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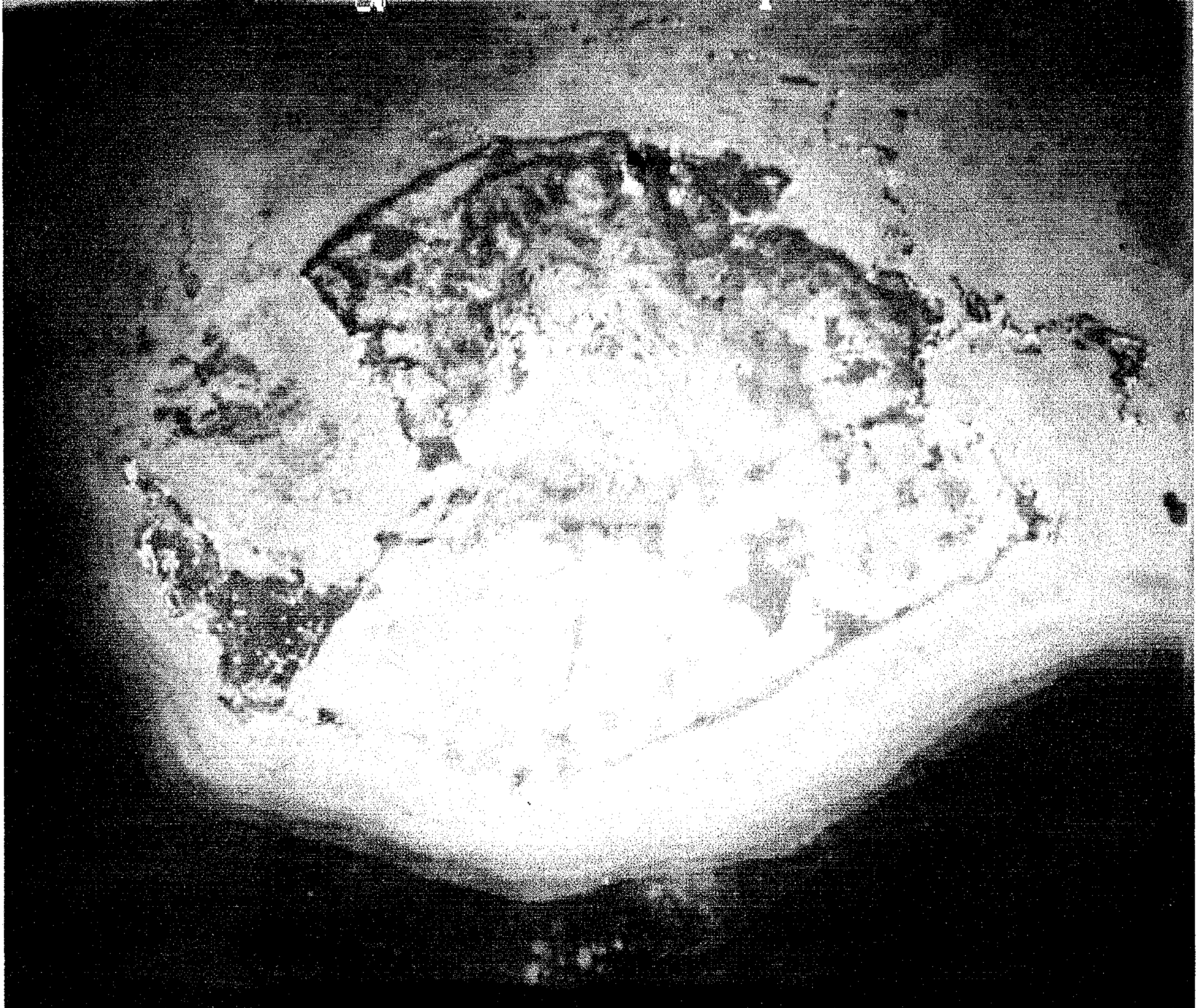
Integrated Programme to Support the National Strategy on Industrial Competitiveness in Cuba



ISLA de la JUVENTUD

Verbundplan
DIPL-HTL-ING.
REINHARD ENZENEBNER

UNIDO-CONTRACT P.2000/220-12.10.2000

Integrated Programme to Support the National Strategy on Industrial Competitiveness in Cuba

ISLA DE LA JUVENTUD

Agenda:

0. PREFACE

The study accomplished in the Island of Youth demonstrate the real possibility of increasing significantly the participation of renewable energies in its energy supply in the wake of the utilization of different alternative sources of energy.

Biomass Plant
Wind-Craft-Plant
Small Hydro Power Plant
for generation of electrical energy

Use of Electro-cars to reduce the import of fuel

should give a big impuls for the economy and independence of Cuba`s biggest island .

To achieve these purposes is necessary to strengthen the institutional capacity of the island for the development and administration of renewable sources of energy, the creation of companies specialized in this field and the improvement public awareness about the role of renewable energies in the framework of the sustainable development.

The financing of this project will require international collaboration, because, not in all cases the applications of the renewable technologies are economically advantageous in comparison with the conventional, for this reason the implementation of this project means economic sacrifices for the environment that these small countries are not in conditions of accomplishing.

The **Program for Electricity at Isla de la Juventud** is executed as part of the energy development of the main island Cuba. It includes an **Energy Education Program** directed to the **population of the territory** , to the **business sector** and to the **Territorial Science** and Technology Program for the Improvement of the Energy Efficiency.

We like to express all our special thanks for the support during the fact finding mission at Isla de la Juventud and provision for all collected datas to

- Dr. A. Curbelo Alosno , Dr. B.Garea Moreda (ACYT)
- Leonardo Cruz Cabrera (Ministry of Science, Technology and Environmet-Island of Youth, Cuba)
- Jorge (Direction of Planning – Island of Youth, Cuba)

1. SUMMARY

1.1 Resumen en espanol:

Una de las metas en la Resolución de KYOTO es la de estabilizar la concentración de gases que generan el efecto invernadero (GHG) en niveles que prevengan que el clima global cause una peligrosa interferencia antropológica. Esta estabilización solamente puede ser alcanzada mediante un incremento dramático de la utilización de tecnologías de energía renovable RETs

Bajo estas premisas fueron analizados cuidadosamente los diferentes tipos de energía alternativa que pueden ser utilizados como fuentes de suministro en este territorio, con el fin de disminuir la actual demanda de combustibles. Asimismo, se han realizado propuestas ambientales y económicas para la instalación de fuentes de energía alternativa, las cuales se resumen al final de este capítulo.

- **Generación con Biodiesel**

Existe actualmente tecnología probada para la utilización de aceites vegetales en los motores Diesel.

Para el caso de la Isla de la Juventud, se requiere investigar la posibilidad de apropiar la tecnología para la producción de aceites a base de las plantas disponibles. Entre las cuales se destaca la Harroba julca, cuyas características la hacen ideal para este tipo de propósitos, con el fin de utilizar dichos aceites en el transporte.

- **Plantas a base de biogas.**

Usando los excrementos de las granjas porcícolas (la mayor de ellas posee actualmente 8000 cerdos), una planta a base de biogas puede generar energía eléctrica y energía térmica en la isla.

La mayor cantidad de Biogas dentro del territorio, es producida por los excrementos de los cerdos. En la isla existen nueve granjas con una capacidad de albergar entre 500 y 12000 animales, con un potencial de producir hasta 900.000 m³ de biogas.

Los costos de inversión para una planta de 100 kW a base de biogas, dependen en buena medida del valor de la obra civil, pero se pueden estimar en US$ 450.000 bajo las condiciones económicas actuales en Europa. Se presume que bajo las condiciones vigentes en Cuba, la inversión para dicha planta sea menor a US$ 250.000

Usando la tecnología del biogas se puede generar fácilmente energía eléctrica en la isla. Una de las localizaciones más útiles podría ser en la cercanía de una de las granjas porcícolas.

Adicionalmente, una planta a base de biogas puede operar conjuntamente con una instalación eólica en la costa sur de la isla, cerca de la localidad de Cocodrilo, la cual se encuentra fuera del alcance de la red de suministro de energía. En esa misma zona se ha previsto el mejoramiento de la infraestructura turística por el gobierno local, en cuyo caso, aparte de la energía eléctrica generada tambien puede ser usada la energía térmica resultante.

❖ **Plantas a base de biomasa**

En este territorio existe una producción anual cercana a los 102,000 m³ de biomasa, que puede ser usada para la generación de energía eléctrica y térmica. Una planta eficiente con un tamaño de 4 MW requiere una inversión de aproximadamente 10 Mio US$.
Mediante dicha inversión se puede ahorrar anualmente una cantidad aproximada de 9 Mio lt de combustible.

❖ **Celdas de Combustible**

Una celda de combustible (FC) consiste de una tecnología que convierte energía química en eléctrica, sin requerir de piezas móviles. De manera similar a las baterías, las celdas de combustible se fundamentan en los principios de la electroquímica.

Estas celdas pueden trabajar tanto aisladamente como en paralelo con la red de energía. Ellas pueden ser usadas para producir electricidad solamente o para producir simultáneamente calor y electricidad. Usualmente generan energía cerca del consumidor final, en lo que se denomina una generación dispersa.

Para la generación de energía se han desarrollaado tamaños hasta de 10 MW, en el tipo CHP-FCs han sido desarrolladas en módulos de 2 Mwel.

Los costos actuales de las celdas de combustible siguen siendo aún muy altos (actualmente unos 3000 US$/kW mas US$ 500 como costos de instalación; sin embargo se espera que los costos caigan a aproximadamente US$ 1500/kW en los próximos 5 años. Otras fuentes estiman que los costos serán inferiores a US800/kW para el año 2005.

Para el caso de las celdas PEFCs (las cuales son desarrolladas específicamente para la industria automotriz) se espera alcanzar un costo objetivo de US$ 60/kW para la próxima década

El mayor mercado se prevé en las unidades de generación entre 3 kW y 50 MWel

Debido a su tecnología tan reciente y a la menor experiencia que existe a este respecto, recomendamos probar durante un mínimo de dos años uno o dos tipos diferentes de vehículos experimentales en la isla, que tengan celdas de combustible como generador de energía. En consecuencia, sería conveniente efectuar un acuerdo con algunos grandes productores de vehículos, para que patrocinen este experimento

Otro mercado para las celdas del combustible es la combinación con un sistema del almacenamiento de hidrógeno en una tecnología sin despacho de la generación de energía, como por ejemplo combinada con una planta eólica, en la cual, en períodos de fuertes corrientes de viento, la energía eléctrica se puede almacenar en forma química convirtiendo el agua en hidrógeno por medio de electrólisis. El hidrógeno así producido se puede almacenar en tanques. Durante las horas de máximas demanda, la energía química se puede convertir de nuevo en electricidad utilizando las celdas de combustible.

❖ **Plantas de energía solar (Fotovoltaica y caor solar)**

Fotovoltaica

Las plantas de energía solar se basan en el fenómeno mediante el cual, un voltaje eléctrico es inducido por la luz que ilumina una celda solar hecha a base de material semiconductor. Este efecto se amplifica cuando una capa de silicio, dopada con elementos del quinto grupo como el arsénico, se encuentra en contacto con una capa tambien de silicio, elaborada a base de elementos del tercer grupo como el boro.

Los sistemas fotovoltáicos operan como unidades generalmente aisladas, contando solamente con el soporte de un motor Diesel, aunque a veces operan conectadas a la red. Requieren asimismo de un acondicionador de energía (operando como unidad de control), una batería de almacenamiento y un convertidos DC/AC.

Con el fin de reducir la importación de la energía primaria (combustible), la instalación de esta tecnología en las plantas industriales podría dar una respuesta satisfactoria a la resolución de Kyoto. La energía generada de esta manera se puede utilizar para reducir el consumo en las industrias, como también para apoyar la red de distribución.

Calor solar

La radiación solar se puede convertir en calor mediante elementos absorbentes embebidos en las paredes de una casa o en el techo.

En las grandes plantas de energía solar, el sol es concentrado mediante espejos altamente reflexivos que siguen la posición del sol, alcanzando temperaturas entre 400 °C y 800°C en el líquido de trabajo que opera en el receptor. La energía así recolectada se utiliza en una turbina de vapor, turbina de gas o en un motor Stirling, para producir electricidad, alcanzando eficiencias de hasta 30 %

Un alto potencial está disponible para las plantas de energía solar en países con los cielos claros, como en el mediterráneo o el Caribe.

Los altos costos de instalación hacen que no exista un gran interés en las plantas de energía solar del tipo fotovoltaico, y hasta ahora han sido poco apoyadas por los gobiernos.

Contrariamente, un gran interés se ha manifestado en el desarrollo de instalaciones para calentamiento de agua a nivel residencial. En ese caso, los costos no son tan altos y su vida económica así como su eficiencia se han incrementado bastante, razón por la cual se puede recomendar su aplicación a nivel residencial en la isla, sustituyendo así energía que de otra forma sería tomada de la red.

❖ **Energía eólica.**

La tecnología relacionada con la energía eólica ha visto un desarrollo rápido en años recientes. La energía eólica aumenta con la tercera potencia de la velocidad del viento, de esta manera, la capacidad máxima del generador se alcanza a una velocidad del viento de 10 a 14 m/s.

De las cuatro estaciones meteorológicas instaladas en la isla, encontramos que la zona donde la velocidad del viento es más apropiada para la generación de la energía se localiza a lo largo de la costa este y sur de la isla.

Tal como se mencionó anteriormente, una planta de biogas o una celda de combustible combinada con una instalación eólica son soluciones recomendables para abastecer de energía la costa sur de la isla, ayudando asi a disminuir la importación de combustibles.

El tamaño económico para este tipo de instalaciones a ser introducidas en la isla es de 3,3 MW; de esta manera estimamos que su costo asciende a unos US$3,0 Mio.

Dependiendo de los costos de operación, el valor esperado de la energía puede alcanzar 0,136 a 0,145 US$/kWh

La energía así generada debe ser suministrada a la red, con el fin de reducir la energía actualmente producida mediante las plantas Diesel en Nueva Gerona.

Mediante la instalación de la planta mencionada, se puede evitar el consumo de 889.600 lt de combustible importado.

❖ **Pequeñas plantas hidroeléctricas**

Las presas de la isla poseen cargas hidráulicas pequeñas, con grandes vertimientos en los períodos lluviosos. Ocurren casos en que los vertimientos se dan de un embalse al otro, pudiéndose aprovechar el agua de manera repetida para la generación de energía

Desde el punto de vista técnico, se estableció que en todas las presas hay condiciones para la instalación de plantas eléctricas hidráulicas micro sin requerirse de grandes inversiones . Se verificó incluso la posibilidad de instalación de turbinas tipo Matrix en el rango de 20 a 60 MW; sin embargo, circunstancias económicas no dan la posibilidad para instalar una planta hidráulica para la generación de energía.

❖ Estructura de proyecto durante la fase de ejecución

Ver el ejemplo correspondiente aun proyecto para la planeación de una central térmica, en el resumen en Inglés.

1.2 Summary in english:

To stabilize atmospheric Greenhouse Gas (GHG) concentration at levels that would prevent dangerous anthropologic interference with global climate is one of the goals in the KYOTO-resolution.
Serious anthropologic interference with the global climate can only be achieved through dramatically increased utilization of **Renewable Energy Technologies** (RETs).
Based to this preconditions all existing kind of alternative energy sources at the "Isla de la Juventud" were investigated carefully to find out economical solutions for energy supply at this territory with the aim of substitution the actual used fuel demand. Ecological and economical proposals and recommendations for installation of alternative energy sources are summarized within this chapter.

- **Bio-Diesel Generation**
  For the decision to install an efficient technology further investigations at the island are required.

- **Biogas Plant**
  Using the liquid manure from the pig-farms (the biggest one has 8000 pigs) together with agriculture goods produced at the island at biogas-plant can generate electrical energy together with calorific energy.
  The biggest amount of biogas at the territory is produced mainly from pig excretes.
  At the island exists nine farms with a capacity from 500 ... 12.000 pigs with an annual production potential of biogas from 900.000m³.

  Investment costs for a **100kW-Biogas Plant** are depending on civil works and will be compared to European wage rate approx. **450.000 US$** .

  Compared to Cuban conditions **total investment costs** are expected less then **250.000 US$.**

  Using the biogas technology electrical power can be produced easily at the island.
  One of the **useful location** for this plant could be **closed to one of the nine pig farms**.

