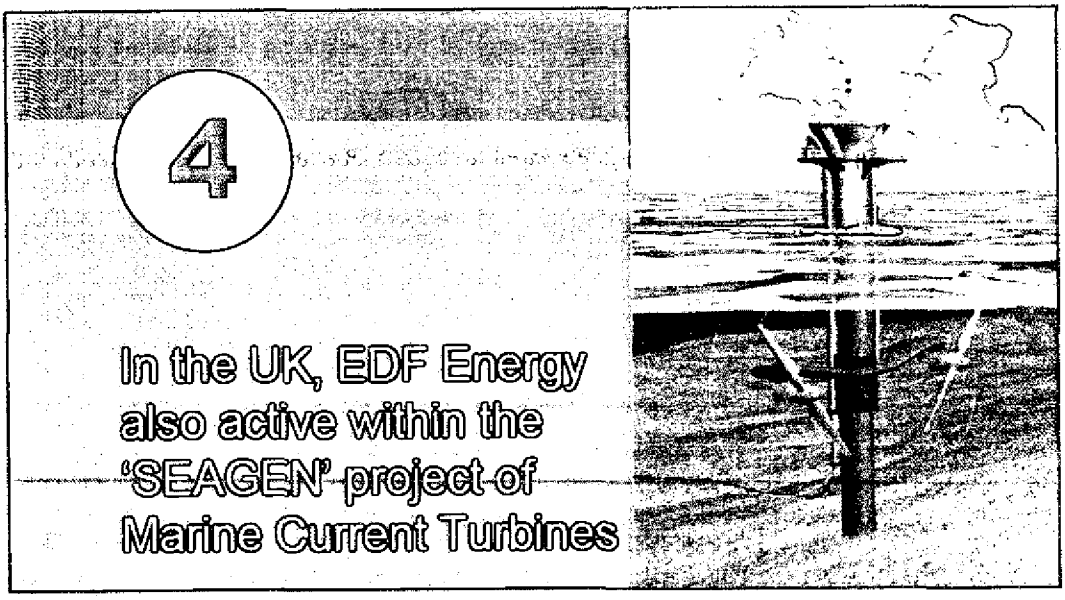
Two kinds of models studied :

- Based on the momentum theory
- Based on vortex theories

Measurements



- Torque
- Rotating speed
- Forces
- Pressure, flow speed...



MCT is one of the leaders in technology development, thanks to its SEAFLOW prototype tested since 2003 in the Bristol Channel. The SEAGEN machine, 1 MW should be deployed during the Spring 2006 in the UK.

EDF

Conclusions on the Marine Current Energy Project of EDF

- The EDF Group, with a wish to diversify the sources of energy, is involved in the development of marine current energy through
  - an R&D project in France,
  - The MCT project in the UK (EDF Energy)
- In the French R&D project,
  - The various technologies being developed are watched over
  - Some studies focus on the improvement of the resource knowledge in the French waters at various scales,
  - The aim consists in developing an experimental site …
  - … and preparing the industrial development of commercial farms
  - Some key-points (administrative, legal aspects…) and unknowns (tariff…) have to be clarified.

EDF

Presentation - Environmental Resources Trust

Leveraging Environmental Markets

Presentation for the Conference on Exploitation of Marine Currents for Energy Production

Messina, Italy - September 15 -16, 2005

Environmental Resources Trust
www.ert.net

Environmental Resources Trust

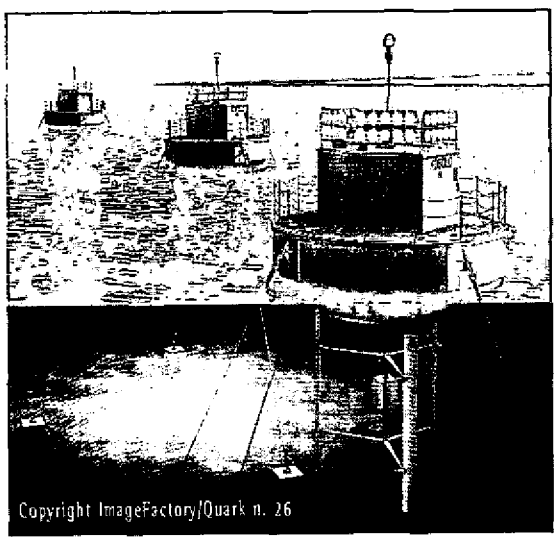
Pioneering Markets to Protect and Improve the Environment

Objectives

Leveraging environmental benefits and markets for renewable energy projects

- Context: environmental benefits & markets
- The Global Environmental Facility (GEF)
- The carbon emissions market

Renewable Energy and ...

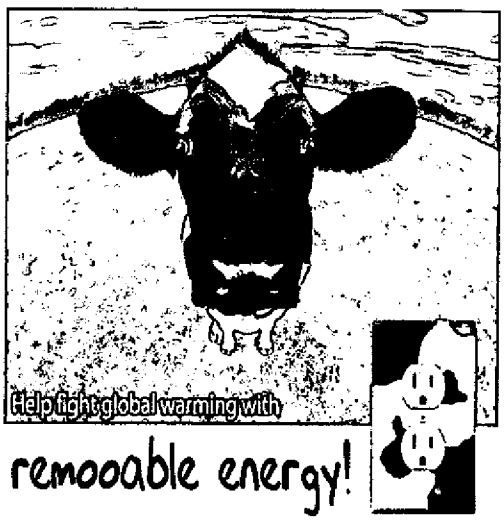


- Marketable goods (KWh)

But also

- "Positive Externalities"
  - Knowledge (new technologies)
  - Less *dependence from foreign* imports (of fossil fuels)
  - More flexible and reliable electricity networks (distributed generation)
  - Environmental benefits
    - Greenhouse gas
    - SO_2, NO_x, PM
    - Biodiversity and ecosystems (but these can also be negative)

From benefit to $



- Payments for the environmental benefits
  - Global Environmental Facility (GEF) Grants
- Carbon Market(s)
  - Clean Development Mechanism
  - EU – ETS
  - Voluntary and mandatory markets in the US (minor)

The Global Environmental Facility

GLOBAL ENVIRONMENT FACILITY

- GEF Pilot Phase
  - 1991 – 1994 = $1 Billion US Dollars
- Replenishments:
  - 1995 – 1998 = $2.0 bn.
  - 1999 – 2001 = $2.75 bn.
  - 2002 – 2005 = $ 3.0 bn.
  - 2006 – 2009 = $ 4.0 (E) bn.

World bank is the trustee of the GEF trust fund

GEF - Climate Change Operational Programs

GLOBAL ENVIRONMENT FACILITY

5. Removal of Barriers to Energy Efficiency and Energy Conservation
6. Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs
7. Reducing the Long-Term Costs of Low Greenhouse Gas Emitting Energy Technologies
11. Promoting Environmentally Sustainable Transport

- GEF is a co-financier providing "new and additional" funds to address global environmental issues
- Principle of "Incremental Costs"

Incremental costs = GEF alternative - cost of baseline

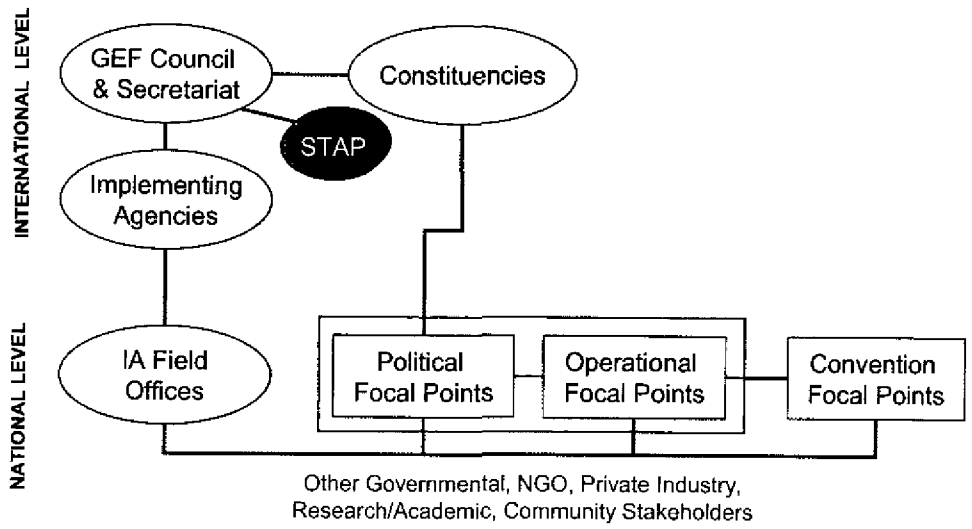
GEF Funding Categories

GLOBAL ENVIRONMENT FACILITY

- Full-Size Projects ($1 million and up)
- Medium-Sized Projects (up to $1 million)
- Financing can be available for preparing projects - Project Development Funds (PDF)
  - PDF-A up to $25,000
  - PDF-B up to $350,000
- Enabling Activities
  - Up to $450,000 for Climate change
- Small Grants Programme (up to $50,000)

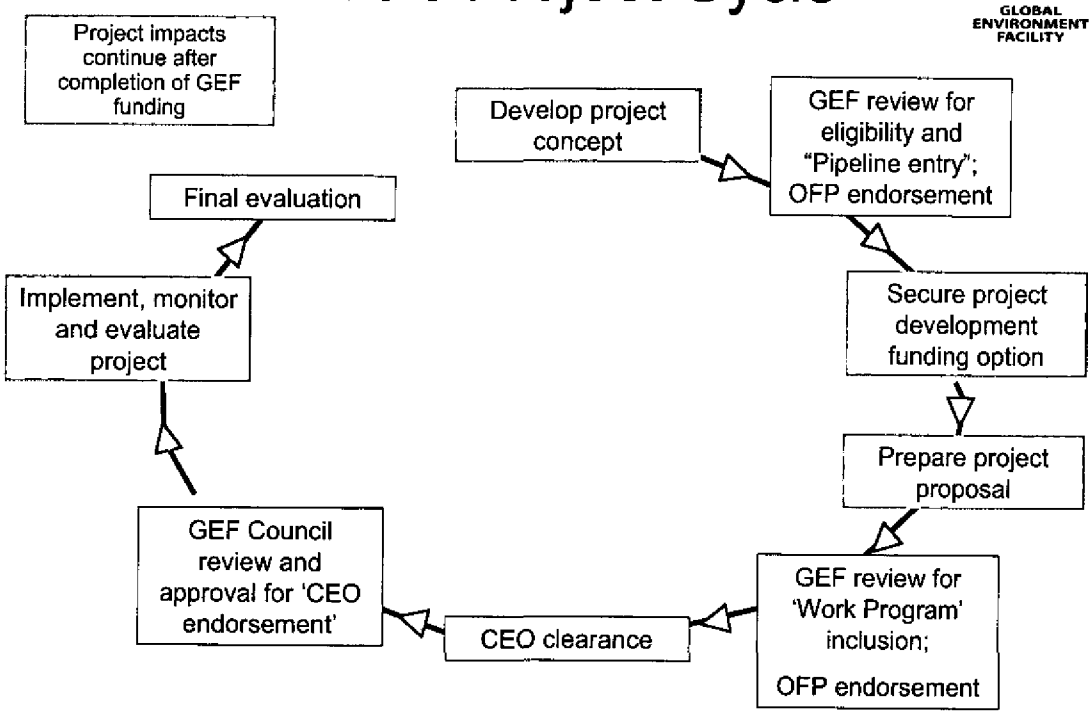
1991 to 2004 → $1.74 billion to climate change projects and enabling activities
Matching → more than $9.29 billion in co-financing

The Global Environmental Facility



Source: UNDP

Basic Project Cycle



Source: UNDP

GEF project Example: RE for the Galapagos Islands

	Activity	GEF $	% Total
1a	Technical assistance to establish foundation for Joint Ventures	200,000	80%
1b	PDF-B	283,100	100%
2	Construct plants on Floreana and San Christobal islands (hybrid PV, wind, diesel)	350,000	5%
3	Construct plants on Isabela and Santa Cruz Island (hybrid PV, wind, diesel)	3,000,000	17%
4	Monitor evaluation and dissemination	250,000	80%

Goal: remove barriers to RE electrification in the Galapagos
Global benefit: 240,000 tons of CO_2 removed over 20 years
(→ with $ 4 Mln. Investment = $ 17 per ton CO_2)

Carbon Market(s)

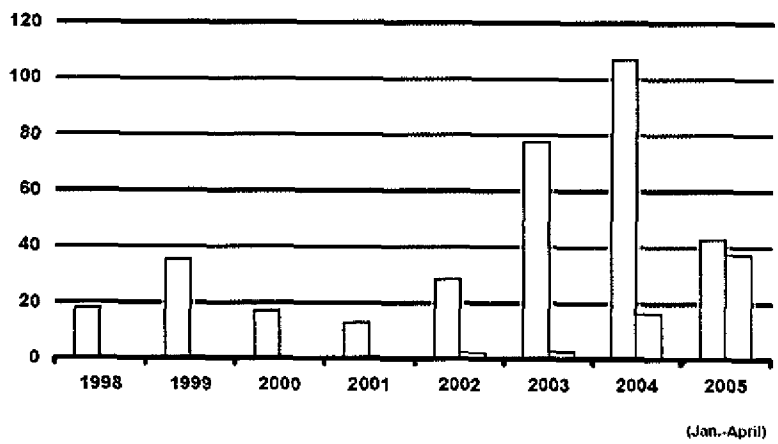
- Kyoto Protocol flexible mechanism
  - Art 12 – " … *3. Under the clean development mechanism:*
    (a) Parties not included in Annex I will benefit from project activities resulting in certified emission reductions; and
    (b) Parties included in Annex I may use the certified emission reductions accruing from such project activities to contribute to compliance …"

- EU-ETS Linking Directive
- Various Carbon Funds
  - World Bank (PCF, CDCF, Italian Carbon Fund, etc.)
  - Governmebt & Private (KfW, Japan Carbon Finance Limited, Rabobank, Natsource, Ecosecurities, Icecap, etc.)