  Furthermore that **Biogas Plant** could be operated **in cooperation with Wind Craft Plant** closed to the South coast of the island were the village **Cocodrillo** is out of energy supply. In the same area the improvement of tourist infrastructure is foreseen by the local government, where the produced electric energy and the thermal energy can be used , too.

- **Biomass Plant**
  Based on the available ressources at the territory annual approx. 102.300m³ of biomass is usable to generate electrical energy and calorific energy with a biomass plant.
  The efficient **plant size of 4 MW** needs investment cost of approx. **10 Mio US$.**
  By installation of this plant approx. 9 Mio l of fuel can be saved annually.

- **Fuel Cells**
  A fuel cell (FC) is a technology which converts chemical energy to electric energy without moving parts. Like batteries, fuel cells are based on the principles of electrochemistry.
  Fuel cells can operate stand alone or connected to the electricity grid. They are used to produce power only or to produce combined heat and power. Usually they will generate energy near to the final consumer in dispersed production.
  FC`s generating electricity only are developed in sizes up to 10 MW,
  CHP-FCs in sizes up to 2 MW_{el}.

  Present component costs of fuel cells are very high; (actual at 3000 $/kW equipment costs plus 500 $/kW installation costs- goal for the total costs is to drop to 1500 $/kW within the next 5 years.)
  Other sources estimate investment cost of less than 800 $/kW by 2005.

  For **PEFCs** (which are developed specifically for the automobile industry) a **cost target of 60 US$/kW is expected** to be achieved within the next decade .
  The main market for **FCs** is seen in dispersed **generation with units of 3 kW to 50 MW_{el}.**

  Due to very new technology and less experience we recommend to try for minimum of two years **one or two different types of testcars** at the island with fuel cells as drive-engine. Therefore special agreements with big car production -concerns should be brought out by the investors.
  Another market for fuel cells is the combination with a hydrogen storage system and a non dispatchable power generation technology as, e.g., a wind power plant.
  In periods of high wind supply and thus high power generation capacity, electric energy can be stored in form of chemical energy by converting water to hydrogen by means of electrolysis. The produced hydrogen can be stored in tanks. In peak demand hours, the chemical energy can be converted back to electricity by fuel cells.

- **Solar Craft Plant (Photovoltaics , Solar heat)**
  Photovoltaics is based on the phenomenon that an electrical voltage is induced by light shining on a semiconductor solar cell. This effect is amplified when a silicon layer doped with elements from the 5th main group like arsenic (n-layer) and a silicon layer doped with elements from the 3rd main group like boron (p-layer) are contacted .

  PV systems operate stand alone, frequently with a diesel engine as back-up facility or grid connected. Further elements of the system is a power conditioner (a control unit), a storage battery and a DC/AC converter .

  To reduce the import of primary energy (fuel) the installation of this technology at industrial plants could give a satisfactory answer to the Kyoto resolution. The generated power can be used to reduce the houseload consumption at the enterprise but also to support the grid.

Solar heat
Solar radiation can be converted to heat by absorbers embedded in a house wall or a solar collector.

In solar power plants large, highly reflective sun tracking mirrors concentrate sunlight to achieve temperatures of 400 to 800 °C in the working fluid of a receiver; the adsorbed energy is used in a steam turbine, gas turbine or Stirling engine cycle to produce electricity at efficiencies of up to 30 %

A high technical potential is available for solar power plants in countries with clear skies, like in the Mediterranean or Carribeanean.

There is a little chance to apply the **Photovoltaik solar energy** due to high installation costs and less promotion by the government.

Therefore the greater interest focuses on the development of the **thermal solar energy in** different building sizes for heating of the boilers at households.
The installation costs are not too high, the efficiency and economic life time are increased, wherefore this technology can be used for nearly all households at the island.
Using this system the actual used primary energy (fuel) can be substituted effectively.

- **Wind Craft Plant**
  Wind Power Technology (WPT) has seen a rapid development in recent years.
  Wind energy increases with the third power of wind velocity. Maximum generator capacity is achieved at a wind speed of 10 to 14 m/s.
  From the four meteorological stations at the island we found out that the zone of greater magnitude of wind speed for power generation is located all along the East and South cost.
  As above mentioned a Wind Craft Plant combined with a Biogas Plant or a Fuel Cell is recommended to energize the South coast area with electrical power . The aim to reduce the import of primary energy (fuel) can be achieved by installation this technology, effectively.

  The economical plant size for installation a Wind Craft Plant at the Isla de la Juventud is **3,3 MW** , wherefore we estimate installation-costs of **3,0 Mio US$** .
  Pending on annual operation costs the generation costs for the electrical energy can be expected between **0,136...0,1435 US$/kWh**. The investigation for WPT is based on a connection to the grid to supply the excess energy to other consumers and to reduce the operation hours from the Diesel Plant in Nueva Gerona.

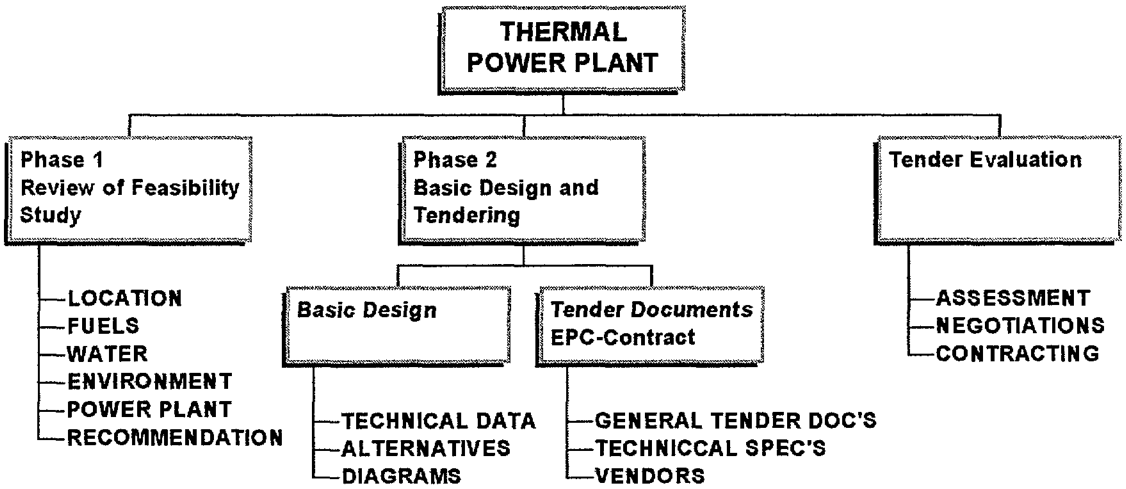
  By installation of one Wind Craft Plant an annual amount of 889.600l fuel can be saved from the imported primary energy.

❖ **Small Hydro Power Plant**

The dams of the island are of small hydraulic charges, with large spilling in rainy periods. There are cases in which the dams spill one to the other and the water can be used for power generation several times.
It was established that in all the dams there are conditions for the installation of micro hydro electric plants without large investments.

Different possible locations for the installation of a small hydro power plants with Matrix-Turbines were investigated around the Island of Youth (facilities is in the range of 20 to 60 kW, total power capacity : 250kW).
Economical circumstances do not give the possibility to install a small hydro power plant at the island.

❖ **Work Structure for Project Design Breakdown**
Example for a Thermal Power Plant Project



Phase 1 Preparation of a bankable Feasibility Study

Review of existing studies
- Visit of the mining area
- Data collection
- Review of existing studies and data material
- Evaluation of studies and data

Geology, Hydrogeology, Engineering Geology
- Description of Geology (only a summary of the existing data)
  Deposit Exploration

  - Regional and deposit geology (structure, tectonics, stratigraphy)
  - Description of coal seam and quality parameters
  - Description of waste properties
- Preparation of a geological model
- Mass calculations based on the geological model
  - Calculation of geological and industrial reserves
  - Determination of technical boundaries
  - Calculation of mineable reserves in open pit operation
  - Stripping volume and ratios
- Hydrogeology
  - Hydrogeological investigations
  - Ground and surface water, precipitation
  - Recommendations for dewatering
- Engineering geology

Mine planning
- Design criteria and basic parameters
  - Open pit coal field boundaries and reserves
  - Conditions of coal seam occurrence
  - Physical and chemical rock properties
  - Hydrogeological conditions, soil mechanics
  - Recommendations on pit slope stability
- Calculation of yearwise coal demand and output
- Mining technology
  - Possible open pit mining technologies
  - Combined open pit mining technologies
  - Selection of best alternative
- Evaluation of various alternatives for pit opening-ups
- Mining operation planning
  - Variants of mining development
  - Calculation of yearwise waste haulage
  - Outside and inside dump development
  - Mine dewatering
  - Investigations of need of drilling and blasting equipment and consumption planning
- Comparison of alternatives and selection of best alternative
- Investigation of the preferential alternative
- Possibilities of post mining utilization

Mechanical and electrical engineering
- Main equipment planning
  - Operation time
  - Selection and dimensioning of main equipment in variants
    - (excavation, transportation, dumping)
    - (type and number of equipment)
  - Investigations of need of washing plant

- Auxiliary equipment planning
  - Dozer, wheel loader, small hydraulic excavators, cars a.s.o.
  - Road maintenance equipment (grader, water trucks a.s.o.)
  - Repair-, replacement- and maintenance equipment
- Energy supply and distribution systems

Infrastructure and support facilities
- Infrastructure
- Transportation (road- and railroad connections)
- Pit facilities
  - Mine office
  - Warehouse and workshops
  - Petrol station / fuel and lube storage
  - Erection yards
- Social facilities / resettlements

Personnel and manpower development
- Structural and manpower Schedule
- Operational regime
- Manpower requirement
- Manpower categories

Environmental
- General situation, initial conditions
- Air quality, noise pollution, water conditions
- Land and soil
- Demography

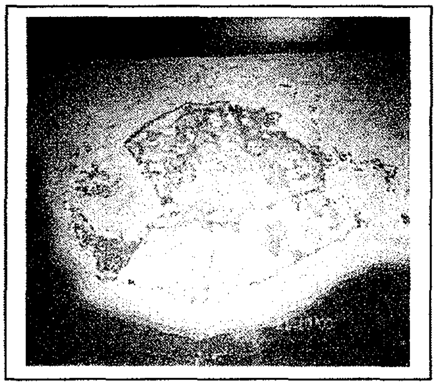
Financial analysis and investment appraisal
- Technical and technological bases
- Preparation of quantity structure of costs
- Cost calculations
  - Calculation methods
  - Investment costs
  - Personnel costs, working time
  - Other operating costs
  - IRR, NPV, average cost per unit
- Cash flow analysis
  - Principles of cash flow analysis
  - Elements of cash flow analysis
  - Coal sales price
- Sensitivity analysis

Project risks
- Geological, operating, marketing, environmental, political and tax risks

Phase 2 Preparation and evaluation of tender design specifications

- Preparation of tender design specifications for Russia
- Preparation of international tender design specifications
- Evaluation of bids

2. INTRODUCTION



Short description of the investigated Island :
Isla de la Juventud (spain) / **Isle of Youth** (english) is located south of Cuba, in the Caribbean Sea. It is bounded on the northwest by the Canal de los Indios and on the north and northeast by the Gulf of Batabanó, which separate it from the mainland of Cuba.
A 1904 treaty recognizing Cuba`s sovereignity over the island was finally ratified by the United States in 1925. The island`s present name was designated in 1978. With an area of 850 square miles (2.200m²), it is the largest member of the Canarreos Archipelago. The northern part of the island is an undulting area of pine forests and savannas, of sandy and rocky soils, with a few low mountains up to 944 feet (303m) elevation.
The main activities are fishing and truck and citrus farming; grapefruit production predominates and is the basis for the economy of the island. The National Reformatory, a prison, is located a few miles from the island`s capital isolated, inhabited only by a few fishermen and charcoal makers. Kaolin and marble are extracted on the island.

Reason for the study:
Currently **96% of the energy services** of the island are provided by means **of conventional sources**. **All the needed primary energy sources** (fuel, gas, diesel) **are to** be **transported from main island Cuba.**
The primary energy at this island is mainly used at

- the electricity generation plants,
- the transport and
- the industrial sectors.

The power produced by using diesel generator-sets. That guarantee the electrical service to 99% of the population.
The **electrical power** is produced by using diesel generating sets (5 old and 3 new) which ensures the electrical service to 99% of the population for this island.

The **United Nations Framework Convention on Climate Change** (UNFCCC) seeks to stabilize atmospheric **Greenhouse Gas** (GHG) concentrations at levels that would prevent dangerous anthropogenic interference with global climate. Serious anthropogenic interference with the climate system can only be achieved through dramatically increased utilization of **renewable energy technologies** (RETs).
The Operation Strategy of GEF puts initial emphasis on three Operation Programs . One of this three Operational Programs, seeks to **reduce GHG emission** associated with energy consumption and production through increased use of already commercially-viable RETs/xli/

In order to **increase the contribution of the renewable sources of energy** in the energy balance of the island, UNIDO ordered an energy study to find out the most effective use of alternative energy sources for this island.
The United Nations for Industrial Development Organization (UNIDO), the Agency of Science and Technology of the Ministry of Science, Technology and Environment (ACYT), together with the Delegation of this ministry in the territory (its local representatives) and the local energy authorithies , had prepared an evaluation of all available ressources at the territory which are taken into our considerations for this energy study, too.

The principal measures identified to reduce the GHG-concentration could be :

- to substitute the **fuel oil** which is used for energy generation by installation of forestry **biomass power plants** by implementation of biomass gasification.
- to substitute the **diesel oil** used to operate ovens and boilers with **biogas** produced from pig excretes
- to substitute **diesel oil** for the public traffic by using **vegetable oil**.

Other alternative energy sources like hidroenergy, wind power , photovoltaik , solar cells and fuel cells will be investigated within this study , too. Due to their less amount compared to the a.m. 3 other renewable energy sources their importance is very low for the Island of Youth..

The **aim of this study** will be to find out **economical solutions to substitute the imported primary energy sources by using alternative sources**, which are either available at the island or suitable to be installed at this territory .

Determining serious solutions for alternative energy generation plants the financial expense to Cuba due to supply the primary energy to the island could be reduced seriously.

3. CHARACTERIZATION of the ISLAND

3.1 Physical-/geographical characterization and use of the land
The "ISLA de la JUVENTUD" is the second island in extension of the Cuban archipelago formed by more the 2000 islands and keys. It is a part of the archipelago of the Canarreos and it is separated from Cuba by the Gulf of Batabano it is located at a distance of 72 km to the south. The island has a territorial extension of 2204 km². The north region has conditions for the agricultural development. The south region includes the "Marsh of Lanier", a zone with abundant natural vegetation that is considered of high biodiversity values. The relief is more or less flat, covers an area of 2009 km² (91,5% of the total area of the territory). The highest elevations reaches 310 m.

The climate is tropical wet, the mean annual temperature of 25,7° C, the maximum of 29,7° C and the minimal temperature of 21,4° C. The annual mean rainfall is of 1467 mm and the mean relative dampness is 80 %.

The agricultural surface comprises an area that represents 30,6% of the total, from which 77% are natural grass.
53% of the islands area are used for the forest activity and 5,6% of its area is covered by water.(/xl/

3.2 Population
The principal characteristic of the population of the „Isla de la Juventud" is its youth since its average is 31,8 years. The number of inhabitants is 85.012 with an annual growth rate of 1,6%.
The densitiy of resident population is 37,7 inhabitants / km², in the north region it is 61,2 inhabitants / km².
The system of urban settlements is conformed by the city of Nueva Gerona with 44.979 inhabitants., Santa Fé with 15.643 inhabitants and the Demajagua with 3250 inhabitants .
The population living in rural zones is 8% residing in 13 settlements of 200 or more inhabitants and 29 minor 200 inhabitants. The average number of persons that compose the familiar collective is made up 3,83 people. /xl/

3.3 Education
In the territory exist subsidiaries from high education institutions of Havanna City: the Higher Pedagogical Institute , the Agricultural University and the Faculty of Medical Sciences. The level of scholarship is the 9th grade. /xl/

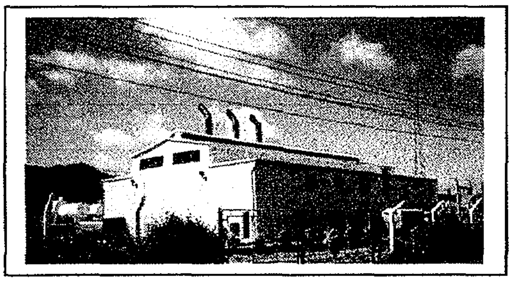
3.4 Culturel and economical connection with Island CUBA
The connection with the rest of the country is fundamentally by the maritime route operated by the Cuban Caribbean Shipping Company .

The air-route is operated by the Cuban Aviation Company, Aerotaxis and Aerocaribbe Airlines. /xl/

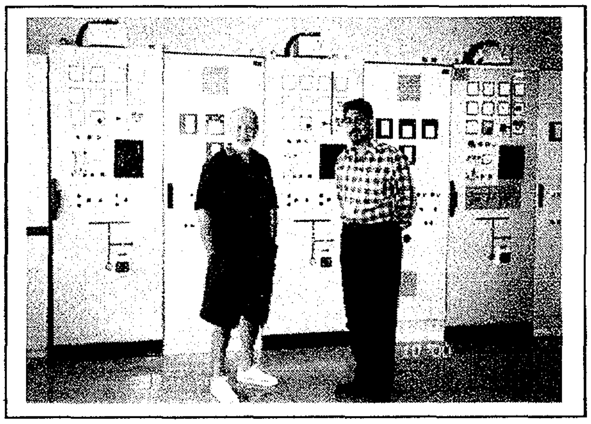
3.5 Economical Situation

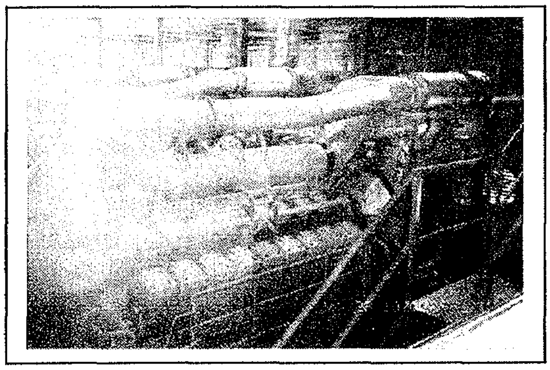
The main economical activities are fishing, agriculture (citrus and peak-production) and the ceramics industry.
The tourism is stepping up, there exist natural sources that can give place to the development of economic activities.
As mineral resources there are kaolin, marble, sand . /xl/

3.6 Energy Situation (Electric, Traffic, etc.)



Electricity is the main carrier in the island. The power generation consumes 54% of the total primary energy.





2 Diesel generator plants (partly being modernized now) produce the electrical power. For generating of **1300kWh** electrical energy approx. **361 t fuel** is needed.

Today 99% of the population has access to electrical services. . /xl/

Only the village **Cocodrilo** do not have connection to the local grid. 2 Dieselgenerator sets (each 370.kW) supply the population of the village Cocodrilo several hours a day with electrical energy.

The **total primary energy consumption** is divided as follows:

Import of fuel : 54% for electricity generation
28% diesel for trucks
8% gasoline for private cars
10% for household

Local source: 4% Renewable Sources for Energy production

Energy Consumption:
Resident sector consumes 29% of total energy (including 42% of generated electricity, with an annual consumption of 1,94MJ/Inhabitant.

The distribution of energy consumption within economic sectors shows that 69% normally are concentrated in the **industrial sectors (30%)**, the **transport (23%)** and the **agricultural sector (16%).**

4. FUTURE DEVELOPMENT of the ISLAND

4.1 Energy Development

Accomplished studies demonstrate that the availability of forest biomass and the possibilities to increase the energy plantation areas, permit to mark out a strategy to meet the increases of electricity demand by means of biomass power plants.
This fact gives the consideration to build a power plant of 4...5MW in 2005 and another one of same capacity in the year 2010
The installation of these power plants permits to estimate that in the year 2005 , 30% of the electricity would be generated with renewable energy and in the year 2010 the generation of electricity could be increased to 50% .

4.2 Electrical Energy Development

Due to missing local data no further development can be proposed.

5. IMPLEMENTATION of ALTERNATIVE ENERGY SOURCES

To stabilize atmospheric Greenhouse Gas (GHG) concentration at levels that would prevent dangerous anthropologic interference with global climate is one of the goals in the KYOTO-resolution.
Serious anthropologic interference with the global climate can only be achieved through dramatically increased utilization of renewable energy technologies (RETs).
Based to this preconditions all existing kind of alternative energy sources at the "Isla de la Juventud" were investigated carefully to find out economical solutions for energy supply at this territory. Useful proposals and recommendations for installation of alternative energy sources are pointed out within this chapter, too.

5.1 Bio-Diesel-Generation

5.1.1 Basic technological informations

The process of converting vegetable oil into biodiesel fuel is called transesterification and is luckily less complex than it sounds. Chemically, transesterification means taking a triglyceride molecule, or a complex fatty acid, neutralizing the free fatty acids, removing the glycerin, and creating an alcohol ester. This is accomplished by mixing methanol (wood alcohol) with lye (sodium hydroxide) to make sodium methoxide. This dangerous liquid is then mixed into vegetable oil. The entire mixture then settles. Glycerin is left on the bottom and methyl esters, or biodiesel, is left on top. The glycerin can be used to make soap (or any one of 1,600 other products) and the methyl esters is washed and filtered. The resulting biodiesel fuel when used directly in a Diesel engine will burn up to 75% cleaner than petroleum D2 fuel.

Key advantages of Biodiesel

- Biodiesel runs in any conventional, unmodified diesel engine. It can be stored anywhere that petroleum diesel fuel is stored.
- Biodiesel reduces Carbon Dioxide emissions by up to 100% because it is a renewable fuel. This is very important because as you can see in the chart here, carbon dioxide contributes to 50% of the Greenhouse Effect.
- Biodiesel can be used alone or mixed in any amount with petroleum diesel fuel.
- Biodiesel is more lubricating than diesel fuel, so it increases the life of engines.
- Biodiesel is safe to handle because it is biodegradable and non-toxic. According to Alan Weber of the NAB, "neat biodiesel is as biodegradable as sugar and less toxic than salt."
- Biodiesel has a high flash point, or ignition temperature, of about 300 F compared to petroleum diesel fuel which has a flash point of 125 F. This means it's safer to transport.
- Auto ignition, fuel consumption, power output, and engine torque are relatively unaffected by biodiesel. So basically, the engine just runs like normal (except for the smell).

5.1.2 Available Ressources at the territory

At present situation only research projects are existing at the island.

5.1.3 Economical Solution

Further investigations are required to receive satisfactory results

5.2 Biogas-Plant and Biological Biomass Gasification

5.2.1 Basic technological informations

Anaerobic fermentation is the wet conversion of agricultural or communal residues by certain bacteria to biogas, a mixture mainly of methane and carbon dioxide. Solid biomass like wood or straw show a very slow biodegradation rate. That is why biofermentation of this kind of biomass is not economic.

Different fermenter types are commercially available. Usually fermentation is performed in a totally mixed reactor as shown in figure 5.2-1. Mesophilic bacteria achieve maximum conversion rate at temperatures of 30 to 40 °C, thermophilic bacteria at 50 to 60 °C. As heat source for keeping the fermenter at the optimal temperature, 15 to 30 % of the produced biogas is used. For the generation of 1 kWh power and 1.24 kWh heat 5-7 kg bio-waste, 5-15 kg municipal waste, 8 to 12 kg cattle waste or 4-7 m³ organic waste is required.

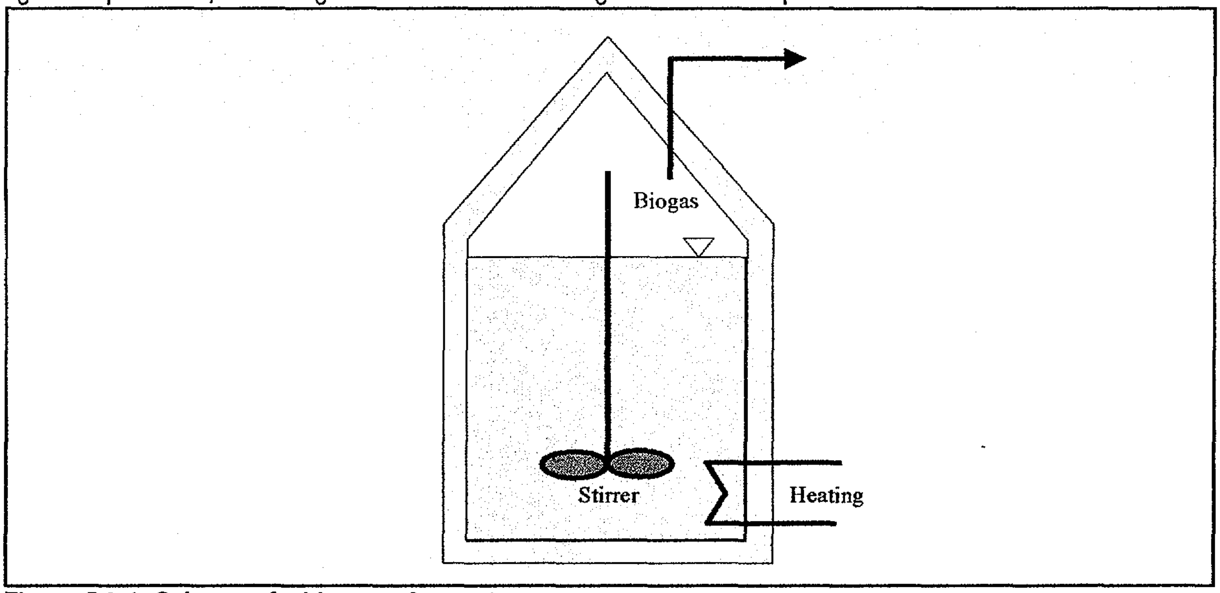


Figure 5.2-1: Scheme of a biomass fermenter

The high share of carbon dioxide in biogas, sewage gas and landfill gas (>30 %) give these gases a high pre ignition resistance. That is why these gases are appropriate for combustion in stationary engines. The conversion of biogas to mechanical energy is usually performed by gas engines. Gas engines are sensitive to biogas impurities (see **table 5.2-1**). That is why gas cleaning frequently is necessary.

Table 5.2-1: Requirements of a gas engine on biogas composition /

H_2S concentration in mg/m³CH_4	Chlorine concentration in mg/m³CH_4	Fluor concentration in mg/m³CH_4
<1500	<100	<50

In the range from 1 to 5 MW_{el} also gas turbines are in use. **Figure 5.2-2** shows the development of the gas turbine efficiency over this capacity range.

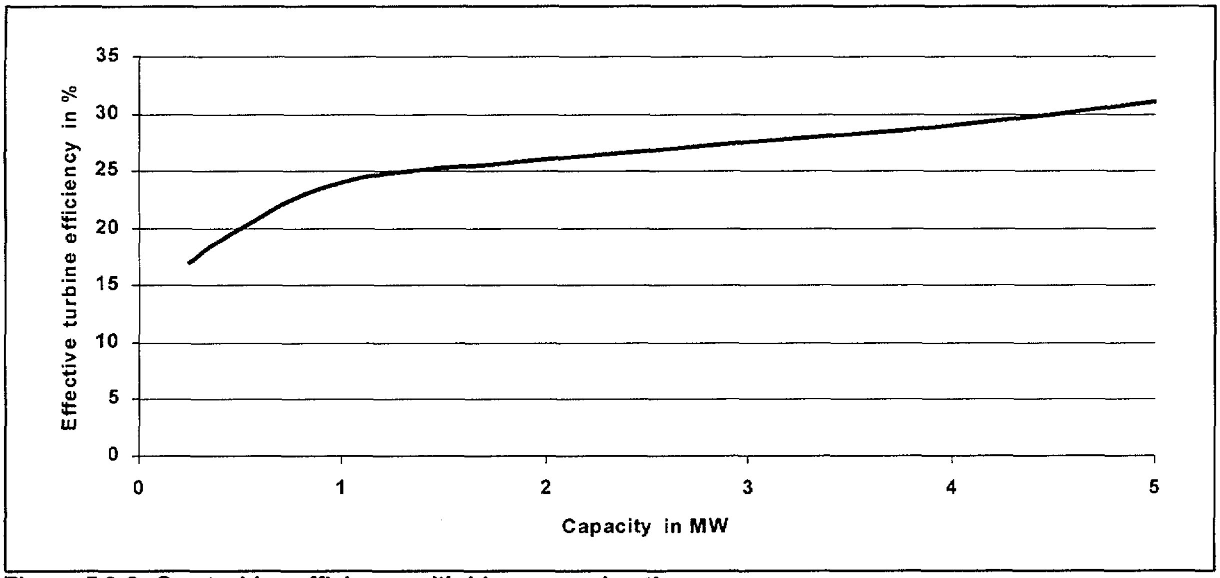
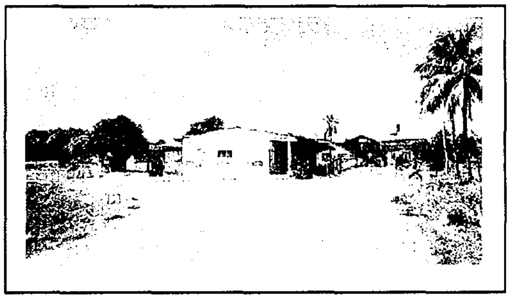


Figure 5.2-2: Gas turbine efficiency with biogas combustion

5.2.2 Available Ressources at the territory

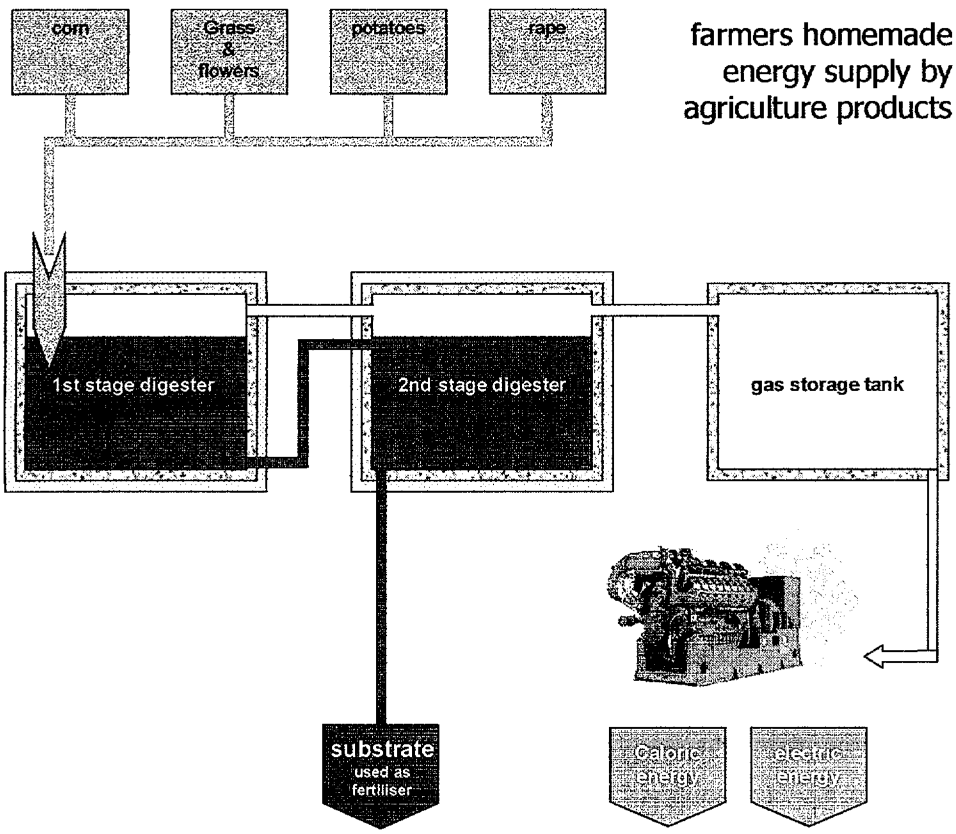
The potential of biogas production is mainly from pig excretes.
At the island exists nine farms with a capacity from 500 ... 12.000 pigs with an annual production potential of biogas from 900.000m³.



The pig farm produces 8000 pigs per year, the liquid manure from the pig-farm will be send directly to the banana-plantation..

5.2.3 Economical Solution

Using the liquid manure from the pig-farms (the biggest one has 8000 pigs) together with agriculture goods produced at the island at biogas-plant can generate electrical energy together with calorific energy.