CO_2 Pricing and liquidity

Project based transactions

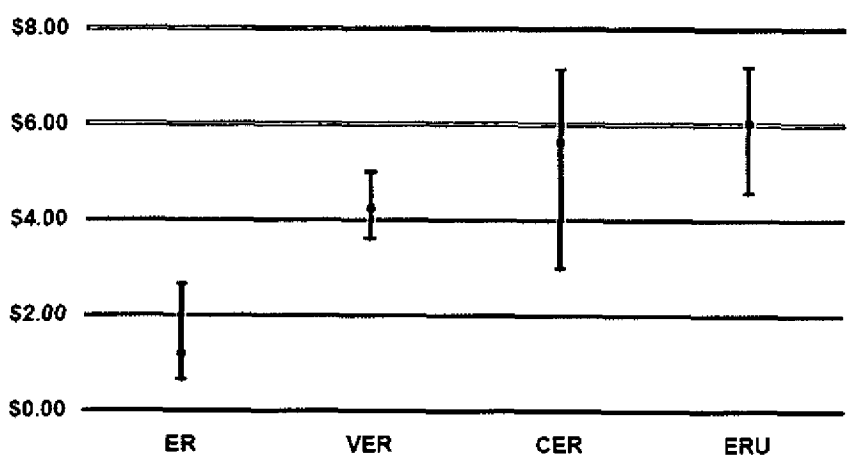
FIGURE 7: VOLUME EXCHANGED THROUGH PROJECT- (green) AND ALLOWANCE- (yellow) BASED TRANSACTIONS (million tCO_2e)



Note: data for allowance markets are only for January to March 2005

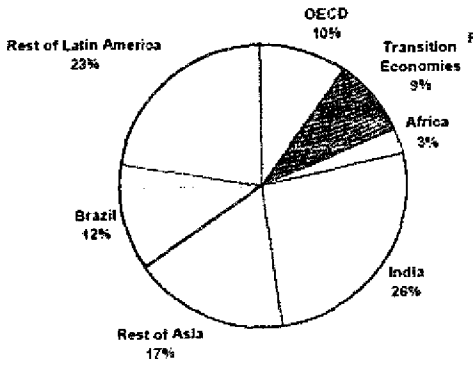
Carbon Market

FIGURE 5: PRICES FOR NON-RETAIL PROJECT-BASED ERs January 2004 to April 2005 (in U.S.$ per tCO_2e)

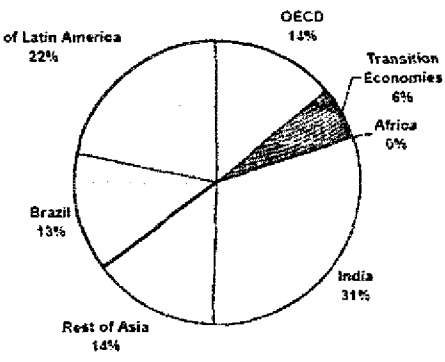


Source: World Bank

Location of emissions reduction projects

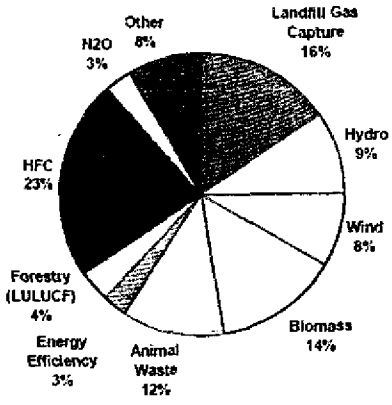


Jan. 2003 – Dec. 2004

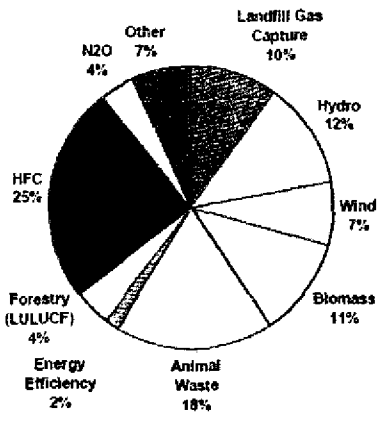


Jan. 2004 – April 2005

Type of projects

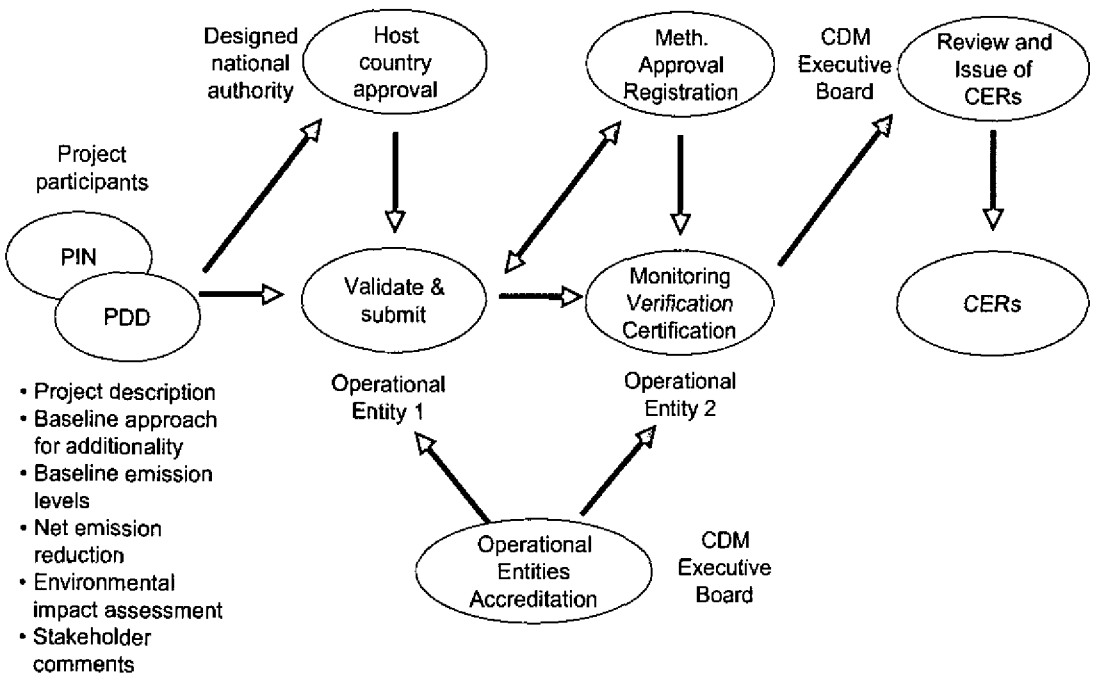


Jan. 2003 – Dec. 2004



Jan. 2004 – April 2005

CDM Project cycle



Hypothetical case (Galapagos Islands?)

Project emissions: Marine current powered turbine

MWh generated/year = 11,700
CO_2 Emissions per MWh = 0
CO_2 Emissions/year = 0

Baseline emissions: Displaced diesel generators

MWh generated/year = 11,000 CO_2
Emissions per MWh = tons 1.025
CO_2 Emissions/year = tons 12,000

Total Emission Reductions per year = 12,000 tons CO_2
@ $ 6 per ton of CO_2 → $ 72,000 per annum

Conclusions

- Environmental markets provide co-funding opportunities to renewable energy projects
- Different sources at different stages of development

  Project development → GEF PDF

  Technology development → GEF operational program 7

  Market entry → GEF operational program 6

  Further market penetration → Carbon markets

Thank you!

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Horcynus Orca Technology Park

Gaetano Giunta
Horcynus Orca Foundation and Ecos-Med Research Center

"The new knowledges which leads us to discover the Earth-Homeland, the Earth-system, Earth-Gaia, the biosphere, and the place of the Earth in the cosmos, have no sense as long as they are separated from each other. It should be stressed that the Earth is not simply the sum of a physical planet, the biosphere and humanity. The Earth is a complex

physical/biological/anthropological totality, in whose history life represents an emergency. Man's relationship with nature cannot be conceived in a reductive or disjointed way"

Edgar Morin - member of the Scientific Committee of the Horcynus Orca Park

The contents of the Horcynus Orca Park were explicitly inspired by paradigms of complexity. In the initial premise of the project, it was proposed that cultural links and labyrinths could be metaphors of the park and possible interpretative approaches to the novel-workshop by which the park itself is inspired. The project, like the novel, in fact involves a complex system of knowledge (from marine biology, the Physics of Chaos, natural sciences and archaeology, to art, earth sciences, literature, anthropology, the knowledge of fishermen and marine ecology) that represents the grammar and syntax of an ancient place: Scylla and Charybdis.

The Horcynus Orca Park is designed to be a living organism in constant flux, a system of relations in which there is continuous osmosis between knowledge and experience. It represents an innovative bridge between scientific research, creative languages and interactive communication, between mythology, history, ethno-anthropology, and high technology. Faithful to its original epistemological framework the park is a sort of 'real hypertext' in which visitors can trace their own personalised paths of research scientific knowledge diffusion and cultural projects.

The "heart" of the park is to be found in four different locations; at Capo Peloro, in the monumental complex of Neolithic origins on the edge of the Sicilian island next to the Ganzirri-Peloro natural reserve; in Palmi and in Scilla in the medieval castle of Basilian origins; on the rock dominating the most beautiful stretch of the Costa Viola, and in the middle of the Straits of Messina on the Kobold offshore platform. These are the locations of creative and scientific culture

diffusion spaces, multimedia applications, reading rooms and libraries, for visual and theatrical experimentation and contemporary art, multidisciplinary interactive routes, underwater installations, diving and sailing schools. Not to mention facilities for studying the energy sources contained in marine currents and for "observing" the chaotic phenomena of the straits, deep-sea marine life, fossils and archaeological finds.

This is also the starting point for exploration, ethnographic itineraries, underwater tours, mini yachting cruises, fishing trips on board the traditional "feluche" boats, as well as historical-artistic/ethno-anthropological/nature trails in an area offering an extremely high concentration of reserves and protected areas, sites of natural interest, and thousands of years of cultural stratification (from the Nebrodi hills to the Peloritani hills and the Aspromonte, from the Aeolian Islands to the Straits of Messina and along to Taormina and Etna).

Such variety clearly requires the support of an equally articulated and varied network of participants from scientific research, social and business fields. The Horcynus Orca Park is in fact a system arranged around 55 subjects, in which institutions, scientific research bodies, the third system, ethically oriented business and young entrepreneurs. They all contribute with a spirit of collaboration, each one according to its specific field, in the actuation of the project and in the experimentation of this model of community economy and welfare.

A cultural Park, located in the Straits of Messina, where the uniqueness, dynamics and variety of the natural ecosystems have always been woven together with processes of human intervention, of complex cultural construction and place of both poetic and scientific representation process.

Thus, it is a contemporary Park, situated in an area where geodynamic, cultural and socio-economic tensions, the whole marine flora and fauna wealth, and whose position, as a nodal point of ancient systems, make it a paradigm of the Mediterranean.

Role of Technology Parks and Centres in Developing Countries

Fabrizio Condorelli
Industrial and Technology Promotion Branch
UNIDO

The concept of "national innovation systems" has been introduced in mid eighties (Lundvall, 1985) to describe the relationships of R&D and technology-oriented institutions with the production system. Later the concept has been broadened (Metcalfe, 1995) to cover a set of institutions which jointly or individually contribute to the development and diffusion of new technologies and provide the framework within which governments form and implement policies to influence the innovation process. Nowadays competition is not just occurring between companies, but between countries and more extensively, geographical areas. The Regions that achieve the organization of national innovation systems and attract most investment in innovation are those that grow most and distribute most wealth. In a national innovation system, government, technological institutions and production system work together to encourage a broader use of innovation and new technologies among existing companies and help the start-up and growth of new hi-tech ventures. In developing countries a national innovation system, though based on the same institutional context of developed ones: government, technology-related institutions and business sector, not always manages to achieve an impact on wealth, because of structural and cultural diversities in each institutional actor. In developing countries university is not often a place for research, but a place of education. Any research that may be commercialized is developed in industrialized economies (Soltani et al., 2003) and/or any researcher who may develop a technology business leaves the country of origin to wealthier regions. The government usually pays no special attention to national innovation systems and unless a few exceptions, innovation is left to individual businesses. On the private sector side, local enterprises used to protectionist measures for many years have rarely developed the need for innovating their businesses. However in the last decade, due to the current globalization process, each country at government, university and/or private sector levels is trying to recuperate this cultural gap. If we analyze major reasons of success in Silicon Valley, a prime factor is the prevailing culture of risk taking, competitiveness and freedom to fail. (Lalkaka, Bishop, 2002).

Albeit culture cannot be considered anymore a fixed hindering factor in the development of innovation. Culture is integral part of a country, but technology itself, through satellites, Internet, cable TV, is sweeping away

local boundaries and creating a global culture. Even forces opposing this incontrovertible trend, such as anti-globalisation movements are a paradox, being themselves global (Sanz, 2002). The challenge is how common culture can lead to greater shared values and how developing countries can benefit of this trend to shorten the learning innovation curve, rather than falling passive victims of the "consumer" model. Some Asian experiences, such as China, India and Singapore are clear examples of how governments and civil society organizations utilize "glocal" knowledge to gain competitive advantages while maintaining their cultural identity.