Biomass many times is a rabbish of production process, which easily can be used to produce energy during rotting.
More and more clever farmers see a chance using their products not only for food but also as biological energy supply. The CO2 production during combustion of the bio gas is the CO2 bound in the plants during growing on the fields.
So this method is an ideal process to reduce the generation of CO2 by enabling standard technologies.

Main data of a realized small farmhouse project:

Substrate-Input :
approx. 70 GVE liquid manure
15 ha agriculture area
5 ha green land
300 m³ mowing (grass, flowers)

Present electric output: 62 kW **Present thermic output: 120 kW**
Future electric output: 100 kW Future thermic output: 190 kW

Bilance of energy

	Electric energy	Thermic energy
Production biogas energy	**502.056 kWh/a**	**1.022.042 kWh/a**
Houseload consumption	25.000 kWh/a	170.000 kWh/a

Investment-costs

Acc. to European prices the investment costs for generating of **100kW** electric power will be approx. **450.000 ... 500.000 US$.**
Nearly 50% of the investment costs are created by civil construction works . This civil prices on the local market can give a serious influence to the total costs.

5.3 Biomass-Plant

5.3.1 Basic technological informations

For incinerating relatively coarse biomass like wooden residues, straw and waste, solid bed firing is applied. Several technologies are in use:

- The **spreader-stoker firing** (see figure 5.3-1) A screw called "stoker" feeds a moving grate called "spreader". This technology is applied for low-ash fine-grained biomass fuels like saw dust, pellets and fine wood chips **up to 6 MW_{bio}** /i/.
  By addition of magnesium oxide the formed slag stays in loose consistency.
- With **feed grates,** biomass transport is achieved by periodic movements of every second grate element. The grate is divided into a number of grate zones which can be regulated separately. Feed grates are used for capacities **up to 50 MW_{th}.**
- The **travelling grate** uses a revolving grate for moving the biomass through the burning chamber. The fuel bed is not overturned and thus fuel particles are not whirled up. Due to the even distribution of the fuel on the grate, the thermal stress is lower than with the feed grate. The travelling grate is especially appropriate for burning wood chips, pellets and old wood. The Travelling grate cannot be applied for combusting coarse-grained, inhomogeneous or very small grain fuels.
- Water cooled **sloped vibration grates** are used especially for fuels with a high tendency to slagging (e.g. straw). With vibration grates combustion control, however, is difficult.

Following **flue gas cleaning techniques** are applied with biomass combustion:

- feed of urea into the upper part of the incineration chamber in order to reduce NO_X formation;
- a combination of cyclones and electrostatic precipitators for dust removal ;
- textile filters for dust removal.

An **advantage** of solid bed incineration is its low costs, a **disadvantage** its low flexibility with respect to particle size. An irregular distribution of particle size can lead to temperature peaks and high CO or NO_X emissions.

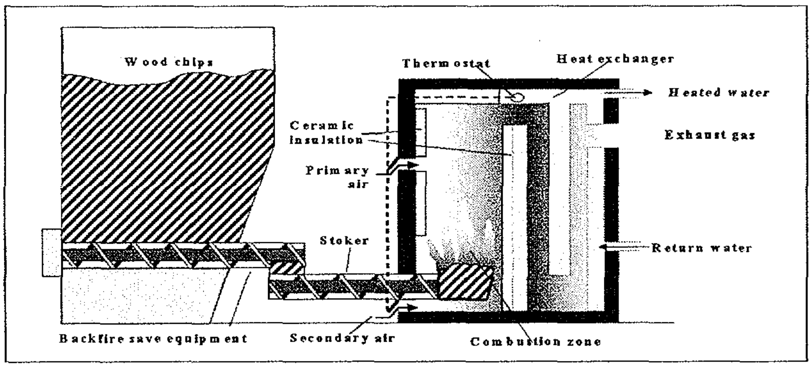


Figure 5.3-1: Scheme of "stoker" wood combustion technology

Fluidized Bed Incineration

The general scheme of a fluidized bed combustor for biomass incineration is the same as for coal incineration. Fluidized bed combustion can be done in one of three operating modes:

- with stationary beds
- with internal circulating beds
- with external circulating

Advantages of fluidized bed incineration are:

- a relatively low burning temperature is achieved (750 to 900 °C), leading to low NO_x and CO emissions;
- sulfur can be removed during combustion by addition of limestone;
- different materials can be burned over a wide spread of particle size;
- less area is needed than with solid bed incineration.

Disadvantages of fluidized bed incineration as compared to solid bed combustion are:

- higher investment costs;
- higher electricity consumption;
- longer start-up period.

Due to the high investment costs, stationary fluidized bed combustion is economic only for $MW_{th} \geq 20$, circulating fluidized bed combustion only for $MW_{th} \geq 30$.

Thermal Biomass Gasification

During thermal gasification at about 700 °C biomass reacts with air, oxygen or steam to form a mixture of CO, CO_2, water and methane. Utilizing air leads to a product gas with low calorific value of 4-6 MJ/Nm^3. With oxygen or water the product gas has an energy contents of 10-14 MJ/Nm^3 (as compared to 18-25 MJ/Nm^3 for bio-, landfill-, or sewage-gas).

The reaction with the wood component cellulose as shown in equation takes up energy:

$$C_6H_{10}O_5 + H_2O \rightarrow 6CO + 6\ H_2 + 3.34\ MJ/kg$$

The reaction energy is provided

- either by burning part of the biomass in the reactor,
- or by recovering heat from the flue gas in a high temperature heat exchanger.

Three basic types of biomass gasifiers are in use:

- **Co-current downdraft gasifiers** with low tar emissions are utilized in the range of **10 kW_{bio} to 1 MW_{bio}** (see figure 5.3-2).
- **Counter current updraft gasifiers** with high tar emissions are used in the range **of 1 MW_{bio} to 10 MW_{bio}** (see figure 5.3-2).

- **Stationary or circulating fluidized bed gasifiers**, with atmospheric or high pressure, leading to medium tar emissions are expected to be economic in the range of **10 MW_{bio} to above 100 MW_{bio}** (see figure 5.3-3).

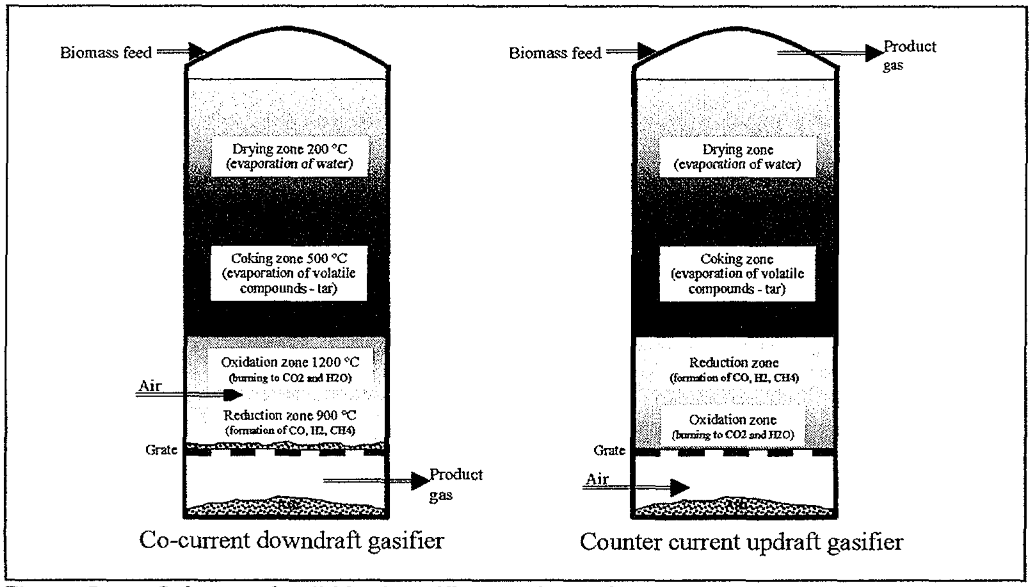


Figure 5.3-2: Scheme of solid bed gasifiers and reaction zones

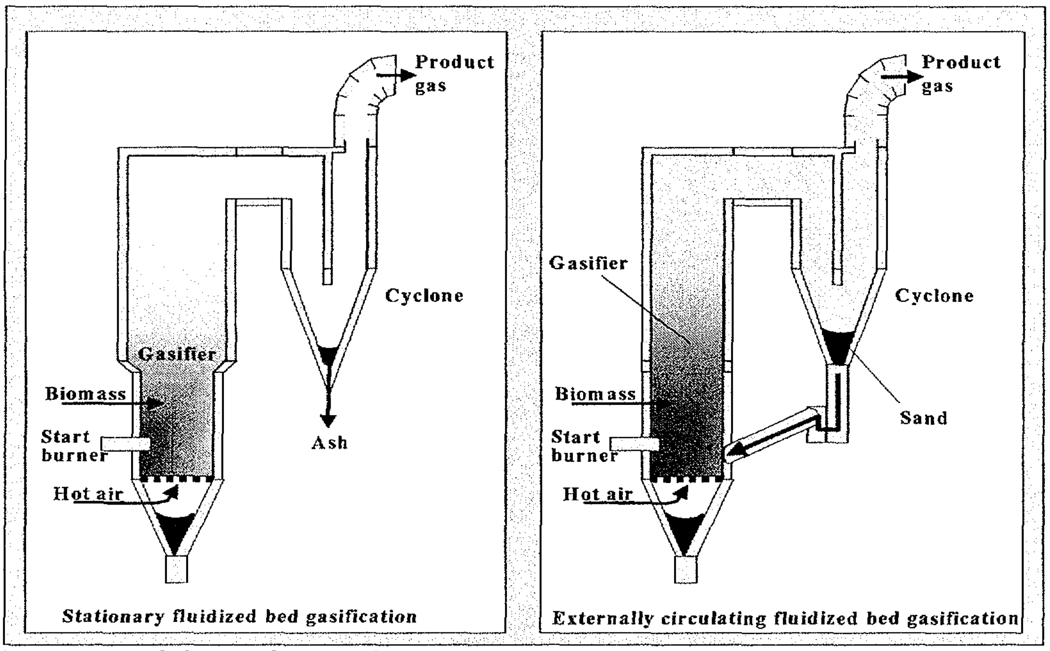


Figure 5.3-3: Scheme of fluidized bed gasifier

An advanced technology is the internal circulating fluidized bed gasifier, in which bigger sand particles make up a stationary fluidized bed for the gasification reaction, while a fraction of smaller sand circulates between the burning zone (= the oxidization zone) and the gasification zone (= reduction zone) and takes care of the heat exchange .

Due to difficulties with high tar contents up to now biomass gasification is commercially available only for heat production. All thermal biomass gasification technologies which aim at power production are under trial run condition since a short time .
In addition to tar also dust has to be removed from the biomass gas. This is done by hot gas cleaning equipment like cyclones and/or textile filters.

Biomass power plants

The focus of developments for large scale biomass power plants lies with improvements of the IGCC process. One design concept of biomass IGCC, the TPS-process, is shown in **figure 5.3-4**. This process is based on two circulating fluidized bed reactors (a biomass-gasifier and a tar-cracker). Demonstration plants are under operation in Hawaii (the fuel is sugar cane residues) and in Vermont (with wooden residues as fuel) funded by the US department of energy Biomass Power Program, in Brazil funded by the World Bank /ii/, in Austria as EU-promoted projects St.Andrä and Zeltweg.

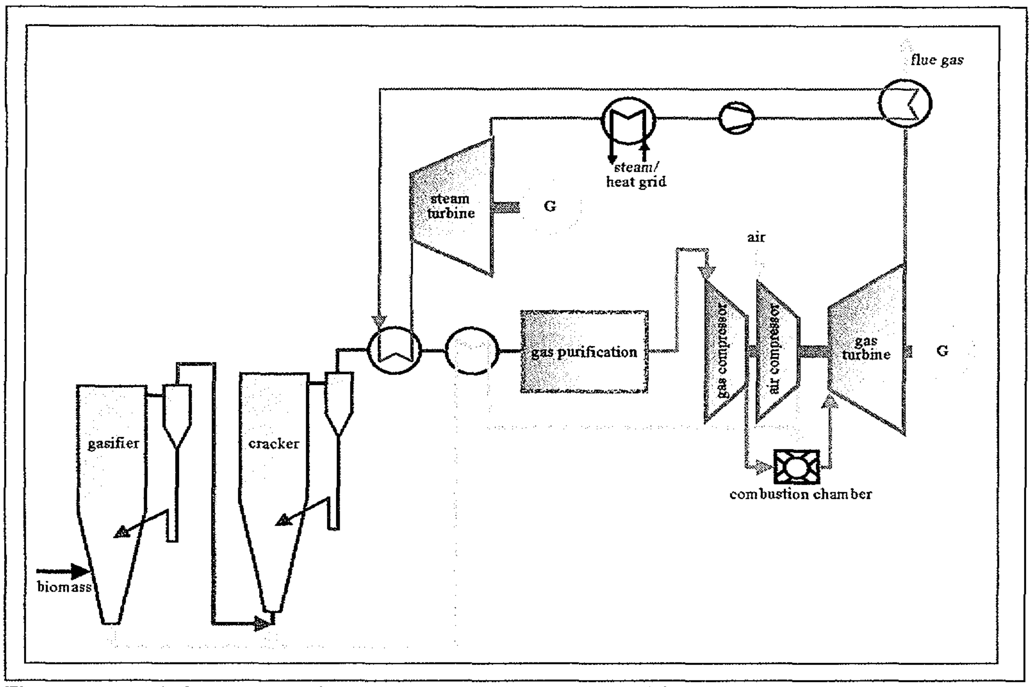


Figure 5.3-4: Scheme of a biomass IGCC (integrated gasification combined cycle) plant

Development goals for biomass gasification power plants are capital costs <1900 $/kW for 2005 and <1500 $/kW for 2010 /vii/.

Figure 5.3-5 shows the expected contribution of different technologies to power production capacity from biomass in the United States. It can be seen that for IGCC the biggest future market is anticipated.

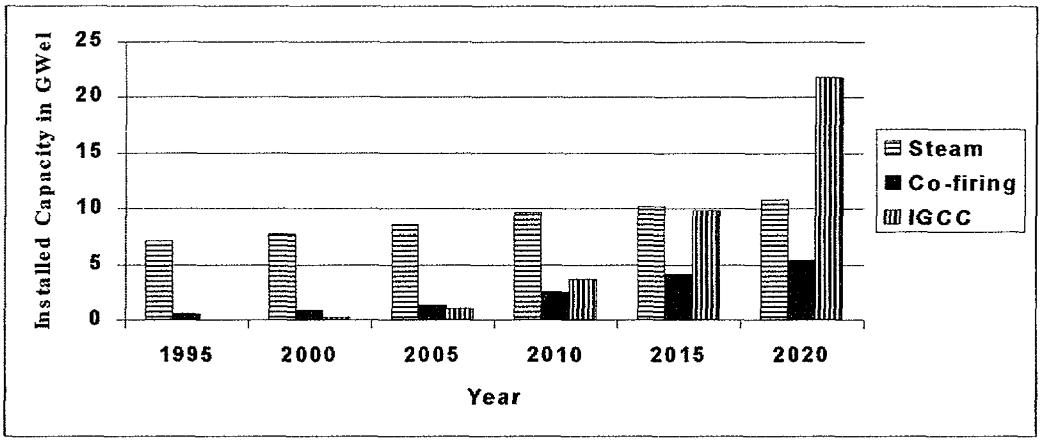
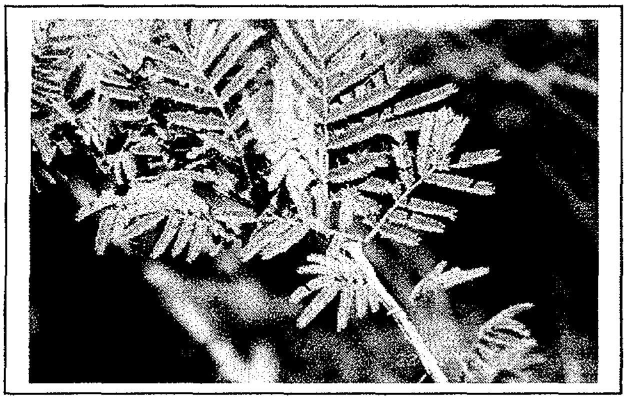


Figure 5.3-5: US power generation capacity from biomass /iii/

5.3.2 Available Ressources at the territory

The main source of renewable energy of the territory is the biomass that is found available in the former forest product.

The **forest area** of the island includes **10.126 ha** of plantations.
There are special plantations where plants are grown up only for **energy production** .
These forests can annually produce **102.306 m³** of biomass. *(acc. to local information 18.905m³/year will be available)*
The **total potential** of available biomass is **251,282 m³.**



Both pictures shows the biomass trees at the island , called **MARABU**

Forestry Indicators for the Forest Development 2000 to 2003

INDICADORES SILVÍCOLAS	UM	2000	2001	2002	2003
-Production of plantations	MU	1375.0	1925.0	1925.0	1925.0
-Total Plantations	ha	600	800	800	800
• Productive	ha	500	500	500	500
Sawmill	ha	300	300	300	300
Energetic Forests	ha	200	200	200	200
• Protector	ha	100	300	300	300
- TotalPlantations	MU	12500	1750	1750	1750
- Plantations Maintenance	ha	1700	2000	2200	2400
-Fertilization	ha	300	300	300	300
-Forestry treatments	ha	800	800	800	900
• Branch extraction	ha	740	740	740	800

INDUSTRIAL PRODUCTION INDICATORS.	UM	2000	2001	2002	2003
-Wood in trunks	**m3**	**12605**	**12605**	**12605**	**12605**
• Conifers	m3	10300	10300	10300	10300
• Precious wood	m3	286	286	286	286
• Hard	m3	577	577	577	577
• Half hard	m3	865	865	865	865
• Softs	m3	577	577	577	577
-Saw wood	**m3**	**6300**	**6300**	**6300**	**6300**
• Conifers	m3	5150	5150	5150	5150
• Precious wood s	m3	100	100	100	100
• Hard	m3	300	300	300	300
• Half hard	m3	450	450	450	450
• Softs	m3	300	300	300	300

INDUSTRIAL PRODUCTION INDICATORS	UM	2000	2001	2002	2003
-Round Wood	m3	10000	10000	10000	10000
-Sticks for Tobacco	m3	200	300	400	400
-Wood Coal (10 500 m3)	Sacks	35000	35000	40000	40000
-Agricultural Package	Uno	15000	15000	16200	16800
-Pine Resin	T	60	100	200	300
-Forest Guabo	MU	2000	2000	2000	2000
-Pulpable Pieces	m3	13320	13320	13320	15000

ECONOMIC INDICATORS	UM	2000	2001	2002	2003
-productivity per man	Peso	5357	5724	6736	7207
-Gross production	MP	1435.9	1230.7	1279.9	1369.4
- workers (average)	U	268	215	190	190
-Cost per weight Gross Production	Peso	0.77	0.72.0.	0.70	0.70
-Gross production Cost	MP	1105.6	886.1	908.7	972.2
PRODUCTION COSTS					
• Production of plantations	MP	96.2	134.7	134.7	134.7
• Plantations	MP	3507	47.6	47.6	476.
• Plantations Maintenance	MP	68.9	81.1	89.3	97.4
• Forestry Treatments	MP	189.1	189.1	189.1	212.8
TRANSPORT COSTS					
• Wood in trunks.	Peso/m3	5.9	5.12	5.09	5.02
• Round wood	"	4.17	4.11	4.08	4.02
• Firewood	"	4.09	4.03	4.01	3.95

PERFORMANCE					
• **Branch extraction**	**ha**	**740**	**740**	**740**	**800**
- Round wood	m3	4808.4	4856.1	4928.9	5323.2
-Efficiency per Hectare	m3	6.5	6.6	6.7	6.7
-Firewood	m3				
- Efficiency per Hectare	m3				
• **Maintenance**					
-Round wood	ha				
-Firewood	m3				
- Efficiency per Hectare	m3				
• **Forestry treatment**	**ha**				
-Round wood	m3				
-Firewood	m3				
- Efficiency per Hectare	m3				

5.3.3 Economical Solution

Based on the figures handed over from ACYT and from the Direction of Planning for Isla de la Juventud, Cuba we checked all figures and prepared the following proposal for an useful installation of biomass plant at Island of Youth, fired with 100% of renewables from the local area.

	Variante 1	Variante 2	
Biomass-generation	102.306 m³/a	18.905 m³/a	
Density	340 kg/m³	340 kg/m³	
Biomass-generation	34.700 t/a	6.412 t/a	
Heat value of Marabu	16.500 kJ/kg	16.500 kJ/kg	
Biomass energy content	159 GWh	29,4 GWh	
Maximal possible plant size for annual operation	19,8 MW-therm	3,68 MW-therm	
Operation duration	8.000 h	8.000 h	
Economical plant size	4 MW electr	0,74MW electr	
Plant costs *)	10,6 Mio€	3,0 MW	
Lifetime of Biomass Plant	30a	30a	
Annual discount rate	10%	10%	
Annual operation costs	233.000€	40.000€	
Annual electricity generation	32 GWh-electr	5,6 GWh-electr	
Generation cost for electricity by using biomass	0,042 €/kWh	0,064 €/kWh	
Generation cost for electricity by using fuel			
Amount of saved fuel by energy-substitution with biomass plant	8,9 Mio l	1,56 Mio l	1kWh-el ... 0,278 l fuel

Costs for different plant sizes acc. to Study prepared by Jürgen Nebarth

In a.m. survey following parameters are excluded:

- Costs of Biomass including transport and treatment for firing
- Not available chemical analyze of Marabu hinders detailed investigation for the emissions to the environment

5.4 Fuel cells

5.4.1 Basic technological informations

A fuel cell (FC) is a technology which converts chemical energy to electric energy without moving parts. Like batteries, fuel cells are based on the principles of electrochemistry. A typical cell provides around 0.7 to 0.8 Volts and power outputs of a few tens to hundred Watts. In order to achieve a significant output, cells have to be assembled in modules or "stacks" and electrically connected in series and/or in parallel. The most common electrochemical reaction in a fuel cell is that of hydrogen with oxygen, as shown in **figure 5.4-1**.

At the anode hydrogen (H_2) releases electrons (e^-) while forming hydronium (H^+)-ions:

$$\mathbf{H_2 \rightarrow 2H^+ + 2e^-.}$$

At the cathode oxygen O_2 takes up electrons (e^-) to form oxygen-anions (O^-):

$$\mathbf{O_2 + 2e^-. \rightarrow 2O^-.}$$

A membrane or an electrolyte separates the hydrogen-cell from the oxygen cell in order to prevent a thermal reaction of these two gasses. The membrane allows only H^+-ions to permeate. After transport H^+-ion and O-ion combine to form water (H_2O), while releasing heat:

$$\mathbf{2H_2 + O_2 \rightarrow 2H_2O}$$

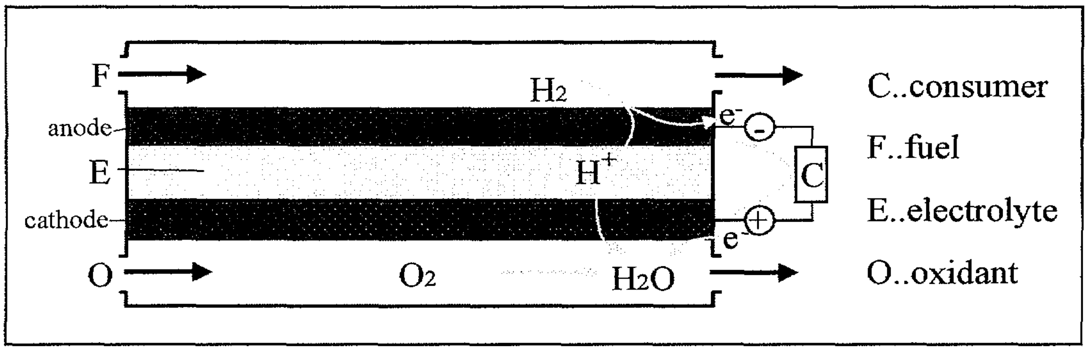


Figure 5.4-1: Scheme of power generation by a phosphor acid (PAFC) or polymer electrolyte (PEFC) fuel cells, respectively /iv/

Oxygen for the fuel cell reaction is usually submitted as air. Hydrogen is usually obtained by steam-reforming of fossil fuels. Natural gas is the most commonly used fuel; however, also other fuels can be used as hydrogen source including, peak shaved gas, air-stabilized gas from local production such as landfills, propane, or other fuels with high methane content.

Fuel cells can be categorized by their electrolyte system.

Five major fuel cell types are currently developed:

- **alkaline fuel cells (AFC)**
- **phosphoric acid fuel cells (PAFC)**
- **polymer electrolyte fuel cells (PEFC)** working on the same principal as PAFCs, but with a proton conducting polymer membrane as electrolyte,
- **molten carbonate fuel cells (MCFC)**
- **solid oxide fuel cells (SOFC)**

Fuel cells can operate stand alone or connected to the electricity grid. They are used to produce power only or to produce combined heat and power. Usually they will generate energy near to the final consumer in dispersed production. FCs generating electricity only are developed in sizes up to 10 MW, CHP-FCs in **sizes up to 2 MW_{el}** /v/. These base load plants will be fuelled through natural gas or coal, with the latter fuel applying coal gasification technologies .

Further **advantages of fuel cells** can be summarized as follows:

- Fuel cells can be sized to accommodate different capacity needs by connecting the same cell designs in series and/or parallel, referred to as "stacking" cells (one single cell providing a voltage of about 1 Volt).
- Fuel cells in the pilot applications have shown high availability of 85 to 90 %.
- They are environmentally benign because of their low emissions
- Fuel cells are quiet, with a 200 kW plant making about the same amount of noise as a window air conditioner /.

Disadvantages of fuel cells in their present state of development are:

- Their costs are high (see figure 5.4-2)
- PAFCs must be operated year round to avoid degredation.
- The support system is not yet fully developed.
- The actual life span of fuel cells is still unknown.

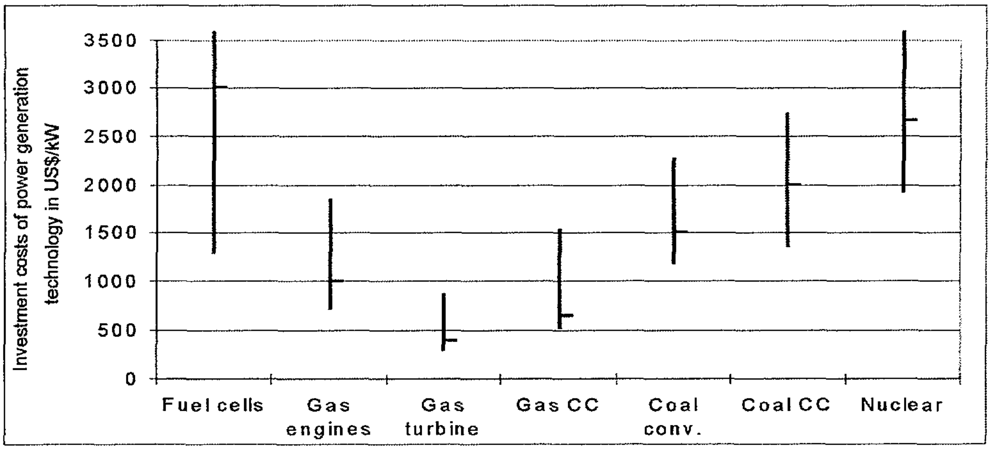


Figure 5.4-2: Power generation technology investment costs
(Gas CC = natural gas fired combined cycle, Coal conv. = coal fired conventional, Coal CC = coal fired combined cycle)

Costs and Market of Fuel Cells

Present costs of fuel cells lie at **3000 $/kW equipment** costs plus **500 $/kW installation** costs.
The goal for the total costs is to **drop to 1500 $/kW** within the next 5 years /.
Other sources estimate investment cost of **less than 800 S/kW** by 2005.

For **PEFCs** (which are developed specifically for the automobile industry) a **cost target of 60 US$/kW is expected** to be achieved within the next decade /.
The main market for **FCs** is seen in dispersed **generation with units of 3 kW to 50 MW_{el}.**

Another market for fuel cells is the combination with a hydrogen storage system an a non dispatchable power generation technology as, e.g., a wind power plant. In periods of high wind supply and thus high power generation capacity, electric energy can be stored in form of chemical energy by converting water to hydrogen by means of electrolysis. The produced hydrogen can be stored in tanks. In peak demand hours, the chemical energy can be converted back to electricity by fuel cells. A demonstration plant for this technical chain is in operation in Germany .

Stringent emissions regulations provide also an excellent market opportunity for fuel cells, which emit fewer pollutants than required by target emission limits.

5.4.2 Available Ressources at the territory

Survey of Transport facilities at ISLA de la JUVENTUD

Typ	Total
• Trucks	1977
• Motorcars	3449
• Pick ups	279
• tryicles	138
• Small cars	908
• Jeep	491
• Taxis	32
• Ambulances and another kind of special purpose vehicles	68
• Trailer	114
• Omnibus	520
TOTAL	**7766**

Maritime Transport

The marine transportation begins to recover technically, introducing new units in the fleet, being the one of its limitations the unavailability of the units of load (containers) that allows to improve the exploitation, elevating the energetic efficiency.

Consumption Annual Average Of Diesel engine	4000 T
Transportation Of Load	3200 T
Transportation Of Passengers	900T
Average of Passengers Transported	351,9 M Passangers
Average of Transported Load	168127,7 T

Power Carriers Consumption from the companies of the Transport Sector

	U/M	REAL
Electricity from grid	MWh	1296.2
Diesel (direct)	ml	4296.1
Diesel (indirect)	ml	20.0
Gasoline Motor Normal (direct)	ml	876.8
Gasoline Motor Normal (indirect)	ml	43.8
Gasoline Motor Super (direct)	Ml	40.0
Gasoline Motor Super (indirect)	ml	4.1
GLP Invoiced in Mass units	kg	10725.4
Total Diesel	ml	4316.1
Total Gasoline Motor	ml	964.7
Total Gasoline Motor Direct	ml	916.8
Gasoline Motor Indirect	ml	47.9
Total Gasoline Motor Normal	ml	920.6
Total Gasoline Motor Super	ml	44.1
Total conventional tons	T	4979.9
T/C Diesel	T	3887.8
T/C Gasoline motor	T	778.2
T/C Electricity	T	301.1
T/C Gasoline Regular	T	742.6
T/C Gasoline Super	T	35.5
T/C GLP	T	12.8

Power carriers consumption in transport (State sector).

Carrier	**U/M**	**Real**
Gasoline Normal	ml	2677.60
Gasoline Super	ml	305.70
Diesel	ml	8094.36
Conventional fuels	tcc	9697.42

Consumption according specific activities Diesel (ML)

Activity	Real
• **Public Transport**	**628.3**
• **Rural Transportation**	
- Cargo	1875.9
- Passengers	1679.5
-Cargo-Transport (Specialized companies)	105.0
• **Agricultural Transportation**	**221.7**
• **Communal services**	**60.0**
• **Food Distribution**	
- Dairy	60.3
- Nourish Industry	21.8
- Commerce	13.8
- Fish Industry	18.7
- Meat industry	4.0
• **Construction**	**16.1**

Gasoline Motor (Ml)

Activity	**Real**
Public transportation	**934.2**
Rural Transportation	**277.9**
Food Distribution	
- Nourish Industry	60.5
- Commerce	17.4
- Fish Industry	0.44
- Dairy	62.1
- Milk Industry	23.9
-Refreshments and drinks	23.0
• **Communal services**	**32.7**
• **Construction**	**80.5**

Consumption per activity.