Science and Technology Parks such as Singapore's Technology Park I and II or the Zhongguancun Science and Technology Park in Beijing are playing a crucial role in achieving knowledge economy status (Evers, Menkhoff, Wah, Meyer, 2004). The national innovation system created in India in the software industry has been known since the seventies, albeit only in the nineties it has started achieving its renown success with the establishment of a national programme on Software Technology Parks (STPI). The first technology parks were established in Bangalore, Pune and Bhubaneshwar in the second half of 1990. In 1991 four additional ones were set-up in Noida, Ganndhinagar, Trivandrum and Hyderabad. As of today 39 technology parks have been established in different locations of India. In terms of software companies operating in STPI, the number has increased from 164 in 1992 to 5,582 in 1999 and 7,000 in 2002/3 and they account now for 80% of software exports from India (Nagesh, K J, 2004). Today 130 of the Fortune-500 companies outsource their software requirements to India.

Actually the nineties represents the booming age for technology parks in both developed and developing countries. According to IASP (International Association of Science Parks) statistics almost half of the existing technology parks in the world were created between 1990 and 2000 and, with an increasing rate of development, 18% have been set-up only in the first two years of the century. The rationale of setting up technology parks in developing countries lies in market failures and in described functional constraints of national innovation systems, which limit the start-up survival and growth of technology and innovation oriented firms. Due to scarce available resources in most developing countries, technology parks and technology centers represent key intermediary institutions for technology commercialization and innovation by assisting both technology spin-offs that cannot easily link to funding and commercial opportunities and existing enterprises that cannot have access to very sophisticated research and laboratory facilities.

As per IASP definition: "A technology park is an organization managed by specialized professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a technology park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities."

Technology parks promote the creation of new innovation-based local companies and support the existing local businesses contributing to alleviate unemployment and fostering regional development. Technology parks contribute also to slow down the "brain drain" from research and educational institutes, by providing jobs that place a significant emphasis on technological skills, fostering the development of cutting-edge industries with the most growth potential. From the investment side, technology parks can improve the economic development at regional and national levels by creating a set of appealing conditions to attract foreign industrial investments to their country.

ROLE OF TECHNOLOGY PARKS IN NATIONAL INNOVATION SYSTEMS

Technology parks and centres are considered to be vital tools in national and regional innovation policies and in particular, can

play a crucial role in encouraging researchers in universities and other centres of research to take their work through to wealth creation, but it is still under debate how they can effectively contribute to national innovation systems.

Soltani (2003) introduces two models of interaction of technology parks with national innovation systems. The first is mainly based on a technology push approach, as in South Korea and Taiwan, where a close relation is established between technology parks and higher educational institutes. Companies in technology parks are mainly created from commercialization of local research by university staff. In the case of developing countries, however, rather than talking of production of new technologies, the term "adaptation" would fit better to real achievable outputs. In this model it is interesting to observe that in those technology parks, taking into account similar age of firms, the ones located off-the technology parks have achieved higher level of employment than the ones located inside. This result may indicate that technology parks may even slow down the growth of companies hosted inside the premises. Further analysis has indicated that most of the firms in the assessed technology parks were created only by academics and ex-academics and those were the businesses that underperformed (Lofsten, Lindelof, 2002).

The second model introduced by Soltani (2003) refers to fourteen different factors, which interact among higher educational institutes, entrepreneurs, government institutions, financial and venture capital institutions. R&D expenses represent a first factor. When R&D expenses in a country are very high, firms tend to buy and transfer foreign technologies rather than developing new ones. Technology parks, because of synergies of action induced within national innovation systems (see previous case of India in the software industry), can lower these expenses and make it accessible for firms to innovate, thus having a role in adjusting the expense structure of innovation development systems. Another technology park contribution to national innovation systems is the "networking" inside and outside premises with local and international markets. On the latter issue particular attention should be devoted to the role played by technology parks in attracting foreign investments.

In the present global economic environment all countries try to develop competitive national innovation systems to attract foreign firms and technologies. Experience shows that in several cases regional and/or local government authorities have been planning technology parks hoping that, once created, foreign investments would have knocked at their doors (Sanz, 2002). When there is no local intellectual capital to incubate and technology competency, many governments pursue the strategy of "build it and they will come". If a country is not able to develop a local technology in addition to the foreign one provided by incoming investments, a technology park will not move much a country from real estate investment to real innovation. Attracting industrial and technological international investments to a country or region depends on some basic structural issues such as: political stability, fiscal attractiveness, legal regulations in place, good services, good international connections, specialized human resources, IT and communications, etc. However, technology parks can still contribute significantly to attract foreign international investment if they can develop an adequate framework of suppliers for international industries. Technology parks in developing countries should therefore focus their efforts in supporting the creation of supplier networks and/or assisting the growth and improvement of existing ones upgrading their quality management and in turn the quality of their products and services (Sanz, 2002). This implies that firstly a decision has to be taken at policy level on which sectors to be supported and which strategy to be developed versus other competitive countries in those sectors. International development agencies, due to their institutional role of facilitating north-south and south-south networking, have a role to play in assisting market comparative analysis first and marketing and promotional phases after the set-up of technology parks in developing countries. (Lalkaka, Bishop, 2002).

Due to globalisation, international competition is high and due also to recent rapid development of technology parks, one may still question why a region and/or a country

may enter into such a long and costly development business. The main objective is to assist "reindustrialisation" purposes, creating new jobs in new industries and replacing declining sectors. Especially in developing countries this happens in the agricultural sector (Castells, Hall, 1994), but following the entry into force of WTO agreements it may soon involve textile and other traditional manufacturing sectors. Product cycle and trade theories suggest that as economies develop and protectionism is lowered, countries specialize in sectors where they have a comparative advantage. The decision will depend then on availability of good raw material and/or the presence of good university and research institutes in specific sectors. This will imply that countries will move up in the learning curve and enter into more sophisticated products and services.

Another reason to develop technology parks is to foster interaction and synergies of action between firms, which is not often a spontaneous phenomenon especially in innovative sectors. Synergy is aiming at formulating "new and valuable information through human interaction" (Castells and Hall, 1994).

There is a growing consensus among state ad local policy officials and academics that region's long-term economic prospects depend on the ability of a national innovation system to generate and sustain a concentration of firms capable to develop new products and processes that can compete in national as well in international markets (Drescher, 2001). The on-going research reveals that, especially in the People's Republic of China, small entrepreneurial firms have to invest substantial resources into network building before they accumulate knowledge and do business successfully (Evers, Menkhoff, Wah, Meyer, 2004). Innovative and technological firms when clustered in a technology park can take advantage of sharing a specialized and skilled labour force, facilities and expertise from university and research institutions, business services, access to market, financial and technical information. From experience in Bangalore, India, the patterns of clustering software activities in a technology park with a pro-active role of the government, investing in a national innovation system through technological infrastructure, R&D institutions and training of manpower, has attracted investments from the private sector, showing also substantial positive externalities. (Nagesh, K J, 2004)

Another positive example of public private participation in a national innovation system supported by the development of a technology park is the case of Myanmar. At the instance of ICT Myanmar Development Corporation a technology park initiated in Hline University Campus in 2001 has been inaugurated in January 2002. In 2003 the technology park had already reached its full occupancy, providing high-level jobs to 700 people and attracting two foreign companies. Similar successful cases have been also noticed in three ICT technology parks in Vietnam (HCMC, Da Nag and Hanoi). It has been surveyed by PC World that by the end of 2002 there were 260 software companies in Vietnam, employing 5,000 IT specialists, with growth rates of 23% per year.

In all successful cases, the recurring strategy has been to pool together resources of various institutional actors, such as civil society organizations, private sector, research institutes, universities, taking advantage of agglomeration economies, instead of spreading the resources all across the country. (Nagesh, K J, 2004) This has been achieved through technology parks where IT and communication infrastructure, business services, built-up space, finance, etc. are beyond the reach of an individual entrepreneur. The investor is also provided with a "single window clearance" avoiding all bureaucratic requirements. Another pre-requisite of success is that participating technological institutions are close to the technology park, thus assisting the absorption of foreign technologies and/or the development of local ones by shortening the skill learning curve.

IMPACT OF TECHNOLOGY PARKS ON ECONOMIC DEVELOPMENT

Starting from countries with longer experience in the operation of technology parks, more and more critical attitudes have been raising towards their effectiveness. Today's attention is therefore oriented towards measuring and possibly justifying the appro-

priateness of technology parks, criticized as being "white elephants" and not effective tools for regional development.

Several issues are rising when a specific business development "phenomenon", as a technology park, is going to be developed, monitored and possibly certified in a defined environment. Nowadays public funds require more and more justifications for their utilization, especially when dealing with private sector development. Until what extent technology park activities are really benefiting a certain region in terms of employment, innovation and wealth?

Recent evaluations of the impact of technology parks on economic development Colombo and Delmastro (2002), Link (2002) and Lofsten and Lindelof (2001, 2002, 2003) have pictured a rosier picture then the one depicted in some earlier studies of Quintas (1992) Van Dierdinck and Debackere (1991). This is also probably due to a different funding and institutional approach used in establishing technology parks during the nineties.

The conclusions of the research carried out by Lofsten and Lindelof (2002) on technology parks in Sweden have shown that NTBF (new technology based firms) on-park have a rate of job creation substantially higher that NTBF off-park. Because of this high employment growth, technology parks can fulfill an important objective of regional policy. It has also emerged that the presence of a technology park has notably increased the formal relationships between NTBF and university and research institutes. However NTBF on-park are not yet able to convert this knowledge investment into R&D outputs (patents and other IPRs). From a study carried out by WIPO (World Intellectual Property Organization) on technology parks and incubators this is also due to lack of management expertise by park staff. International networks of technology parks, including International agencies for developing countries, have a unique responsibility to promote a new management approach to the development and commercialization of IPRs by tenant firms. (Kenny, 1997)

The assessment process of impact on economic development is just at the initial stage when applied to developing countries. Literature on assessments and evaluations of technology parks cover mainly developed countries-OECD members, with some preliminary exercise in India, China and Brazil. In between there is a large scale of medium sized countries for which we know less (Davenport et al., 2002). The evaluation of technology park impact on economic development is a clear area for UNIDO intervention to promote research and better analysis to justify the existence and to measure the success of existing ones, to then promote the establishment of additional effective and efficient technology parks in developing countries.

The analysis should firstly aim at raising and then at finding an answer to "Seven "W"s. What should be assessed if we can possibly define a technology park. Why a technology park should be assessed and eventually certified. Whom should we assess: promoters, clients, park managers, etc. When a technology park should be assessed. Where technology parks should be assessed. Is it possible to compare results of technology parks established in different environments, even in different regions of the same country. Which criteria should be used to assess and possibly certify technology parks in different environments. May certain indicators have same relevance in all countries. And last, but not least, who should carry out the assessment and certification of a technology park: an external expert or park managers, through a self-assessment, considering that international quality certification is often representing a non-tariff barrier to emerging countries' activities.

The attempt would not be to find optimum solutions, but second bests, which can satisfy either promoters or clients, when considering the results of their expectations.

WHAT should be assessed. Several models of technology parks have been developed in the world, however till now no international classification has been established to define the specific characteristics of a technology park. At the beginning of the paper it has been provided the IASP definition of technology park, but many other exist in the literature and in operational applications of the

concept. The general idea of a technology park, independently of the country where it has been established, can vary from Technopoles to last trendy virtual technology parks. A variety of other models stay within these categories and far more difficult is to assess categories involving different levels of technological, management and infrastructure support. To sum up the first step in carrying out an assessment should be to define or at least to delimit the range of variation of the aforementioned variables.

WHY should be assessed a technology park. The question is, to measure the performance, or rather to understand whether a technology park can be or has been a useful tool for regional development. As mentioned, many technology parks have been developed worldwide especially during the nineties, in a period when public expenditure is under strict control and limited to necessary interventions, thus it is of extreme importance to justify the investment in private sector development institutions. However a technology park should be assessed, not only to justify public expenditures, but also to attract more clients, who will be the final ones to sustain and then justify the success of a technology park.

WHOM should we assess. A technology park has multiple stakeholders with diverse goals: university or research institutes, regional development agencies and/or other local authorities. The structure and development of tenant activities should be also assessed, by measuring the satisfaction of clients with respect to technology park activities. It will be difficult to compare data referring to both categories: clients and promoters, and again a specific distinction should be made between the two assessed targets. Furthermore the quality of services in a given technology park is a function of the quality of the people providing the services; thus specific measurements should be attributed to the quality of technology park managers.

WHEN should be assessed a technology park. Here again we face the problem of the age of the Park. Comparing the facilities of a 15-years old technology park with that of a 5 years-old one, which is still in the process of fine-tuning its infrastructure and services is not correct. Long term initiatives like technology parks need a long time to reach optimum levels; hence evaluating the performance of technology parks halfway through its development would only provide a partial assessment.

This paper tries to consider a comparable timing of technology park development. The age of a technology park is of critical importance, even once it has achieved its fixed objectives. Actually after a certain number of years of operation, certain goals, which might have been achieved after five-ten years, should be also modified, due to an overall change of the external and probably internal environment of the technology park. Then a re-engineering process should be established in order to achieve further social, economical and financial results.

WHO should assess the technology park development and/or its established activities. With regard to this question, the consideration is whether external evaluators should be involved and/or which could be the role of a self-assessment. The independence of external assessors could be useful because they are not involved in local political matters, they do not have directed interests in the initiative, and they are specialized in carrying out such activities. International agencies, such as UNIDO, may have a leading role as external evaluator, having no commercial and bilateral interests. It could be further distinguished the assessment of relevance of a technology park, before it has been established and the monitoring and evaluation, ex post. An independent team of assessors might conduct the first; the second could be based on a self-assessment accompanied by an external panel yearly review, for example each three years.

WHICH CRITERIA should be used to perform a comparative assessment of a technology park, involving different actors, different clients, and established in different environments. The criteria being used are not the same in all respect. If we assess the technology park, the cost of quality is relevant too, since most of the tenants in a technology park tend to be small and medium firms, which choose a park due, among other things, to affordable costs of facilities and services. Costs need to be reduced to

a comparable level using Purchasing Power Parity or other measures. This is even more valid when we consider the amount of investment in a technology park and related indicators as cost per enterprise created and cost per job generated.