ACTITIVY	**Diesel (Ml)**	**G.Motor (Ml)**
- Public Transportation	7.7	31.3
- Naval Transportation	143.9	-
-Specialized Cargo Transportation.	1.3	-
-Agricultural Transportation	2.7	9.3

-Food Distribution	1.5	7.4
-Communal services	0.7	1.1
-Construction	9.6	2.7
-Others	32.6	48.2

Energetic Efficiency

Land Transportation	U/M	Specific consumption index
		Real
Drinks and liquors transportation		
Diesel	Ml/Mkm	0.340
Gasoline	Ml/Mkm	0.045
Dairy transportation		
Diesel	Ml/mlxkm	0.0011
Gasoline	Ml/mlxkm	0.384
Agricultural Transportation		
Diesel	Ml/Mtxkm	0.0012
Gasoline	Ml/Mt x km	0.0010
Passengers Traffic	Ml/Mt x km	
Diesel	Ml/pas x km	2.933
Gasoline	Ml/pas x km	3.972
Food Transport		
Diesel	Ml/t x km	0.102
Gasoline	Ml/t x km	0.061
Meat Transport		
Diesel	Ml/t x km	0.0002
Gasoline	Ml/t x km	0.0001
Urban waste collection		
Diesel	Ml/Mm3 x km	1.800
Gasoline	Ml/Mm3 x km	2.105
Specialized transport		
Diesel	Ml/Mt x km	0.0208
Citric transportation		
Diesel	Ml/ x km	0.3066
Fish Products transportation.		
Gasoline Ml/txkm	0.074	0.566
Transportation Naval		
Passengers traffic		
Diesel	Ml/Mpas x km 2)	50.836
Cargo traffic		
Diesel	Ml/mt x mkm 1)	82.639

1) Ml = 1.000.000 l
mt = 1000 t
mkm = 1000 km

2) ML = 1.000.000 l
Mpas = 1,000.000 passengers

5.4.3 Economical Solution

For testing purposes in minimum 2 different types of electro-cars are recommended to be introduced .
The sponsering of these cars should be clarified with considerable car-production companies as MERCEDES , FIAT, MAZDA, etc.

5.5 Solar-Craft-Plant (Solar heat , Photovoltaics)

5.5.1 Basic technological informations

Solar Heat
Solar radiation can be converted to heat by absorbers like a house wall, or a solar collector. The scheme of a solar collector is shown in figure 5.5-1. Light energy is taken up by an absorber of dark color which in turn heats the heat carrier. As heat carrier water or air is in use. The collector cover is light transparent and limits convective heat losses.

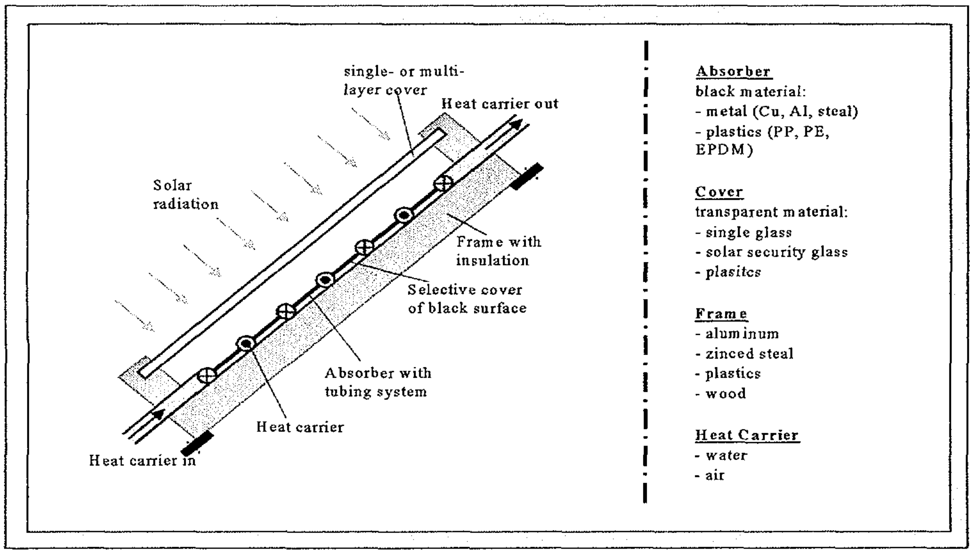


Figure 5.5-1: Scheme of a solar collector

There are **non-concentrating** and **concentrating solar collectors**.
Concentrating collectors are only applied in countries with cloudless skies.
In more cloudy countries non-concentrating collectors are used as they can utilize also the diffusive part of the light.
Two technologies of non-concentrating solar collectors with water as heat carriers are available:

- the less expensive **panel collectors** (as depicted in figure 5.5-1)
- and the more stable **tubular collectors**.

For a comparison of the costs of these collector types see table 5.5-1.

Table 5.5-1: Costs of solar collectors /x/

	Invest costs	O&M costs	Specific heat yield		Heat generation costs		Deprecia-tion period
	US$/m²	US$/(m²*a)	kWh/(m²*a)		USc/kWh		a
			Min	Max	Min	Max	
Panel collector	894	12	350	500	15.5	22.0	20
Tubular collector	1788	12	350	500	16.7	28.6	20

In addition to the collectors a total solar heating systems comprises tubing, energy storage equipment and a pump.

The losses referred to the incoming solar energy are as follows:

- 14 % reflection at the collector
- 7 % incomplete absorption in collector
- 30 % heat losses to environment
- 6 % heat losses in tubing
- 6 % heat losses in storage system
- 1 % auxiliary energy for pump.

In total only 36 % of the incoming solar energy are actually utilized for heating.

Solar collectors are applied for:

- heating of swimming pools,
- warm water preparation in households,
- support of room heating. In countries like Austria, Germany the solar energy supply is anti-correlated to the room-heat demand.

Solar heating is a mature technology which provides only limited space for further development and cost reduction /vi/.

Photovoltaics (PV)

Photovoltaics is based on the phenomenon that an electrical voltage is induced by light shining on a semiconductor solar cell. This effect is amplified when a silicon layer doped with elements from the 5th main group like arsenic (n-layer) and a silicon layer doped with elements from the 3rd main group like boron (p-layer) are contacted (see figure 5.5-2). But also layer combinations of elements from the 2nd and 6th (cadmium-telluride), the 1st, 3rd and 6th main group (copper-indium-selenide) the photovoltaic effect.
The carrier material silicon can be either mono-crystalline (higher efficiency, highest costs), polycrystalline or amorphous. The doping elements can be equally distributed in the whole silicon layer of 50 to 100 µm thickness or concentrated in a 1 µm thin-layer directly below the surface of the silicon layer.
Table 5.5-2 shows the electrical efficiencies and the state of the art of different solar cell types.

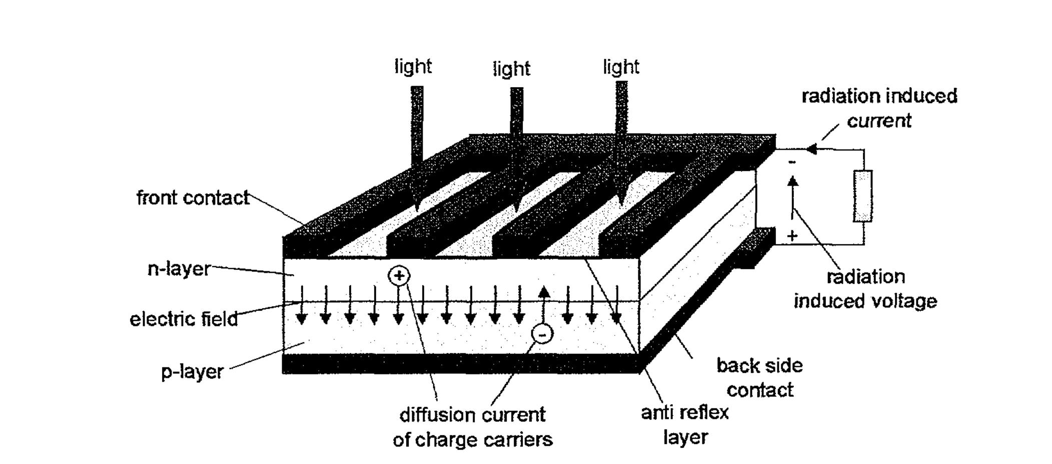


Figure 5.5-2: Scheme of a solar cell

Table 5.5-2: Electrical efficiency of solar cells /vi/, /vii/				
Material	Type	Laboratory efficiency in in %	Industrial efficiency in %	State of the art[1]
Mono-crystalline silicon	crystalline	23	14-18	1
Poly-crystalline silicon	crystalline	18	13-15	1
Amorphous silicon	crystalline	13	5	1
Gallium-arsenide	crystalline	29	19	2
Cadmium-telluride	thin film	17	11	2
Copper-indium-diselenide	thin film	17	-	4
[1] 1 commercially available, 2 available on small scale, 3 demonstration phase, 4 development phase				

PV systems operate stand alone, frequently with a diesel engine as back-up facility or grid connected. Further elements of the system is a power conditioner (a control unit), a storage battery and a DC/AC converter /viii/.

The **power generation costs over the installed capacity of PV plants** is shown in **figure 5.5-3**.
It can be seen that PV power generation costs are 1 order of magnitude bigger than costs with other power generation technologies. A significant potential for improving the industrial efficiency, for developing new PV processes and for cost reduction is left.

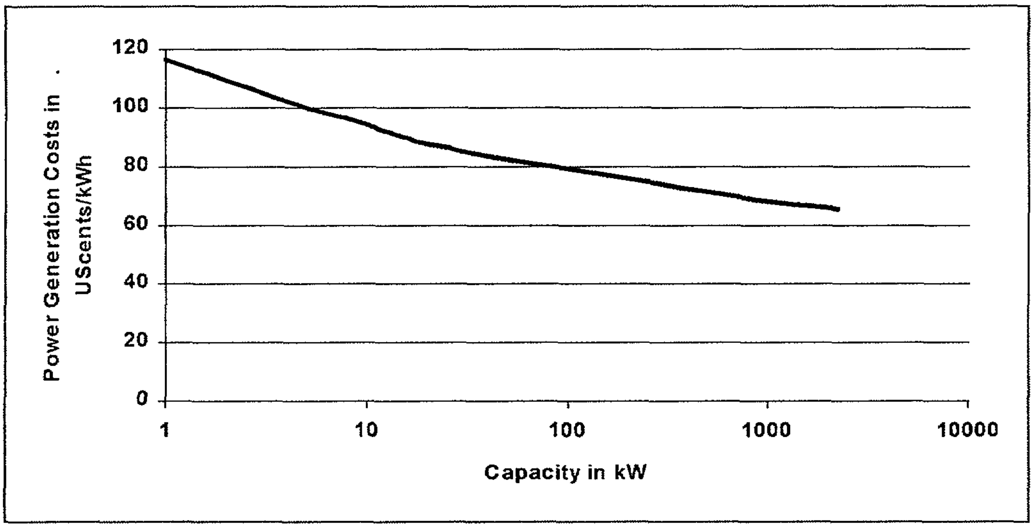


Figure 5.5-3: Power generation costs from PV /vi/

Solar Power Plants

In solar power plants large, highly reflective sun tracking mirrors concentrate sunlight to achieve temperatures of 400 to 800 °C in the working fluid of a receiver; the adsorbed energy is used in a steam turbine, gas turbine or Stirling engine cycle to produce electricity at efficiencies of up to 30 %. Different technologies are developed:
The working fluid of parabolic trough systems is thermo-oil. The plant sizes can range from 10 to 100 MW. 9 plants, with a total capacity of 354 MWel operate in California at 12 US¢/kWh power generation costs.
A power tower system uses many large heliostats to focus the energy to a tower mounted receiver filled with a molten salt working fluid that produces steam. The hot salt can be used also for energy storage. Plant size ranges from 10 to 200 MWel. A 10 MWel demonstration plant is operating in Barstow California.
The dish/engine system uses a dish shaped reflector (10-25 kW) to power a small Stirling engine. The dishes can be used individually or in clusters of up to 10 MWel. This system is in the demonstration phase in Spain and Colorado.

A high technical potential is available for solar power plants in countries with clear skies, like in the Mediterranean or Carribeanean.
Schemes are discussed in which northern countries finance the installation of solar power plants in southern countries in exchange of part of the produced electricity. Examples are the Almeria power plant in Spain and the 50 MWel Theseus plant in Crete. The former features a parabolic trough system with direct steam production, dispensing the thermo-oil cycle.

Development efforts aim at reducing the power generation costs to lower than 5 US¢/kWh /vii/. The ConSolar development project in Israel aims at heating air in the solar power plant up to 800 °C, with the hot air then being used in a hot-air turbine process or a combined cycle process.

In order to lower the specific power generation costs and to assure a year round power supply, also hybrid systems of solar plants with fossil fuel fired steam and combined cycle processes are proposed /ix/.

5.5.2 Available Ressources at the territory

There is a little chance to apply the photovoltaic solar energy due to high electrification rate of the territory .

Therefore the greater interest focuses on the development of the **thermal solar energy** for heating the boilers.

The average hours of lighting in the territory range from up to 12 hours/day. The days of better sunshine occur during the month in which the days begin to lengthen. After beginning of spring , the days are cloudless and the day light lasts between 10 and 12 hours. In the months of June and August , though the sunstroke is more intensive, the permanence of the sunlight is not extended in spite of the longest days of the year since the cloudiness is abundant.

The days of less sunstroke, averaging in 7 and 9 daily hours occur in September, it is the month of greater cloudiness and in this period the days tend to be shortened by the proximity of Autumn though it is not established definitely in the tropical climate.

Month per Year	**02-04**	**06-08**	**09**	**10-01**	**Year-Average**
Average lighting hours	10...12	8...10	7...9	9...11	**8...12**
Sunstroke (kWh/m^2.day)	5.8...7.0	4.6...5.8	4.1...5.2	5.2...6.4	**4.9...6.1**
Radiation (kW/m^2)	13.2	10.8	9.6	12.0	**11.4**

5.5.3 Economical Solution

Further detailed investigations are required to give a satisfied economical proposal for this island.

5.7 Wind-Craft-Plant

5.7.1 Basic technological informations

Wind power technology has seen a rapid development in recent years. While in 1990 the average capacity of a wind plant in Germany was 166 kW, in 1997 the average plant size was 629 kW, and now the 1.5 MW plant is standard /x/. **Figure 5.7-1** shows different technology types and their efficiencies. In recent years the 3 blade rotor plant, which leads to the highest efficiency, has gained the highest market share. **Figure 5.7-2** shows the scheme of such a 3 blade rotor plant.

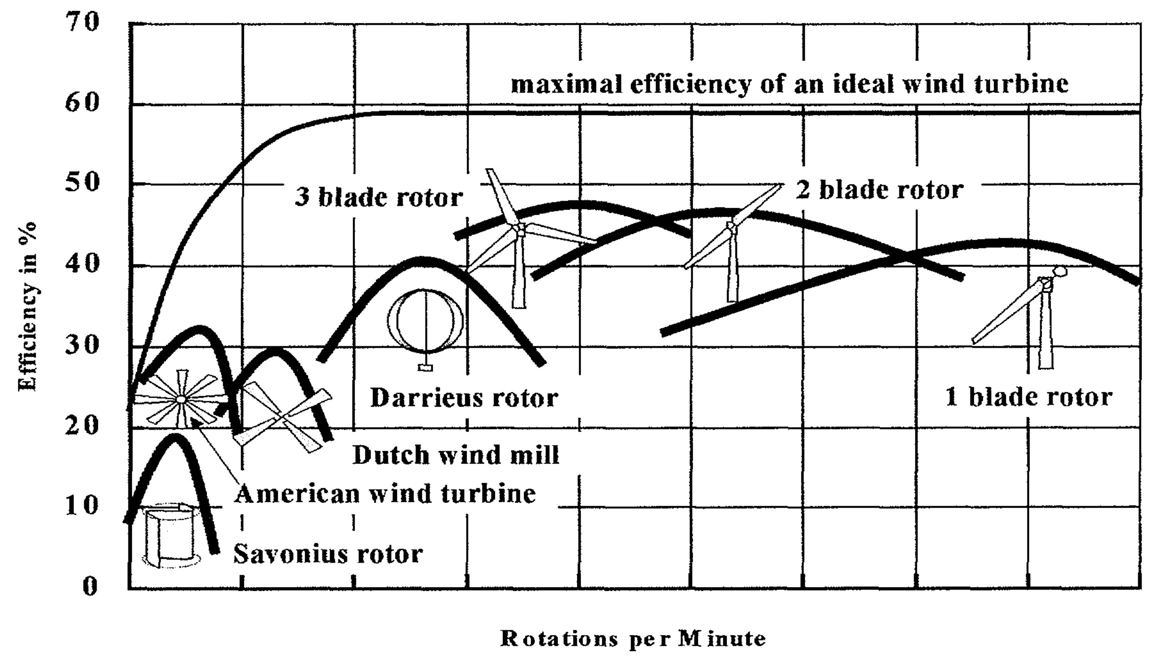


Figure 5.7-1: Wind technologies and their efficiencies

Wind energy increases with the third power of wind velocity. Maximum generator capacity is achieved at a wind speed of 10 to 14 m/s. If wind speed exceeds 25 m/s the generator can be overload. In order prevent damage the rotor blades either are formed in a way, that the wind flow tears-off behind the blades at high wind speeds (this is called stall control) or the blades can be turned around their longitudinal axis into idle position (which is called pitch control). **Figure 5.7-3** shows the area of losses of a wind plant. It can be seen, that the highest losses can be referred to the aerodynamics of the rotor blades.