These are only some of many indicators, which have already been designed to measure the performance of a technology park. These are quantitative indicators of the assessment and nevertheless should be corrected to actual PPP of the country. Even more difficult will be to assess the quality of certain indicators such as added value of the technology park to its tenants firm, the number of firms started with active support off-the technology park organization, level of political satisfaction of the promoter, social wealth in the community, etc. If some specific criteria are to be developed for the assessment of the technology park, a clear limit to the range of variation of such variables should be defined to compare them internationally, then a benchmarking will be of use.

WHERE to compare different initiatives, which belong to different environments. Even if we arrive at an exhaustive list of performance indicators, a mechanical comparison of these indicators, as between technology parks may not be very helpful. We need to take into account the impact of the overall environment "on the performance of the technology park". The economic and technological milieu, a technology park is operating in, will have a bearing on its different facets.

Comparing a technology park based in USA with a Vietnamese one may not make much sense; in fact a Vietnamese technology park cannot be compared even with a Korean one on account of the huge difference in the environments of the two countries, though in the same Region.

There is the hypothesis that "successful" technology parks are more often found in "successful regions".

Even if the quality of facilities and services in a particular technology park is rather different, the tenants will still be better off-the technology park located in a region with highly developed infrastructure facilities and support services. We may only compare performance of technology parks located in comparable regions/countries.

Trying to compare the grade of a technology park in Sweden with that of a technology park in Poland is futile; even postulating that a technology park with a grade A3 (say, the lowest score) in Sweden is equivalent to A1 (the highest score) in Poland may be logical.

To sum up, the step towards designing a methodology for impact assessment and certification of technology parks in developing countries is to attempt to position them in appropriate slots to tale into account their focus, their age, their promoters, their clients, the region (developed countries, newly industrialized countries, economies in transition, least developed countries, etc.) and then administer the certification norms within each slot.

The certification process needs necessarily to start at the very beginning. We have to examine the strategic aims of the technology park and determine how far the choice of location, the facilities planned and the package of services provided are in conformity with predetermined goals of the technology park.

For instance if a technology park sets for itself the goal of promoting small and medium firms in knowledge based industries like software and biotechnology, it has to satisfy a set of conditions like: proximity to a centre of excellence, university or research institute, appropriate physical facilities with advance telecommunication, library, conference halls at affordable prices, industry specific infrastructure, full range of professional business development support, such as feasibility studies, business planning, patent licensing, funding options, internal and external networking of clients and proximity to a urban centre. Having considered an assessment mainly during the process of a technology park establishment, a further consideration, ex post, should be done for its impact to surrounding social and economic environments.

The objective of the ex-post evaluation is to

measure the impact of the technology park on the regional socio-economic environment, i.e. to verify the efficiency of its actions with regard to the strengthening of innovative performance of the country or Region. In particular, the ex post evaluation should assess the results against the initial, and possibly modified during the on-going monitoring, objectives set for the technology park.

Ex post evaluation should answer to questions related to regional development indicators, such as: how many jobs have been created in the companies, which have benefited directly and indirectly of the existence of the technology park? Have they triggered the development of activities outside the technology park, in the Region? Has the coordination of support organizations and other regional players, achieved through the technology park, resulted in a better visibility, an improved use of their competencies from companies' point of view?

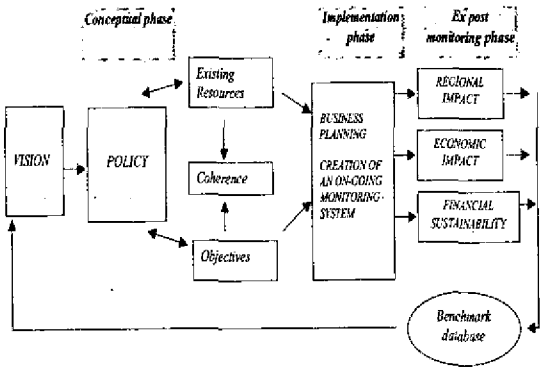
Nevertheless such indicators are notoriously difficult to create, as one cannot attribute effects to sole causes.

A compromise needs to be found between the need for precise data, as required by policy makers and the feasibility of indicators to be created and their cost.

What will be proposed here is to establish a coordinated "monitoring and evaluation system", which would forge rather than inhibit, shared vision. Its role should not be to evaluate specific activities and added value of each regional actor as far as the technology park is concerned, but rather to provide all actors with a common tool, which will allow them to discuss, on commonly agreed base, the *implementation timing*, scope, targets and results as compared to the initial objectives. No matter what type of project /initiative is contemplated, the time to lay the foundations for a useful follow-up is early on, preferably before the implementation starts. This is the period when objectives and targets are set, and monitoring and evaluation arrangements can be established, so that appropriate information can be collected and used strategically.

The figure below tries to resume the process of assessment. It is pretty obvious that debiting scientific certification techniques in regard to technology parks is an extremely difficult task and surely represents a continuous process in development, which this paper has only tried to start or "continue".

Figure: Model for a monitoring and evaluation system for technology parks.



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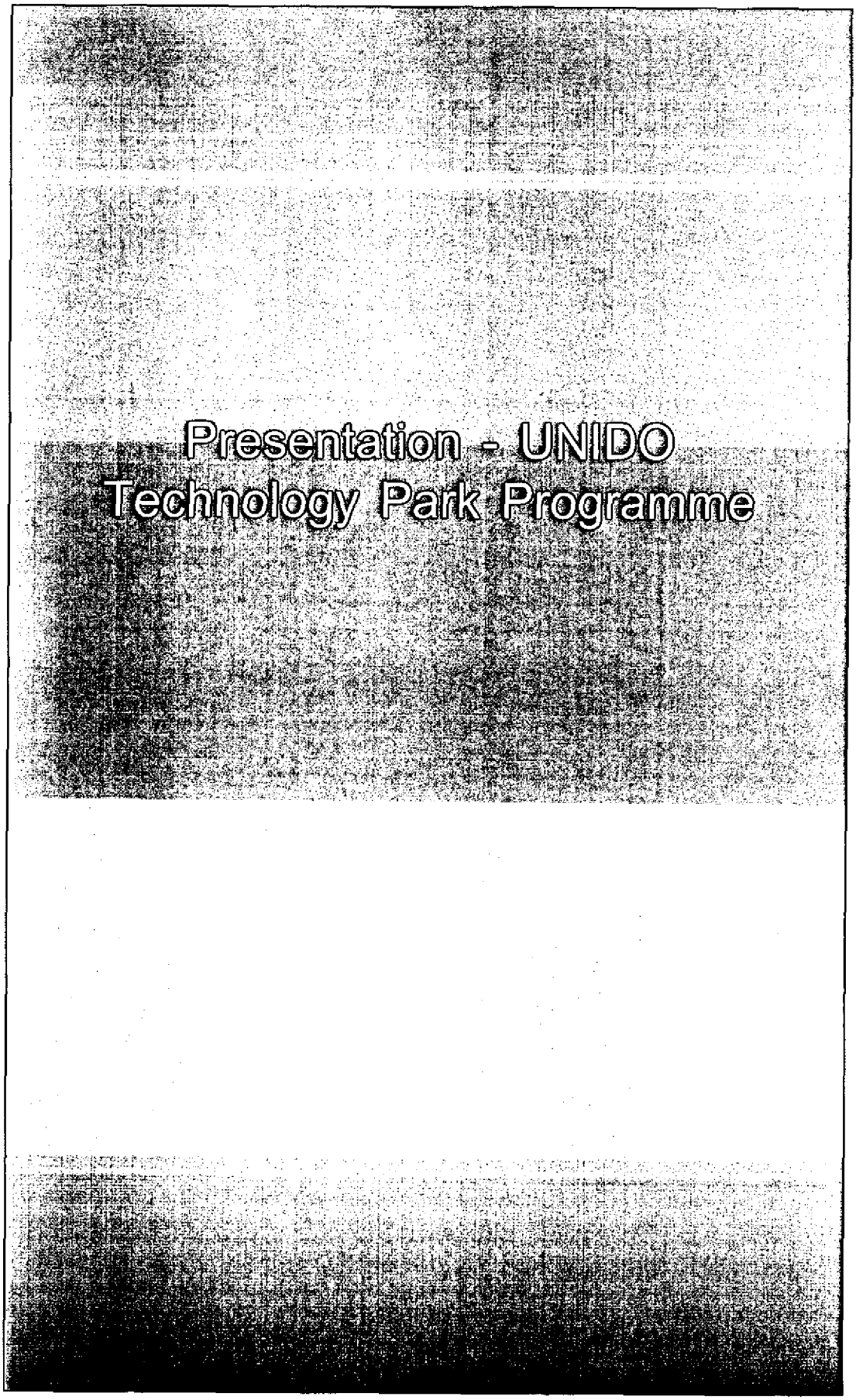
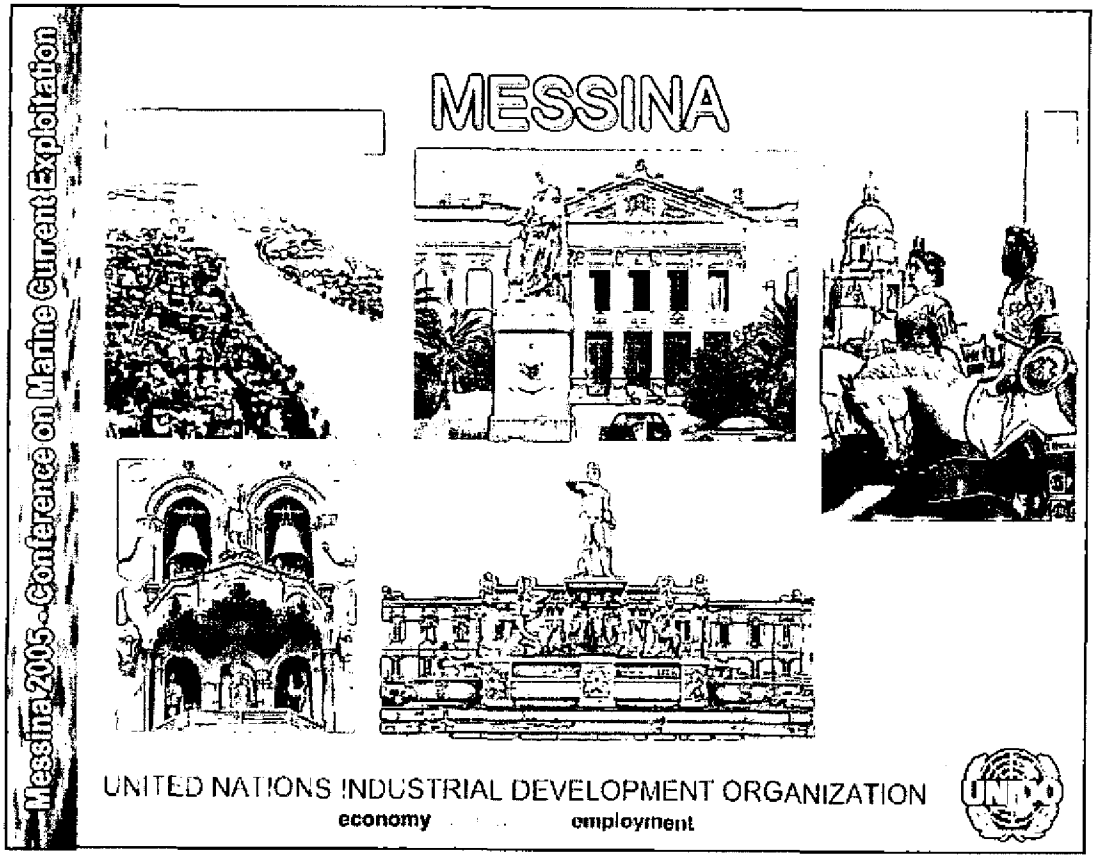

Presentation - UNIDO
Technology Park Programme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A Proposal for
an International Programme
on Marine Current Technologies
at Messina Horcynus Orca Park
Emilio Vento
Marco Matteini
Gaetano Giunta
Messina, Italy
15-16 September 2005
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Outline of Presentation

- UNIDO in brief
- Ocean Energy System
- Character of Marine Current Technology Industry
- Present International Initiatives
- International Centre on MCT
  - Objectives
  - Focuses
- Why UNIDO
- Way Forward

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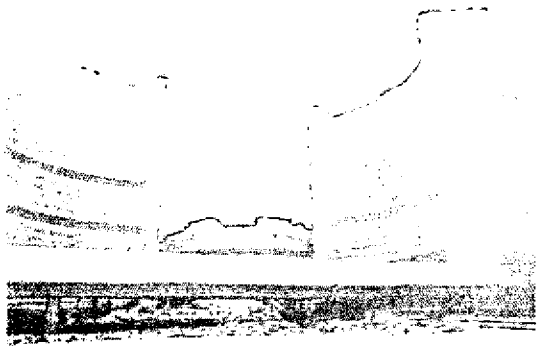
United Nations Industrial Development Organization

UNIDO's MANDATE is to *assist developing countries* and economies in transition to improve the living conditions of their people and foster local prosperity through the offer of *tailor-made solutions* for achieving a *sustainable industrial development*.