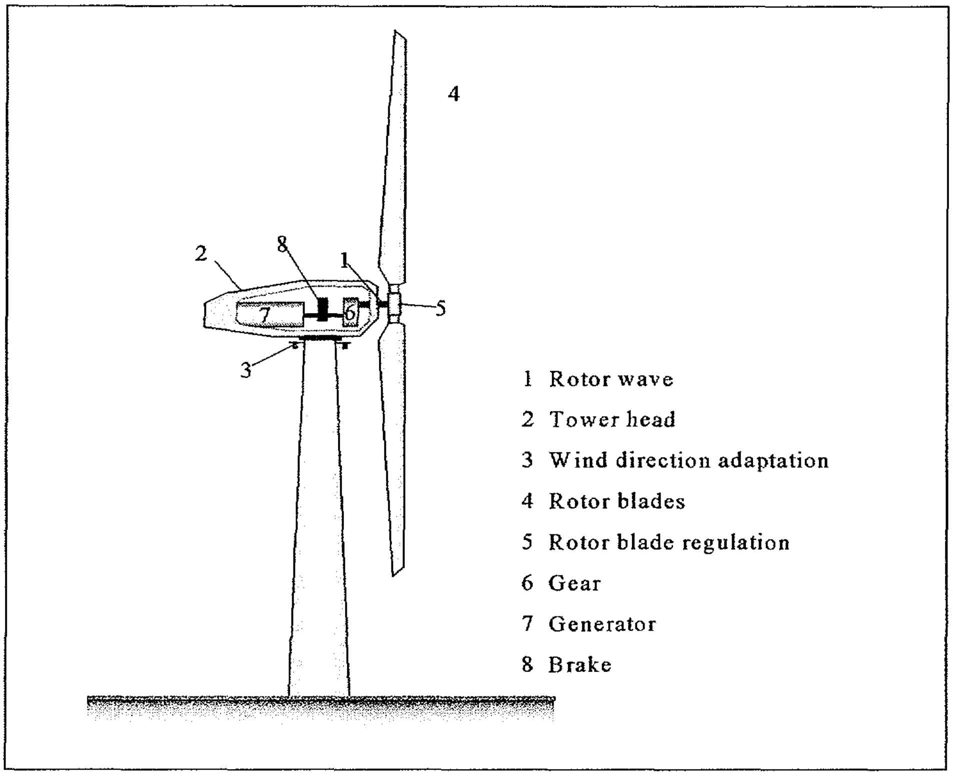


Figure 57-2: Scheme of a wind plant

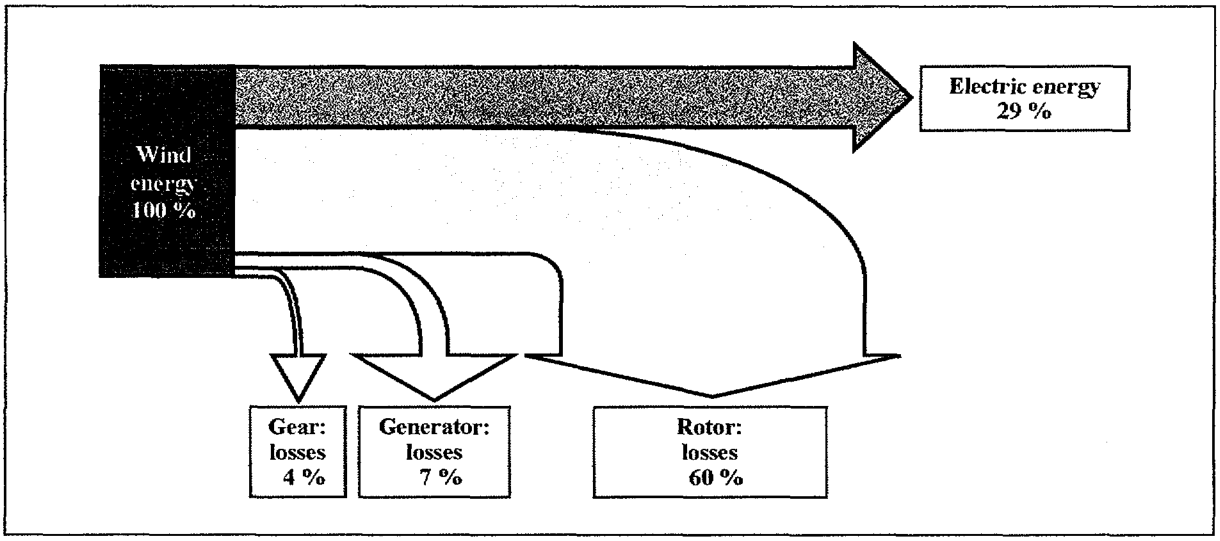


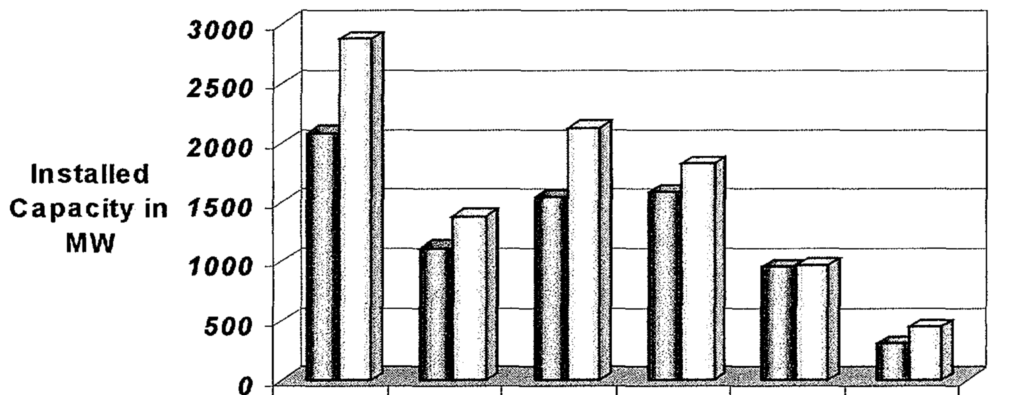
Figure 5.7-3: Losses of a wind plant

The wind power plants, primarily replace mid load coal plants and avoided **costs of 3.5 US¢/kWh** when wind covers 3.5 % of installed capacity and at avoided costs of 2.2 US¢/kWh when wind market penetration achieves 20 %.

Market and Costs of Wind Power

It can be seen from **figure** 5.7-4, that currently the wind power production is concentrated in 4 countries (Germany, Denmark, the USA and India) and one region (the European Union). The highest growth can be seen in Germany and other countries of the European Union. The high growth in Germany (see **figure** 5.7-5) as compared to other countries in Europe (like Austria, also shown in **figure** 5.7-5) can be accounted to following favoring conditions:

- the availability of average annual wind speeds with 6 m/s and more in flat or hilly areas (due to atmospheric conditions and the far distance to consumers, in mountainous areas there is only limited economic potential for wind power /xi/),
- the possibility to go off-shore, and
- favorable legislative and economic frame conditions, i.e. the obligation on power utilities to take all power from wind plants at prices, so called feed-in-tariffs, which fully cover the costs.



	Germany	Denmark	Rest of European Union	USA	India	Rest of World
1997	2080	1116	1543	1584	950	309
1998	2873	1380	2126	1819	968	449

Figure 5.7-4: Spread of wind power capacity over the world

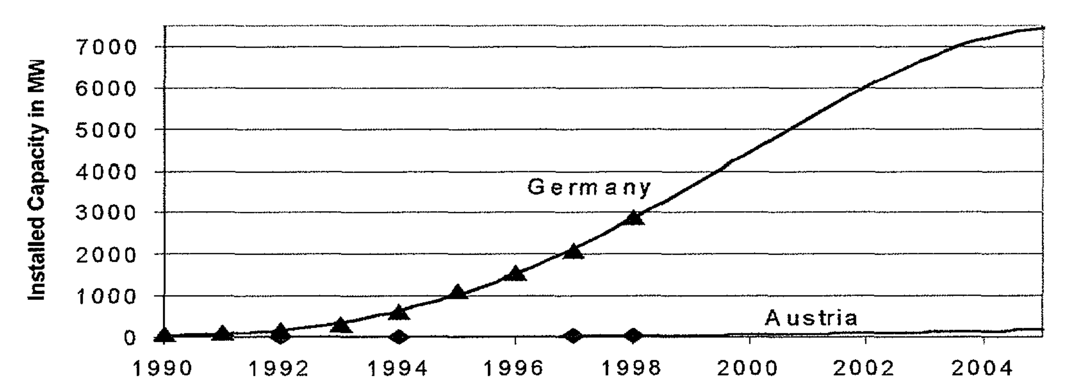


Figure 5.7-5: Market penetration of wind turbines in Germany and Austria

The market penetration of renewables for power generation on liberalized electricity markets will mostly depend on the legal and economic frame conditions. As can be seen from **figure 5.7-5**, the investment costs of renewable technologies like wind and biomass lie at approximately the same level as conventional coal or nuclear power plants, but lie on a considerably higher level than gas turbine or combined cycle power plants. The power generation costs from wind plants depend on the available wind speed (see **figure 5.7-6**), whereby currently in Germany the areas with an average wind speed of 6 m/s and more are exploited. The corresponding power generation costs covers the range from **5 to 10 US¢/kWh** with a typical value at **8 US¢/kWh** This is nearly double the costs of power from a gas turbine, at the additional disadvantages, that wind power is supplied stochastically and generation cannot follow the power demand without applying additional energy storage and power generation technologies.
Concepts for combining the wind turbine with another energy generation system, so called hybrid systems, e.g. with fuel cells are investigated, but not yet economic.

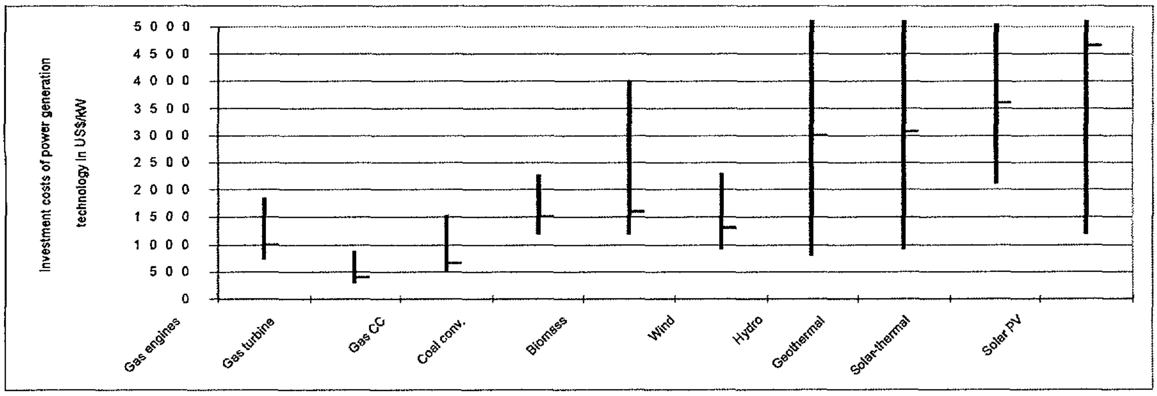


Figure 5.7-5: Investment costs of power generation technologies
(geothermal, solar thermal and PV from /xii/)

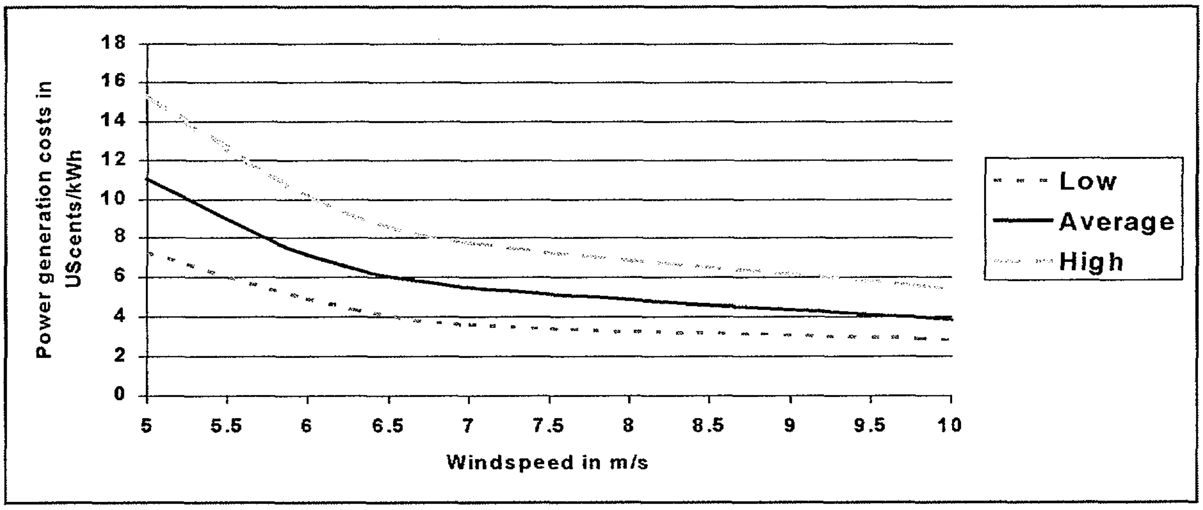


Figure 5.7-6: Wind power generation costs over available average speed in 10 meters above ground level

5.7.2 Available Ressources at the territory

Four meteorological stations in the locality with series of more than 10 year old of speed measurements of the wind. **The zone of greater magnitude is located all along of East and South coast**, besides there are zones with biological indicators that show constant winds of magnitude of practical interest for power generation . In accomplished local studies it has been determined a value of the

minimal monthly mean wind speed of 3,5m/s in August and the
maximum monthly mean wind speed of 4,5 m/s in January.

The principle applications of wind power energy would be the water pumping for the cattle raising and for cultivation in oven zones and for electrical generation for the territorial electrical system. /xl/

5.7.3 Economical Solution

Based on the figures handed over from ACYT and from the Direction of Planning for Isla de la Juventud-we checked all figures and prepared the following proposal for an useful installation of Wind-Craft-Plant at Island of Youth.
Our main idea is to use the energy from Wind-Craft-Plant for feeding the village Cocodrilo permanently with electrical energy (the existing DG-Units should be used as stand-by-equipment) , to operate the pumping stations from deep water well and to supply the remaining energy to the grid.

For energy supply to village of **COCODRILO** following basic data were estimated:
Operation of Diesel-Generator **2 h/day**,
Capacity of Diesel Generator approx.**370kW**.
Annual electrical energy generation = **271 MWh**.
Used amount of fuel = **75.440l**

The available measuring data for wind velocity do not show the exact point of measuring height. For useful data the velocity measuring point should not be lower then 100 m above ground level.

	Variante 1	Variante 2	Variante 3	
Average of wind velocity	4 m/s	4 m/s	4 m/s	
Generation of energy / kW installed power	970 kWh/kW.a	970 kWh/kW.a	970 kWh/kW.a	
Common size of Wind-Craft-Plant	500kW... 1MW	500kW... 1MW	500kW... 1MW	
Economical plant size	3,3 MW	3,3 MW	1MW	
Plant costs	3,3 Mio €	3,3 Mio €	1 Mio€	
Annual operation costs	30€/kW	30€/kW	30€/kW	
Lifetime for Wind-Craft-Plant	15a	20a	20a	
Generation cost for	0,1607€/kWh	0,15€/kWh	0,15€/kWh	

electricity by W-C-P				
Generation cost for electricity by using fuel				
Annual energy production	3,2 GWh	3,2 GWh	0,97 GWh	
Amount of saved fuel by energy-substitution with Wind-Craft-Plant	889.600l	889.600l	270.000l	

All 3 different projects are based on a connection to the grid to supply the additional energy to other consumers and to reduce the operation hours from the Diesel Engine Plant in Nueva Gerona.

5.8 Hydro-Power-Plant

5.8.1 Basic technological informations

With hydro power plants the targeted power generation capacity, the head and the water discharge flow determine the type of turbine to be used (see **figure 5.8-1** and **table 5.8-1**). The efficiency of the turbines are between 85 and 93 %. Hydropower units show excellent part load efficiency making them the plants of choice for load control and spinning reserve .

Aside of the turbine losses, 2-5 % losses for shift gear and auxiliaries, 1-5 % losses for the generator and 1-2 % losses for the transformer have to be taken into account.
The overall **efficiency** of a pumped storage scheme when also considering pumping and tubing losses lies at **70 %.**
Typical technical parameters for different size classes of run of river plants are shown in **table 5.8-2.**

Table 5.8-1: Field of application for different turbine types at mid to large capacity /vi/	
Turbine type	**Head in m**
Pelton turbine	600-2000
Francis turbine	30-700
Kaplan turbine, vertical axis	10-60
Kaplan turbine, horizontal axis	2-20
Discharge turbine	1-200

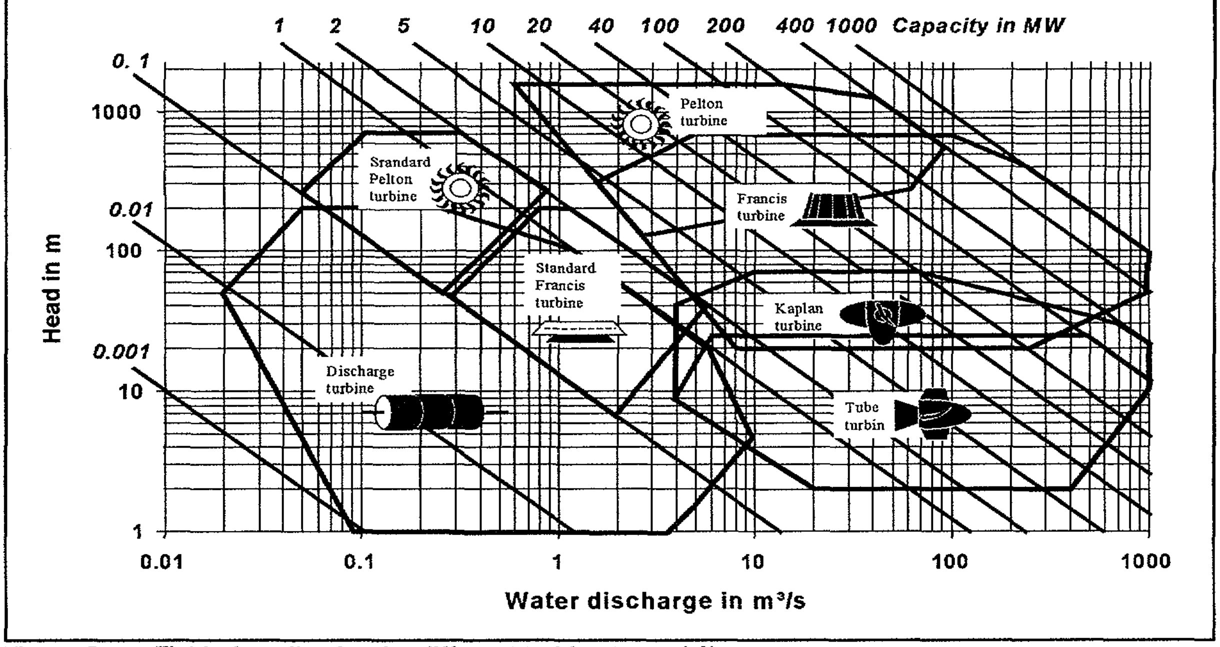


Figure 5.8-1: Field of application for different turbine types /vi/

Table 5.8-1: Technical parameters of typical run-of –river hydro power plants /vi/			
	Very small hydro plant	Small hydro power	Medium hydro power plant
Electrical capacity in kW	50	500	5000
Technical availability in %	99	99	99
Technical life time in a			
civil works	60	80	80
mechanical parts	30	40	80
Average full load hours in h/a	4500-5500	5000-6000	5500-6500

In spite of being a well established, conventional technology, with hydro power improvements and efficiency measures are needed in dam structures, turbines, generators, substations and transmission lines, and environmental mitigation technologies to sustain hydropower's role as a clean, renewable energy source.
An innovative development is the matrix-turbine, which utilizes the off-water from river-locks for producing electricity. In Freudenau/Austria such a matrix-turbine consisting of 5 times 5 small (200 kW each) turbines was constructed. In 6500 lock-cycles per year the 5 MW matrix turbine produces 3.7 GWh electricity at costs of 5 US¢/kWh. Investment costs are 1170 US$/kW. At higher head, the power generation costs can be a s low as 3.8 US¢/kWh /xiii/.

Figure 5.8-2 shows the investment costs of conventional small and medium sized run-of-river hydro power plants. It can be seen that this technology is characterized by a substantial economy of scale.

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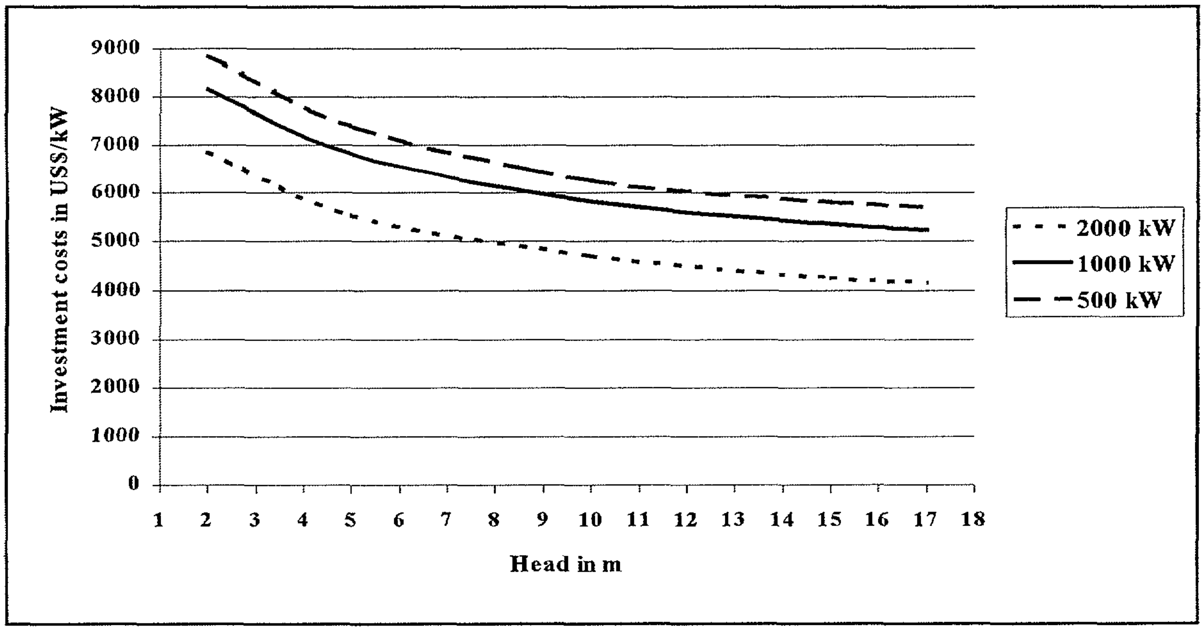


Figure 5.8-2: Investment costs of small and medium sized hydro power plants

The results of calculation for power generation costs from very small hydro power (< 500 kW) can be found in /x/. The results are shown in **table 5.8-2**.
At 5500 full load hours, O&M costs of 58000 US$/a, investment costs of 5.5 million US$, a discount rate of 4 %, a depreciation time for civil works of 80 years and a depreciation time of 40 years for the machinery, power generation costs for a typical 1 MW run-of-river plant lie at 5 US¢/kWh.

Table 5.8-2: Costs of power from hydro plant < 500 kW /x/

Investment costs	O&M costs	Full load hours		Power generation costs at 4 % discount rate		Depreciation period
US$/kW	US$/(kW*a)	kWh/(kW*a)		US¢/kWh		a
		Minimum	Maximum	Minimum	Maximum	
8342	107	5000	6000	9.2	12.5	30

5.8.2 Available Ressources at the territory

The dams of the island are of small hydraulic charges, with large spilling in rainy periods.
There are cases in which the dams spill one to the other and the water can be used for power generation several times.
The studies accomplished for the utilization of this energy source in the territory included 14 dams and 2 water jumps. /xl/
It was established that in all the dams there are conditions for the installation of micro hydro electric plants without large investments.
Preliminary studies demonstrate the possibility of installing a power capacity of 250 kW.
The power of the facilities is in the range of 20 to 60 kW . /xl/

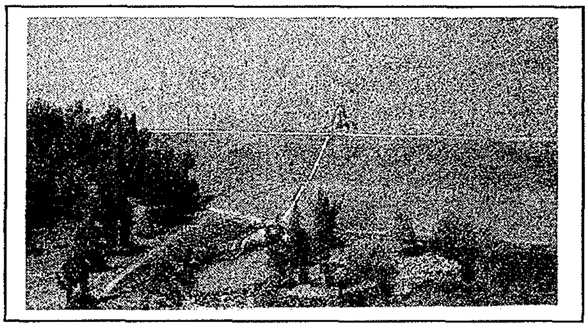
5.8.3 Economical Solution

Different possible locations for the installation of a small hydro power plants with Matrix-Turbines were investigated around the Island of Youth.
Economical circumstances do not give the possibility to install a small hydro power plant their.
We investigated also the possible installation locations at the Main Island Cuba.
At Cuba several projects show payback rates <5..7= years wherefore these small hydro power plants are pointed out within this report, too.

Operating efficiency and economy considerations for hydraulic-projects with a MATRIXTURBINE in CUBA

Name of the Plant	Location	Annual capacity (m^3)	Max. dam-height (m)	Q_{max} (m/s)	P (kW)	Production (GWh)	Payback-time with 5 Cents/kWh	Payback-time with 3 Cents/kWh
ALACRANES	Villa Clara	325 Mio	24,5	35,0	5.622	14,5	6 Years	5 Years
ZAZA	Sancti Spiritus	661 Mio	38,5	25,0	1.702	12,5	7 Years	5 Years
Protesta de Baraguá	Santiago de Cuba	298 Mio	43,0	35,0	3.159	7,5	16 Years	10 Years
Bueycito	Granma	194 Mio	42,0	20,0	1.856	5,0	>30 Years	10 Years

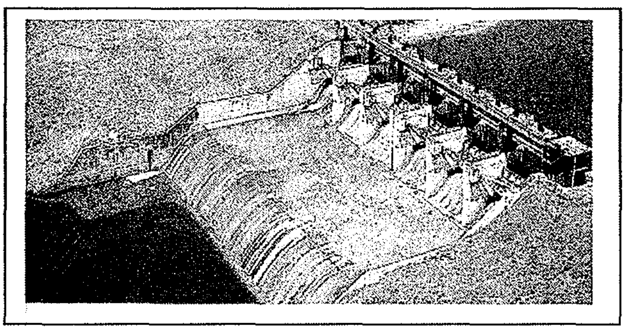
Parameters :
Invest costs : 2,0 ... 2,2 Mio US $
Interest : 7 %
Maintenance costs : 6.500 US $



ALACRANES, CUBA

P=5,622 kW , Q= 14,5 GWh ,
Invest costs = 2,18 Mio US$
Pay-back time (3 Cents) = 6 Years
Pay-back time (4 Cents) = 5 Years

Interest = 7% ,
Maintenance cost = 6.500 $



ZAZA SPIRITUS , CUBA

P=1.702kW , Q=12,5GWh
Invest costs = 2,12 Mio US$
Pay-back time (3 Cents) = 7 Years
Pay-back time (4 Cents) = 5 Years

Interest = 7% ,
Maintenance cost = 6.500 $

6. NECESSARY MEASURES

Following **main items are necessary to be realized**:

- Increase the safety in the energy supply and the electrification of the village COCODRILO
- Decrease the Greenhouse Gas Emission can be realized by using of alternative energy sources at the island (e.g. biomass plant, wind-craft-plant, electric cars, ...)
- Continuously measurements at 3 different location of the island (South-coast, West-coast, Surrounding of Nueve Gerona) could improve the expressiveness of solar-, and wind data which will be used as basic information's for further detailed investigations for implementation of alternative energy projects.
  The use of the newest instrumentation- and telecom-technology gives the possibility for atomization the measuring systems (Online-Measurements) by low operation costs to evaluate the data wherever they are needed.

An **advantage** for the inhabitants of the island could be the implementation of new technology for generation of electricity and to install additional jobs (e.g. forestry-manpower to care for the biomass , electrical and mechanical technician to operate the power stations,)
Increase the *gross internal product* of the territory.
Improvement of the quality of forests at the island.

6.1 Solar-Measurements

Regular measurements are needed for further detailed investigations.

6.2 Windspeed-/ Winddirection-Measurements

Wind measurements at height of 100m above ground level should be performed continuously to increase their expressiveness and accuracy.

6.3 Biomass-chemical analyses

6.2 Biogas- chemical analyses

The treatment of 144,5 Mm^3 of urban solids refuses lands 2.472,9 Mm^3 of annual waste water

7. FINANCIAL FRAMEWORK

7.1 General

The financing is one of the main barriers for execution this project .
With this aim ACYT foresee contributions from international institution for development, non-governmental organizations, lends from national and foreign banks and the foreign investments.

Legal Framework:
In relation with the energy activity it is ruled by laws and decrees elaborated with this purpose. At this time, the electrical law of the country is being studied.
In foreign investments matter there exists the law for the Promotion and Protection of the Foreign investment.

This law anticipates the economic associations between the Cuban and the foreign part, by means of Joint Venture companies as well as by economic contracts, the energy sector is included among the economic areas authorized for foreign investments.
In this legal framework they have already been accomplished two investments for power generation one by means of a Joint Venture company and the other one is own by the foreign part in a BTO contract.

7.2 Biomass-Plant

Expected costs of a biomass plant
(4MW-electr. : approx. 10,6 Mio €, 0,74MW-electr : approx. 3 Mio €)

7.3 Bio-Diesel-Generation

Experience of a research project are expected and will be added to this report a.s.a.p.

7.4 Biogas-Plant

Expected investment costs of a biogas-plant with an electrical capaicity of 100kW will be approx. 450.000 ... 500.000 US$

7.5 Testcars , driven by Accus

Clarification with supplier of Electrocars should be done separately

7.6 Testcars, driven by Fuel-cells

Clarification with supplier of Electrocars should be done separately

7.7 Wind-Craft Plant

Expected costs for a Wind-Craft Plant:
1MW –Plant : approx. 1Mio €
3,3 MW-Plant : approx. 3,3 Mio €

/i/ Obernberger, I.; Hammerschmid, A.; Dezentrale Biomasse-Kraft-Wärme-Kopplungstechnologien; bm:wv Schriftenreihe Thermische Biomassenutzung, dbv-Verlag, Graz, (1999)

/ii/ Energy Efficiency and Renwable Energy Clearinghouse; Biomass Used for Power Production; http://www.nrel.gov/research/industrial_tech/power.html

/iii/ US Department of Energy, Office of Solar Thermal, Biomass Power and Hydrogen Technologies; DOE Biomass Power Program – Strategic Plan 1996-2015

/iv/ Schoofs, S., Lang, J.; PEM-Brennstoffzellen; BINE Projekt Info-Service, ISSN 0937-8367, Nr. 7/Oktober 1998

/v/ Deutscher Wasserstoff Verband; Hattrick fuer die Brennstoffzelle; Pressemitteilung Nr. 2/99, http://www.dwv-info.de/pm_9902.htm

/vi/ Kaltschmitt, M., Wiese, A. (eds); Erneuerbare Energien; Springer, Berlin, 1995

/vii/ National Laboratory Directors; Technology opportunities to reduce U.S. greenhouse gas emissions; http://www.ornl.gov/climate_change, October 1997

/viii/ Notton, G., et al.; Costing of a stand-alone photovoltaic system; Energy, 23 (1998) pp. 289-308

/ix/ Trieb, F., et al.; Markteinfuehrung solar-thermischer Kraftwerke; Energiewirtschaftliche Tagesfragen, 48 (1998) 6, pp. 392-397

/x/ BINE; Erneuerbare Energien in Deutschland; ISSN 0937-8367, Nr. 5, September (1998)

/xi/ Zeinhofer, H.; Neue Energie-Techniken – Energie-Spar-Ratgeber; EnergieAG Oberösterreich (1999)

/xii/ Gruebler, A., et al.; Dynamics of energy technologies and global change; Energy Policy 27 (1999) 247-280

/xiii/ ku; Matrixturbinen: Billiger Strom aus Kleinstkraftwerken?; Presse, 25.04.2000, p. 14