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UNIDO's Taylor-made Services

- Industrial Governance and Statistics
- Investment and Technology Promotion
- Industrial Competitiveness and Trade
- Private Sector Development
- Agro-Industries
- Sustainable Energy and Climate Change
- Montreal and Stockholm Protocols
- Environmental Management

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UNIDO: Sustainable Energy & Climate Change

- Industrial Energy Efficiency:
  - Energy efficiency improvement in existing plants and systems
  - Production of better qualitative products with lower energy intensity in production and use
- Promotion of renewable energy technologies with emphasis on rural & decentralized energy supply
- Energy Policies and Kyoto Protocol compliance

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UNIDO's Taylor-made Services

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Perspective on MCT Industry

- 5 TW of marine current energy
- Sporadic work around the world
  (Italy, UK, Australia, Ireland, USA)
- Many prototypes but not yet commercial devices
  (Kobold, Gorlov, Seaflow)
- Wide variety of problem areas
- Further R&D still needed

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International Initiatives

- **IEA Implementation Agreement on Ocean Energy System**
  Review, Exchange and Dissemination of Information
  Recommended practices for OES Test and Evaluation
- **European Thematic Network on Wave Energy**
  Its work address most of the areas which contain aspects of device development that are common to all wave energy devices, as well as themes that will be of benefit to wave energy as a whole.
- **EurOcean**
  It s a recently created focal point for information in Europe on marine science and technology. It currently provides information in three main domains: marine research infrastructures, national and European RTD programmes.

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An International Center on MCT

Proposed Objectives:

To strengthen the institutional capacity of the Horcynus Orca Park in:

- promoting knowledge,
- disseminating information,
- building management capacities
- developing application skills, and
- promoting international R&D and cooperation

in relation to Exploitation of Marine Resources and Marine Technologies with special attention to the needs of developing countries

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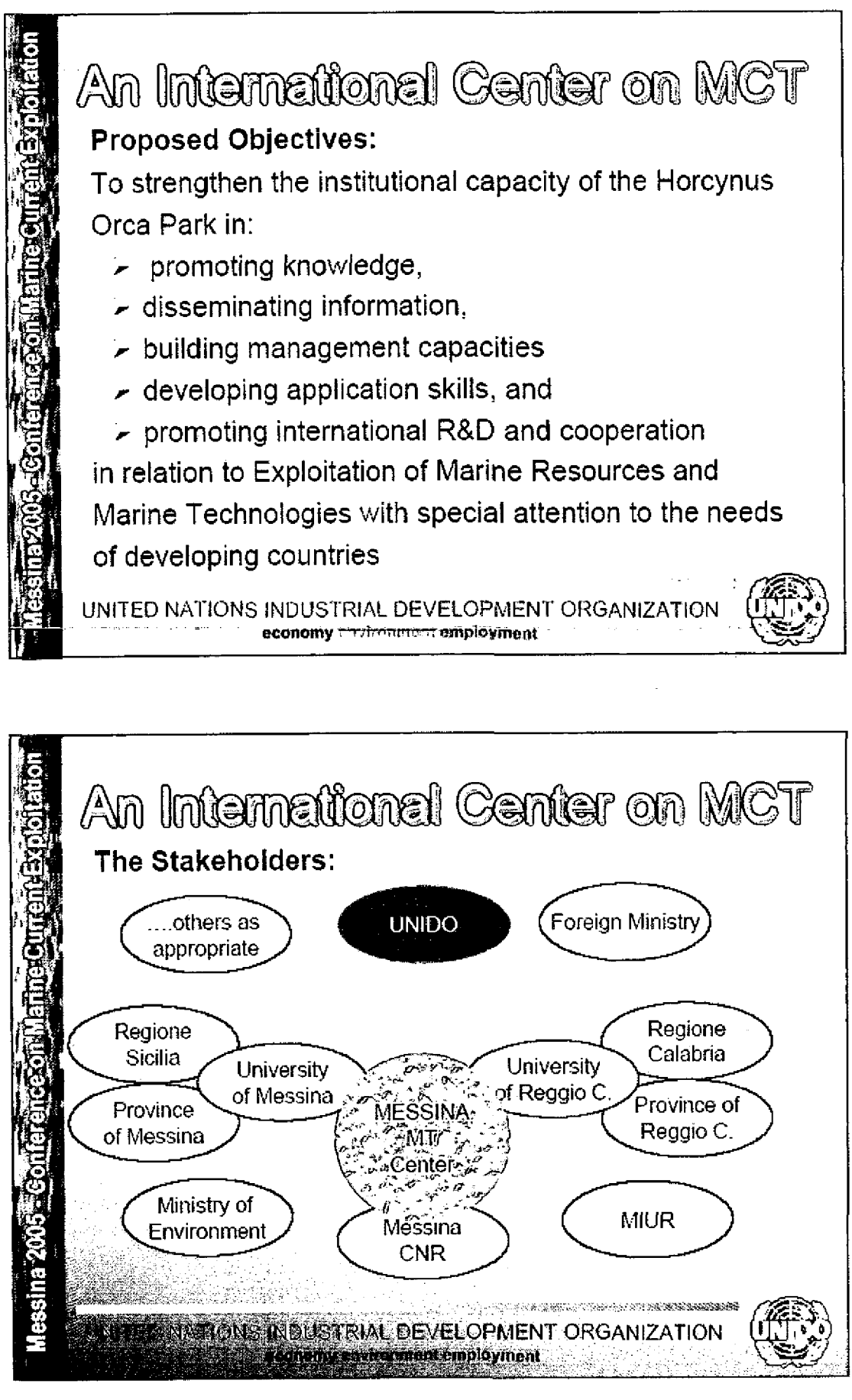

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MCT/Messina - Focus 1

Information and Resource Centre on MCT

- Repository of relevant literature and publications
- Agenda of Events
- Roster of international consultants, specialists and technology developers
- Database of international ongoing research and technology development efforts

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MCT/Messina - Focus 2

Networking with other international centers and networks on ocean and marine energy system and technologies:

- Ocean Thermal Energy Conversion
  (Saga University, Japan; NREL, USA)
- Ocean Wave Energy
  (UK, Denmark, Portugal, Ireland)
- IEA Implementation Agreement on Ocean Energy System

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MCT/Messina - Focus 3

Networking with universities, researchers and project developers of developing countries with an interest and/or potential for marine current and/or low-head hydro energy applications ***(i.e. Mediterranean Countries, South-East Asia Countries, Small Island Developing States)***

- Facilitation and establishment of twinning cooperation
- Establishment and coordination of fellowships and exchange programmes

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MCT/Messina - Focus 4

Marine current energy resource assessment

- Collecting information and setting up suitable *mathematical model of tidal streams*
- Running models, creating meaningful outputs and evaluate results
- Conducting and coordinating field measurements

KEY POINT

A full cost-resource assessment is required to understand the real scope for the deployment of the technology

Rationale for International Cooperation

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MCT/Messina - Focus 5

Identification and development of projects in partnership with industry players and beneficiary developing countries counterparts

- Site-specific assessment
- Pre-feasibility and feasibility studies
- Socio-economic analysis

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MCT/Messina - Focus 6

Training and Capacity building

- Methodologies for marine current and low-head hydro energy resource assessment
- Computational hydrodynamics applied to oceanography and tidal flows
- Development of MCT projects and applications ***(EU calls, GEF, Regional Banks, WB, others)***
- Technology operation, maintenance and troubleshooting
- ...

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MCT/Messina - Focus 7

Organization and hosting of International

- Experts Group Meetings,
- Seminars,
- Workshops,
- Conferences

on MCT with the participation of decision-makers, researchers as well as industries (marine construction and engineering companies, equipment suppliers, etc.)

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MCT/Messina - Focus 8

Participation in and promotion of R&D programmes on MCT

- Interaction of MCT with marine environment (Environment Impact Assessment)
- Biofouling
- Cavitation and turbulence
- Power conditioning
- Installation, Foundations and Moorings

Wide range of expertise involved ⇒ targeted cooperation agreements with research institute, universities and industries having strong competency and experience should be pursued

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MCT/Messina - Focus 9

Participation in and promotion of R&D programmes on outstanding technical issues related to MCT applications and commercialization such as:

- Connection to grid
- Energy storage interfaces for isolated power networks (Fuel Cells, Super Capacitors, etc.)
- Testing, proofing and certification
- Standards

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MCT/Messina - Focus 10

Development a non-proprietary energy model for pre-feasibility study of marine current technology projects.

The model should include:

- *Marine current energy and load calculation model*
- Equipment data
- Cost analysis model
- GHG analysis model
- Financial summary

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Why UNIDO?

- International Technology Centres (ITCs)
- Investment and Technology Promotion Offices (ITPOs)
- Subcontracting and Partnership Exchanges (SPXs)
- National Clean Production Centres (NCPCs) Network
- Africa-Asia Investment and Technology Promotion Centre (AAITPC)
- SME Clusters and Networks Programme
- Trade Facilitation Programme
- Exchange Platform
- Technology Foresight & Road mapping Programme

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UNIDO Services for TPs

- Methodologies and tools available on-line
- Web network of technology parks and associations established in industrializing countries
- On-line counseling and training services
- Hub with specialized access to news, international tenders and cooperation programs for technology parks and tenants
- Database of technology parks, tenant companies and experts operating in and for industrializing countries

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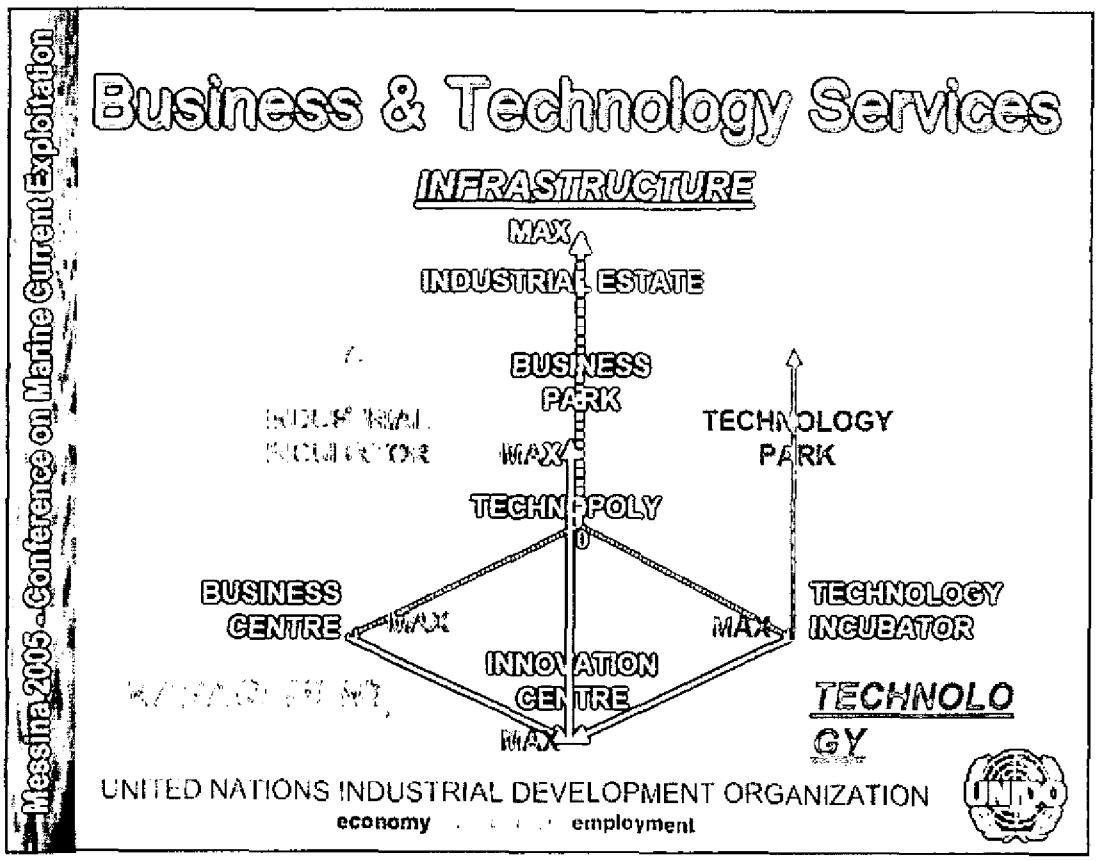
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Business & Technology Services
INFRASTRUCTURE
MAX
INDUSTRIAL ESTATE
BUSINESS PARK
TECHNOLOGY PARK
MAX
TECHNOPOLY
BUSINESS CENTRE
MAX
MAX
TECHNOLOGY INCUBATOR
INNOVATION CENTRE
MAX
TECHNOLOGY
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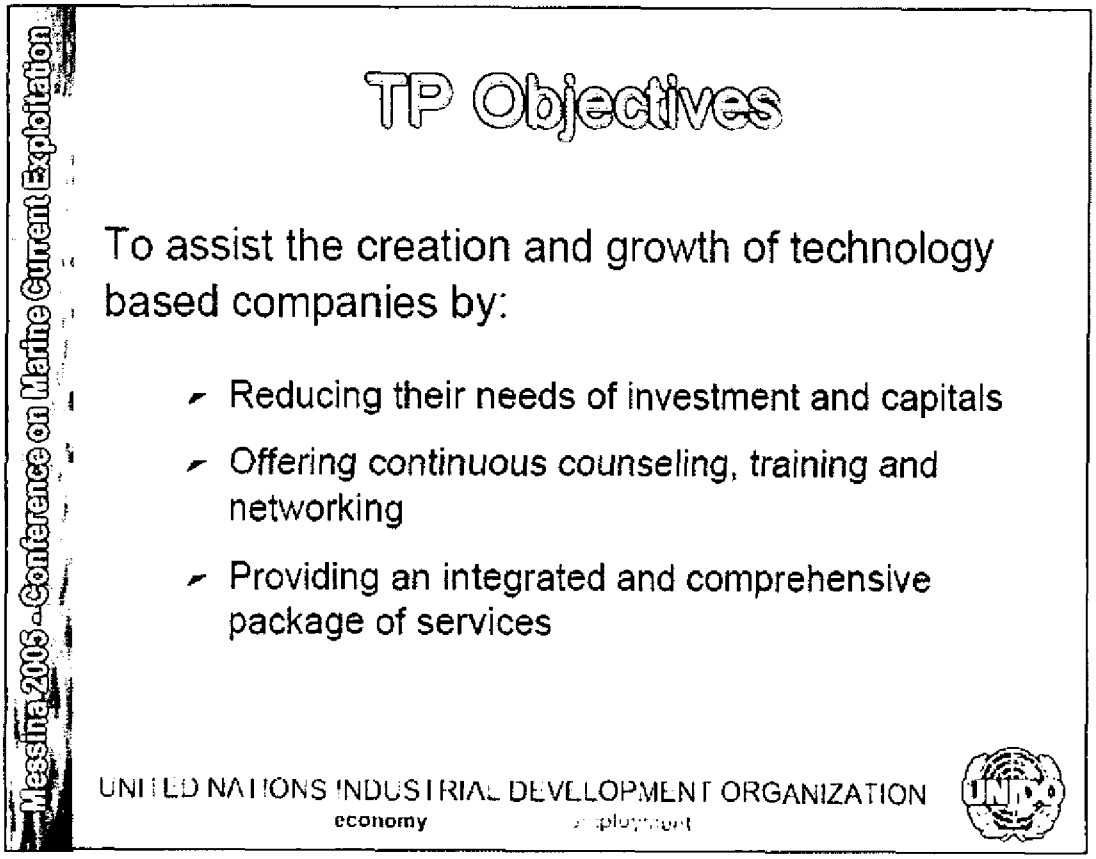
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TP Objectives
To assist the creation and growth of technology based companies by:
Reducing their needs of investment and capitals
Offering continuous counseling, training and networking
Providing an integrated and comprehensive package of services
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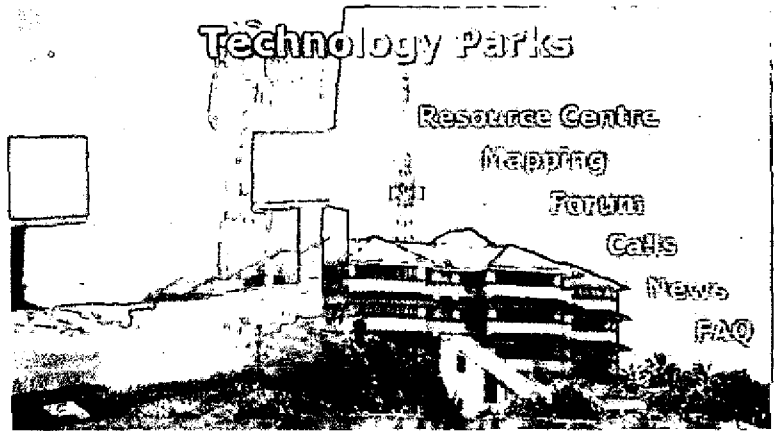
UNIDO Platform on Technology Parks (PLATECH)



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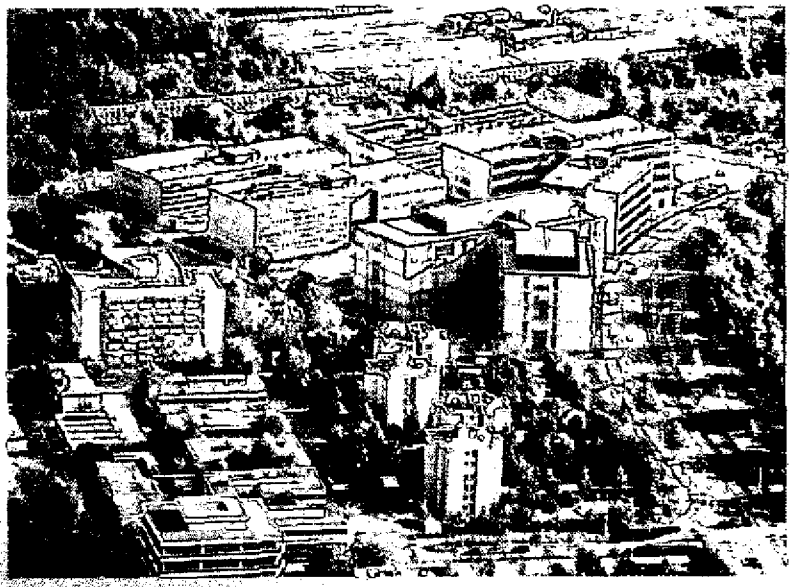
HEIDELBERG TP



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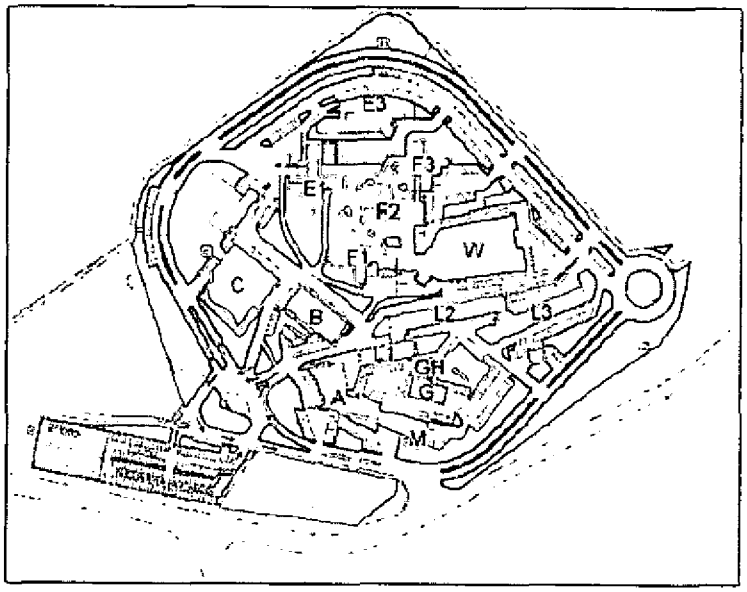
Area Science Park TRIESTE



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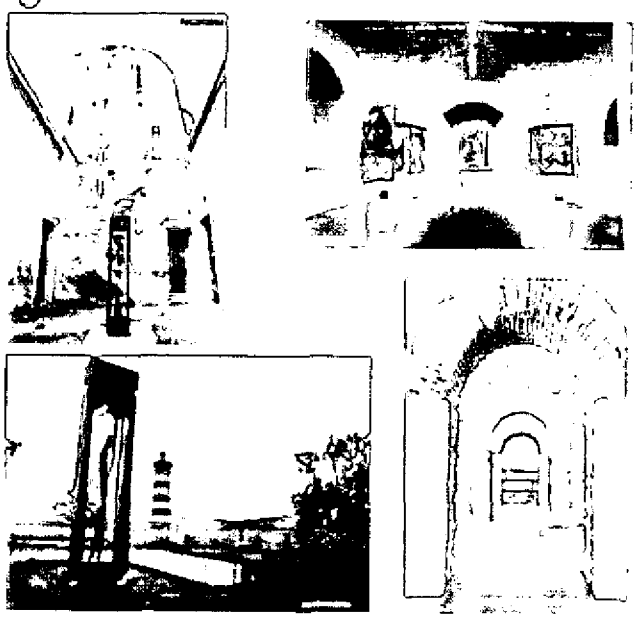
Horcynus Orca Park MESSINA



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A tentative Programme

2006 Mediterranean Conference on MCT
EGM on MCT for Africa
Workshop on Tidal Energy

2007 Workshop on Energy in Coastal Areas
EGM on Kobold turbine applications
Conference on Coastal Management

2008 Training on Harbors Management
Workshop on Wave Energy
International Conference on MCT

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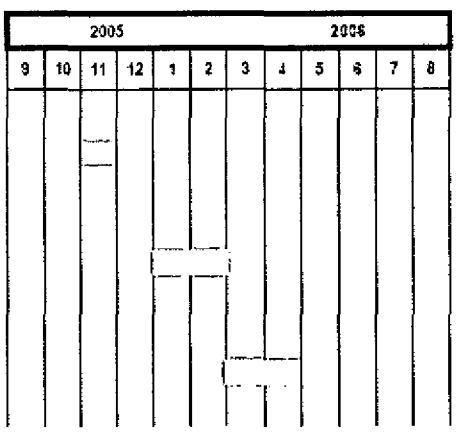
Way Forward

1. MCT Stakeholders and ad-hoc Expert Group Meeting
2. Definition of an Activity Programme for the MCT for the first triennium
3. Development of an Implementation Plan for the MCT in Messina



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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
economy environment employment

Archimede
un Genio Siracusano

Gaetano Giunta

"Vedendoti... come ho detto, diligente ed egregio maestro di filosofia, e tale da apprezzare anche nelle matematiche la teoria su cui accada di riflettere, decisi di scriverti e di esporti nello stesso libro le caratteristiche di un certo metodo, mediante il quale ti sarà data la possibilità di considerare questioni matematiche per mezzo della meccanica. E sono persuaso che questo (metodo) non sia meno utile anche per la dimostrazione degli stessi teoremi. E difatti alcune delle (proprietà) che a me dapprima si sono presentate per via meccanica sono state più tardi da me dimostrate per via geometrica, poiché la ricerca (compiuta) per mezzo di questo metodo non è una dimostrazione: è poi più facile, avendo già ottenuto con (questo) metodo qualche conoscenza delle cose ricercate, compiere la dimostrazione, piuttosto che fare ricerca senza alcuna nozione precedente. Perciò anche di quei teoremi, dei quali Eudosso trovò per primo la dimostrazione, riguardo il cono e la piramide, (cioè) che il cono è la terza parte del cilindro e la piramide (è la terza parte) del prisma aventi la stessa base e altezza uguale, non poca parte (del merito) va attribuita a Democrito, che per primo fece conoscere questa proprietà della figura sopraccitata, senza dimostrazione" - Archimede.

Lo scritto sul metodo, dedicato ad Eratostene, evidenzia la straordinaria modernità dell'impostazione epistemologica dello scienziato siracusano. Non vi è alcun dubbio che egli, collocandosi in modo creativo nella tradizione dei filosofi-matematici greci, anticipò di molti secoli una riflessione matura sul metodo scientifico. Archimede sviluppò un approccio circolare teorico-sperimentale che si potrebbe definire, nel linguaggio Popperiano, ipotetico-deduttivo, se si accetta che a monte le ipotesi sono costruite attraverso intuizioni non artificiose, fondate sulle esperienze.

In Archimede ritroviamo per intero quello spirito del vecchio Talete che Platone indicava come simbolo dell'approccio teoretico-contemplativo, che mira ad interpretare le cose visibili come uno spiraglio attraverso il quale si può giungere all'invisibile, alle leggi universali. Le sue convinzioni, però, sul linguaggio, verrebbe da dire sull'estetica e sulla storicizzazione dell'evoluzione scientifica anticipano in modo sorprendente più filoni del pensiero contemporaneo ed alcuni presupposti filosofici dei grandi paradigmi della fisica del 900 interamente costruiti sis-

temicamente, forse in coincidenza, con le nuove teorie ed i nuovi linguaggi della matematica. E' certamente vero, infatti, che la riflessione sulla strutturale correlazione, sull'inesistenza di un confine netto fra realtà e pensiero, fra pensiero e linguaggio è una riflessione portante del pensiero sofisticatissimo di Archimede (anche se da lui risolta al singolare) così come lo è della complessa cultura contemporanea.

Archimede nacque a Siracusa verso il 287 a.C.. Era figlio di un astronomo, di nome Fidia. Per qualche tempo visse ad Alessandria, dove forse fu allievo di Euclide. Egli preferì, però, trascorrere la maggior parte della sua vita a Siracusa; d'altronde era unito alla casa regnante da legami di parentela e di amicizia.

Di tutte le sue opere, che furono numerose, le più conosciute sono:
Sulla sfera e sul cilindro
Sulla misura del cerchio
Sulle spirali
Sulla quadratura della parabola
Sull'equilibrio dei piani e loro centro di gravità
Arenario
Sui corpi galleggianti.
I risultati dei suoi studi delle aree e dei volumi di figure piane e solide anticiparono molti dei contenuti della moderna geometria: ad esempio, determinò l'area della superficie sferica e dimostrò che il volume di una sfera è pari a due terzi del volume del cilindro a essa circoscritto. Dedicò molto tempo al problema della quadratura del cerchio ed introdusse il numero p. Gli studi sui conoidi, gli sferoidi e sulle spirali contengono importanti risultati così come tutti i suoi altri capitoli di geometria.

Nell'Arenario, vi sono nozioni interessantissime riguardo l'aritmetica greca. Infatti, in esso Archimede escogita un sistema per esprimere numeri molto grandi, cosa che con il sistema greco era pressoché impossibile, dato che, per indicare i numeri, venivano utilizzate le lettere dell'alfabeto.
In un trattato di statica, definì la posizione del baricentro di diverse figure solide e diede una chiara spiegazione del principio di funzionamento delle leve. Sono probabilmente da attribuire ad Archimede l'invenzione della vite senza fine e della coclea, usata per il sollevamento dell'acqua.
Nell'ambito dell'idrostatica, egli enunciò il celebre principio (detto, appunto, principio di Archimede) secondo il quale un corpo immerso in un fluido è sottoposto a una spinta verso l'alto pari al peso del fluido spostato.

A lui si devono numerosi geniali dispositivi meccanici utilizzati dai soldati e macchine da guerra: tra queste sono da citare la catapulta e un sistema di specchi ("specchi ustori"), probabilmente leggendario, usato per concentrare i raggi solari sulle navi degli invasori e incendiarle, primo esempio di utilizzo tecnologico di energia solare.

Nonostante egli, considerandosi un matematico puro, valutasse uno svago le scoperte fatte nel campo della meccanica, e della fisica in generale, e addirittura una forzatura le loro applicazioni militari, proprio per esse divenne famosissimo e leggendario ancora in vita, tanto da essere insieme ammirato e temuto. I siracusani assediati tennero sotto scacco l'esercito romano per ben tre anni, nonostante le forze fossero grandemente impari, proprio grazie alle invenzioni di Archimede.

Archimede era il prototipo dello scienziato geniale e dedicato in modo esclusivo alle sue ricerche ed ai suoi pensieri. Trascurato nella persona, oltremodo distratto, si dice che a volte dimenticasse persino di mangiare. Quando gli si presentava alla mente una intuizione importante, per lui urgente, con la punta del dito si disegnava sul corpo, unto d'olio, i dati del problema. Facendo il bagno, per esempio, giunse alla formulazione del primo principio dell'idrostatica. Narrano le cronache del tempo che il distrattissimo Archimede, preso da improvviso entusiasmo per la scoperta, uscì nudo di casa e corse per le vie di Siracusa, tra gli sguardi attoniti dei suoi concittadini, gridando Eureka! Eureka!

Proprio la sua distrazione fu causa della sua morte, o almeno così narrano i vincitori romani. Durante il saccheggio di Siracusa il console Marcello, comandante delle truppe romane, grande ammiratore del genio di Archimede, aveva dato ordine che venisse risparmiata la vita all'uomo che, con le sue continue invenzioni, aveva bloccato e semi-

distrutto la sua flotta. Archimede, incurante di quanto stava succedendo attorno a lui, era intento ai suoi studi, completamente assorto nei suoi pensieri. Quando un soldato romano gli si avvicinò e gli chiese chi fosse, Archimede assente non gli rispose. Allora il soldato, irritato, non avendolo riconosciuto, lo uccise. Era l'anno 212 avanti Cristo. Marcello, addolorato per la morte del genio, gli fece tributare solenni onoranze funebri. Indi, come perenne tributo alla sua mente prodigiosa, gli fece erigere una tomba sulla quale, secondo il volere dello stesso Archimede, venne posta una sfera inscritta in un cilindro con i numeri che regolano i rapporti fra questi due solidi.

Cicerone, in seguito, quando fu questore in Sicilia, ritrovò la tomba, nel tempo abbandonata, la fece restaurare e la rese oggetto di grande venerazione.

SECTION IV - Speakers

CYRILLE ABONNEL

Marine Current Energy Project Manager,

National Hydraulics and Environment Laboratory,

EDF R&D, Paris, France

- o Hydraulics Engineer with international experience in networking and project development as, from 1998 to 2000, he has been working in Vietnam, based in the Institute of Mechanics - CNST, Hanoi, to strengthen research collaborations between EDF and Vietnamese bodies on flood management projects, under the supervision of the French Embassy Scientific and Cultural Cooperation Service.
- o During this time, he was responsible for the "hydraulic analysis" in a Flood Protection Subproject Feasibility Study, part of a wider project on the Red River Basin management, funded by the Asian Development Bank.
- o Since 2001, back in the R&D Division in France, he has been managing the development of marine renewables activities for EDF, in particular through the French Marine Current Energy Project - initiated in 2004 and preparing the conditions for the installation of first prototypes in the French waters. He is also the representative of EDF in the European Coordinated-Action on Ocean Energies, facilitating its watching over ocean energy initiatives worldwide.

DIANA BATTAGGIA

Director Investment and Technology Promotion Office

UNIDO, Rome, Italy

- o Immediately after her graduation in Political Sciences (M.A. equivalent) at Padua University, Ms. Battaggia took, from 1988 to 93, the assignment of Chief Export Department at a leading Venetian glass company.
- o From 1994 to 1996 she has been member of the Italian Parliament under the XII Legislature where she was:
- o Member of the Commission for Foreign and EU/EEC Affairs
- o Member of the Parliamentary Commission of Inquiry into terrorism in Italy
- o Member of the Commission for Constitutional Affairs Counsel of Ministers and Internal Affairs Ministry.
- o From 1996 to 1998 she was Small and medium-sized enterprises business consultant for the Institute for Industrial Promotion and the Ministry for Industry, Commerce, Artisanwork and Tourism. During the period 1996 - 2000 she was consultant for the Confederation of the Italian Private Industry with responsibility of institutional relations with territorial organizations in Northeast Italy as well as economic and legislative entrepreneurship issues.
- o Having gained international experience working with UNCTAD as Programme Coordinator of the "Mediterranean 2000" initiative, as well as consultant for the American International Airport, from 2004 Ms. Battaggia become Head of UNIDO's Investement and Technology Promotion Office in Italy.

LI BAOSHANG

Chief of Renewable Energy Division, Ministry of Science & Technology, P.R. of China

ALESSANDRO BIANCHI

Rettore, Reggio Calabria University

- Immediately Prof. Bianchi obtained his degree from the University La Sapienza, Rome in 1970, in Engineering .
- Immediately In 1978 he became an expert in urban planning and infrastructure with the Ministry of Public Works.
- Immediately From 89 to 1991 he functioned as the Director of the research project for the mapping of the architectural treasures within the region of Calabria.
- Immediately He has been a member of the steering committee of the Institute for Calabrian and Bizantine Antiquities, as well as coordinator for the regional planning of the Calabrian territories with the University of Reggio Calabrio.
- Immediately In 1994 he was appointed Full Professor of the department of Urban Strudies within the faculty of Architecture at the University of Reggio Calabria.
- Immediately As from 1990 he was nominated Rector of the Univesity of Reggio Calabria and reelected in 2003 for a second term.

MARCO BUTTAZZONI

Director of Environmental Market Strategies at ERT

- Marco focuses on the policy, business and information strategies that enable the creation and operation of environmental markets.
- Prior to joining ERT, Marco worked as a management consultant, advising companies and regulators in Europe, the United States and Asia.
- As part of ERT's team Marco assists companies, government agencies, and nonprofit organizations in identifying, articulating, and implementing strategies that leverage market forces to simultaneously deliver environmental, economic and social benefits.
- Marco holds a Masters in Environmental Management from Yale University, New Haven; a MSc in Information Systems from the London School of Economics, London; and BA in Economics from Bocconi University, Milan

GUIDO CALCAGNO

INSEAN - Italian Naval Hydrodynamics Research Institute, Rome

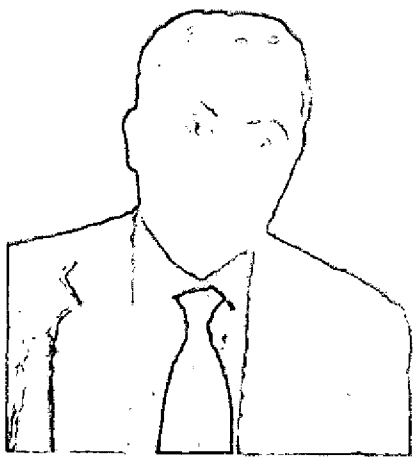
- After graduated in Aeronautical Engineering at the University of Rome in 1994, with a thesis on an innovative numerical method for aerodynamic analysis, he continued on this field of research applying that method also to naval hydrodynamic. Then he moved to Trieste where he obtained a PhD in Naval Engineering at the University of Trieste in 2001.
- He has a wide experience both in numerical and in experimental methods for naval hydrodynamic research. As researcher at Insean he worked first in the Towing Tank laboratory and now in the Large Circulating Channel where he's responsible for the application of innovative non-intrusive laser techniques for the analysis of the flow characteristic around ship models.
- He is also an educational consultant for training courses for Aeronautical Maintenance Technicians, having designed, organized courses and taught for several Italian companies.
- He's also involved in issues related to business follow-ups and knowledge dissemination of industrial applications of applied research.
- Currently he's finishing an Executive Master in Business Administration at the University of Malta.

EUGENIO CAMPO

Department for International Cooperation

Ministry of Foreign Affairs

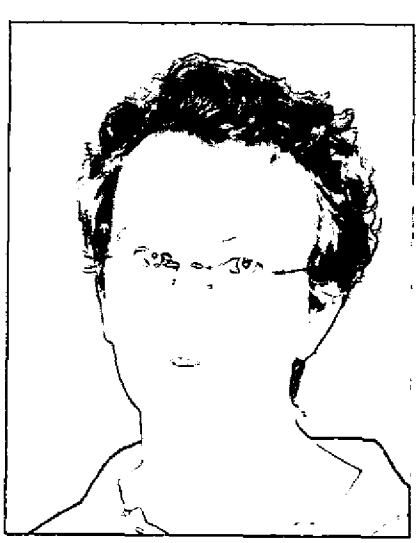
Italy Rome



- Mr. Eugenio Campo graduated in Political Sciences from the University of Rome in 1965.
- In 1970 he started his diplomatic carrier with the Italian Foreign Ministry during which he had difersified work experiences and growing responsibilities in different international locations.
- Amongst other responsibilities he was; entrusted with the charge of Mission Secretary in Nigeria form 1973-75 Consul in Switzerland in 1976, First Secretray and Counsellor in Yemen from 1979-80, Counsellor in Beijing from 1986-90, First Counsellor in Washington 1990-92 and Ambassador in Bolivia 1999-02.
- While working at the Foreign Ministry in Rome, Mr. Campo has been part of the team dealing with International Development Cooperation. From period 1992-93 he was appointed Head Officer of the Division for Cultural Relations. 2002 saw him being back in Rome where in close cooperation with the Director General of the Cooperation Division he is nowadays responsible for the Coordination of the Multilateral and Emergency Intervention of the Italian Foreign Ministry.

ALFREDO CIGADA

Dipartimento di Meccanic, Politecnico di Milano



- Mr. Cigada is a Mechanical Engineer with a PhD in Applied Mechanics obtained at Politecnico of Milano in 1994.
- After have been Assistant Professor and Associate Professor he became in the year 2002 full Professor in Mechanical and Temperature Measurments at Politecnico di Milano and in year 2003 also at University of Pavia.
- Mr. Cigada has written more then 70 papers related to topics ranging from Fluid Structure Interaction, Cable Vibrations, Image processing and Electro-mechanical Interaction.
- Further to his teaching commitments with Politecnico di Milano, Mr. Cigada is also memmber of the Administration Boad of the Politecnico, secretary of the national group ING-IND/12 Mechanical and Temperature measurements, head of the "Measurement and experimental techniques" group at the Department of Mechanics of Politecnico di Milano, director of the educational center of experiemental techniques, campus Bovisa, Staff member in the PhD school: "Mechanical systems engineering" at Politecnico di Milano, Staff member in the PhD school: "Metrology" at Politecnico di Torino.

KOMNINOS DIAMANTARAS

Scientific Officer New and Renewable Sources, EC Directorate General for Research, Bruxelles

- Mathematician as background and master in Public Administration, Dr. Diamantaras is project officer at DG RTD responsible for the sectors on ocean energy and energy related socio-economics. He is also member of the Task Forces related to the Energy Research Infrastructures, and to the Maritime policy.

- For a period of over 20 consecutive years he has been working as scientific or project officer at DG Energy (now DG TREN) and DG RTD. So far he has been evaluating over 2850 proposals and has negotiated and managed over 820 research or demonstration renewable energy projects including those on ocean energy.

- Since December 2002 he is working at J3 as project officer responsible at the beginning for bioenergy related projects, and since 2005 on ocean energy and socio-economic issues as well as ExCo member of the IEA Implementing Agreement for Ocean Energy Systems.

LUDOVICO FULCI

Vice President, Ponte di Archimede SpA

Messina, Italy

- Mr. Fulci graduated in 1958 in Law studies at the University of Rome. He then extended his studies in reknowned international Universities as Ecole de Droit in Paris, College of Europe in Bruges and the Harvard Law School in Cambridge Massachuset.

- For nearly 10 years, private secretary of the Italian Viceminister for Foreign Affairs and the Minister for Foreign Trade, Mr. Fulci gained a very broad international experience both in term of international relations and international trade.

- As from 19968 he has been working as member of the Italian Trade Commission in Budapest, Moscow, Brussels and Tokyo. In view of is extensive experience and expertise in 1992 he was then appointed Director of the Italian Trade office for the European Union in Brussels.

- Among other commitments, presently Mr. Fulci is special advisor to the Rettore of the Politecnico di Milano and Vice President of the Ponte di Archimede S.p.A.

GAETANO GIUNTA

President of Horcynus Orca Foundation and Ecos-Med research center; Member of european network of Cities and Regions on social economy - REVES.

- Mr. Giunta graduated from the University of University of Pisa and University of Messina with a PhD in theoretical physics in 1988

His areas of interest include:

- Studies on many body systems and complex systems through theoretical and computer simulation methods.
- Relationship among technologies, science, societies and ethics. Mathematical quantitative models of cultural growth in short and long term.
- Complex theories on social and economical systems. Integrated social project and social economy

His research activities involve:

- More than 30 research projects published on essays and main international reviews
- More than 90 national and international projects on social and cultural economy

DAN LIANG

Director

Industrial Promotion and Technology Branch

UNIDO, Vienna, Austria

- Graduated from Beijing University, obtained a Master of Public Administration degree from Harvard University in 1989.

- She has been Director-General of CICETE before joining UNIDO in Vienna, Austria in 2000, where she id Director of the Industrial Promotion and Technology Branch.

- As Branch Director she is responsible for, among other programmes, UNIDO's investment ansd technology promotion, trade facilitation programmes, operation and maintenance of global network of International and Technology Centres, including the recently established Investment and Promotion Agency network for Africa.

ELIO MATACENA

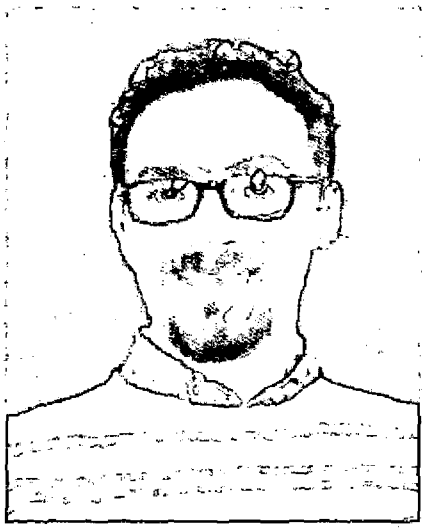
President, Ponte di Archimede SpA

Messina Italy

- President of Ponte Archimede S.P.A. Company, Elio Matacena actively championed technological innovation and technology exchange especially between Italy and China.
- Inventor of the Kobold turbine. Many international appreciations were collected by the innovative Kobold turbine which prototype is working since three years in the Messina Strait (Italy).
- The European Community financed a study of the Kobold turbine in the framework of the Joule II Program and a joint Sino-Italian research in the framework of the Synergy Program, for a study of an application of the Kobold turbine in the Zhoushan Archipelago (People's Republic of China).
- The Italian Ministry of Foreign Affairs has financed the UNIDO Project for the dissemination of the Kobold turbine in Indonesia, Philippines and People's Republic of China.
- Elio Matacena is also President of Caronte & Tourist Shipping Company, operating the ferry boats in Messina Strait and a shipping line between Salerno

MARCO MATTEINI

Expert on Renewable Energy, Energy and Cleaner Production Branch, UNIDO



- Marco holds a Bachelor degree and a PhD in Electrical Engineering, both obtained at the Department of Electrical Engineering, University of Bologna, Italy, where he also worked as research assistant before joining UNIDO.
- Since Fall 2002 he is part of the professional team of the Energy and Cleaner Production Branch of UNIDO where he is involved in the development and management of technical assistance projects in the areas of renewable energy technologies and energy efficiency especially in Small Island Developing States.

ALBERTO MOROSO

Project Manager

Ponte di Archimede SpA, Italy

- Naval architect and marine engineer, he obtained his degree at University of Napoli "Federico II".
- Co-inventor of the Kobold Turbine, since 1995 he is involved in studying, developing and designing marine current devices for Ponte di Archimede Co.
- As a ship designer he designed and built many ships of different sizes and typologies such as fishing vessels, passenger ships and tugs. He also performs marine steel structure calculations, as well as stability and mooring calculations.
- Alberto is also an official instructor of the shipbuilding and designing software from Autoship Corporation of Vancouver (Canada).

ROGELIO A. PANLASIGUI

Undersecretary for Research and Development

Department of Science & Technology, Philippines

- Dr. Panlasigui earned his bachelor's and master's degree in chemical engineering at the University of the Philippines - Diliman in 1963 and 1965. He attended IOWA State University in the US, as Ford Foundation Fellow. He pursued and earned his doctorate in 1970. His expertise is in the field of Chemical Engineering Analysis (specializing in process development, heat transfer, and mathematical methods) and R&D Management.
- Undersecretary Panlasigui had a long and varied career in the DOST system. He was the first Executive Director of the Philippine Council for Advanced Science and Technology Research and Development, a position he held from PCASTRD's founding in 1987 until 1992.
- From 1992 to 1999, he served as Director of the Industrial Technology Development Institute and as Officer-In-Charge from 1999 to 2000.
- As Undersecretary for R&D, he supervises all the research institutes under the Department of Science and Technology. He is also responsible for the Department's Grants-in-Aid (GIA) program. He chairs the National Committee on Biosafety of the Philippines (NCBP), which regulates planned release of genetically modified organisms (GMO) and potentially harmful and exotic species (PHES) into the environment. He is also the Philippine Chairman of the ASEAN-wide Committee on Science and Technology (COST), whose members meet regularly to discuss and resolve regional issues concerning Science and Technology.

ABEL J. J. RWENDEIRE

Managing Director

Technical Cooperation Division

UNIDO, Vienna, Austria

- Having obtained a Bachelor of Science and Doctor of Philosophy in Biochemistry, Mr. Rwendeire has a more than fifteen years experience as University academician both in Uganda and New Zealand where he taught and researched in Biochemistry at Makerere and Canterbury universities;
- From 1992 to 1996 as Polytechnic Principal in the Ministry of Education and Sports, Uganda he build up strong competencies as Educational technical Expert formulating and implementing medium/long term plans for Sustainable Development and adoption of appropriate technologies; Promoting Public-Private Partnerships.
- From 1996 till 2002 he was Minister of State for Industry and Trade as well as Member of the Uganda Parliament, building excellent credential as international negotiator and policy maker in the fields of Trade, Industry and Education;
- Presently Mr. Rwendeire is Managing Director for programme development and Technical Cooperation Division of UNIDO, Vienna, where is leading the Organizational programmatic initiatives in industrial promotion and technology diffusion, agro industries, small and medium enterprises, energy and cleaner production and multilateral environmental agreements.

RAUL SABULARSE

Deputy Executive Director

Department of Science and Technology, Philippines

- Graduated from the University of the Philippines - Diliman in 1978 with a Bachelor of Science degree in Metallurgical Engineering.
- Worked as Heat Treatment Engineer at the Metals Industry Research and Development Center (MIRDC) before joining the Philippine Council for Industry and Energy Research and Development (PCIERD) of the Department of Science and Technology (DOST) in 1983.
- Has more than 25 years of experience in Research and Development (R&D) management. As Deputy Executive Director, he is in charge of running the Council's activities on programs/projects development, evaluation, monitoring, information dissemination, promotion and technology transfer in the areas of industry and energy research.

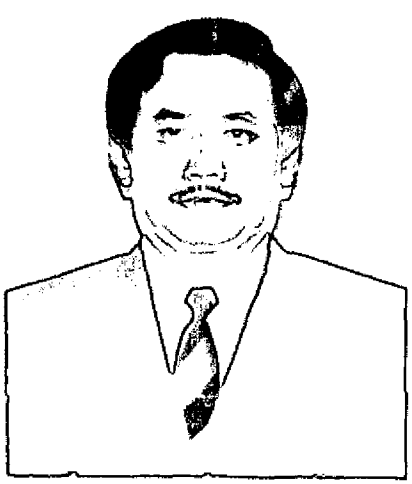
FRANCESCO SALVATORE

Propulsion and Cavitation Departmen

INSEAN Italian Ship Model Basin, Rome

- Francesco Salvatore has a background as an aeronautical engineer, with a PhD in Aerospace Engineering at the University of Rome, 'La Sapienza,' in 1996.
- From 1996 to 1998 he was research assistant at the University of Rome, 'Roma Tre,' working on theoretical modelling of aircraft and helicopter rotor aerodynamics.
- In 1998 he joined INSEAN, the Italian Ship Model Basin, where he is currently a research scientist and project manager in the Propulsion and Cavitation Department.
- His research activity is essentially dedicated to theoretical modelling of marine propeller hydrodynamics and hydroacoustics. In particular, propeller cavitation and cavitation-induced noise are addressed. A relevant part of his work is related to the development of computational tools for the automated design of marine propulsors and other rotorcraft systems. He is involved in both national and international research projects on marine propulsion.
- Since 2001, he is member of the Propulsion Committee of the International Towing Tank Conference (ITTC).

ANDI EKA SAKYA



Assistant to the Deputy for Priority and Strategy

Ministry of Research & Technology

Jakarta Indonesia

- Andi Eka Sakya was born in Solo, September 4, 1957. He finished his undergraduate at the Department of Physics, Bandung Institute of Technology.
- He got his Master and Doctor degree in Aeronautical Engineering from Nagoya University of Japan, in 1991 and 1994 respectively.
- He was a researcher in the Aero Gasdynamics and Vibration Laboratory, the Agency for the Assessment and Application of Technology since 1983 before he joined the State Ministry of Research and Technology of Indonesia in 2001.
- At present, he is assigned as the Assistant to the Deputy for Priority and Strategic Research Program.
- Related to his duty, he has established so-called Center for Management of Innovation and Technology

BRUNO SBORDONE

Government Administrator of Municipality

Messina Italy

- Commissario Bruno Sbordone was born in Napoli in 1938. He has been Vice-Commissario for the local Government of the Friuli - Venezia Giulia *Region. Among other public assignments he man*aged the Municipalities of San Vito al Tagliamento (1979), Zoppola (1989), Olbia Costa Smeralda (1997), Anzio (1998), Velletri (1999), Nuoro (1999), Imperia (2001) e Oristano (2001).
- Further to this he was nominated as Commissario Straordinario for the provisory management of the Taranto province (1992), and also Commissario *Governativo for the Establishment of the new* province and Chamber of Commerce, Industry and Handcraft of Rimini (from 1992 to May 1995).
- He was personally involved in the Commission dealing with the examination and reso*lution of the problems and issues related to law 142/90, and of the Commission for the* Reform of the Italian Civil Administration.

BAMBANG SUTJIATMO,

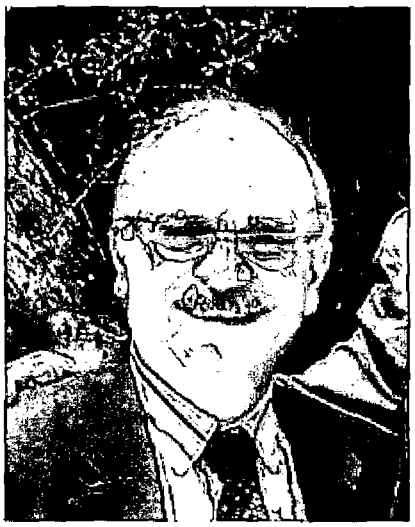
Minister

Ministry of Research & Technology

Jakarta Indonesia

- Professor Sutjiatmo was born in Solo, December 6, 1946.
- After graduated from Bandung Institute of Technology in 1972, he became a lecture in the Department of Mechanical Engineer at the same Institute.
- He got his Doctor Degree in 1989.
- He has published books especially in Linear Vibration, Strength of Material and Foundation of *Control System.*
- Before joining the State Ministry of Research and Technology in 2003, he was the Rector of State Open University from 1996 to 2001.
- Currently, he is the Secretary of the State Ministry of Research and Technology.

EMILIO VENTO



Senior Industrial Development Officer,
Investment and Technology Promotion Branch
UNIDO, Vienna, Austria

- o Mechanical Engineer with a more then 30 years of international experience in project management, turn key technology transfer and international joint ventures, he has been working in Africa, Middle East and Central America;
- o As from 1993 to 2003 he has been the operational coordinator of the activities of one of the most challenging capacity building programme in UNIDO, the International Center for Science and High Technology, Trieste, with management and operational responsibilities in relation to international networking and developing countries needs assessment;
- o Presently, Senior Industrial Development Officer at the Investment and Technology Promotion Branch he is responsible of the promotional and institutional capacity building initiatives related to innovation, technology diffusion and technology roadmapping as well as coordinator of the Technology Parks and Technology Centers programme.

FRANCESCO TOMASELLO

Rettore, Messina University

- o Prof. Tomasello graduated in Medicine and Surgeryugy in 1970 from the Universirty of Messina specialising in in neosurgery.
- o After obtaining his undergraduate he became an "Ordinary Assistant" in neosurgery at the University of Naples, during which time he was exposed to international experiences in Rochester, Minnesota, USA and London Ontario, Canada.
- o Prof. Tomasello was apppointed Associate Professor at the University of Messina in 1983, after which he became Full Professor in 1986 with the responsibility to lead the School of Specialization in Neurosurgery.
- o In 1993 he was appointed Dean of the faculty of Medicine and Surgery, Messina. In 2004 he was then nominated Rector of the University of Messina.
- o In addition to the above Prof. Tomasello was involved in a large number of research-projects ranging from the treatment of cranial trauma to genetic therapy of glioblastoma.

Prof. Tomasello has also been a member of the following Associations:

- o Research Committee dell'European Association of Neurosurgical Societies (EANS)
- o Steering Committee of Società Italiana di Neurochirurgia
- o Member of the EANS Training Committee
- o Tresurer of Società Italiana di Neurochirurgia
- o Vice-President of EANS
- o As from 2003 he was nominated as an expert of the Consiglio Superiore di Sanità, Italian Health Ministry.

ZHI YU

Sun Yat University

Guangzhou, People Republic of China

o Mr. Zhi, Bachelor of Engineering in Flight Mechanica and Astronautic with master in Flight echanics, is presently Professor of School of Engineering, at Sun Yat-sen University (SYU) with the responsibility as Chief Expert of Sustainable Energy Expert Group of the National Hi-Tech Program.

o After nearly 10 years of work as reseracher and associate reserch professor at Guangzhou Institute of Energy Conversion (GIEC), Mr. Zhi become Chief Professor and Head of Ocean Energy Division of the same institute, assignment that he kept till year 2000, with broad involvement in all issues related to renewable energy among which also wave and marine current energy.

o The specialised areas of competence of Mr. Zhi are renewable energy and intelligent transportation system. Further to this he has been liaising with renowned internation institutions and university as visiting researcher or guest professor in Japan, Norway and Portugal.

STEFANO ZIRILLI

Consultant for International Cooperation

o Was born in Rome on the 1st of April 1949, awarded his master Degree in High Energy Physics in 1974. After military service as Official of anti-aircraft artillery and teaching of Physics, he performed R&D and management activities on behalf of ENEA in different fields, such as X-ray Diffraction, Irradiation Technologies, Structural Dynamics and Reliability.

o In 1990 he was the Scientific Advisor of Ministry of Foreign Affairs for energy and in 1993 for S&T bilateral and multilateral cooperation and Antarctic's Treaty. He was member of the following joint governmental commission committees for S&T cooperation: (1992) Argentina (S&T and Antarctic's Treaty), Belgium, France, South Korea, Holland Quebec Romania Russia (Antarctic's treaty), Spain, (1993) China, Pakistan, USA, (1994) RUSSIA, ROMANIA and (1995) POLAND, USA, CHINA.

o From 1995 to 2003 was responsible of the S&T Office of the Italian Embassy in Beijing, competent also for Mongolia and North Korea.

o Other relevant activities were: Referee of the Journal of Applied Crystallography, Representative of ENEA in Euredata Association, Adviser for the evaluation on S&T bilateral and multilateral cooperation and Antarctic's treaty of ENEA,. Member of Matacena Foundation Board.

o The Chinese Government conferred to him the Friendship Award 2004.

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