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Stockholm 2005

Cooperation: Chilean Energy Commission, UNDP and GEF

Company: 5G Consultants

Date: 2005-02-19

Project for Energy and Power System Supply for Easter Island (Rapa Nui) using Renewable Energies

CONTENT

Abstract

Basically the Project Management Plan for Energy and Power Supply for Easter Island Using Renewable Energies Project has a defined route map. This map includes project introduction, overview of the project, detail planning and schedule, risk management, and project cost and benefit analysis project.

Introduction

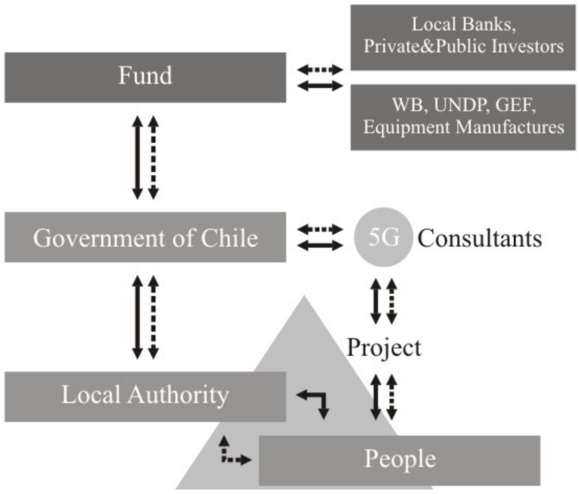

Figure 1: Operation Structure of the Project

5G *Consultants* are proposing this project on the Tender of Chilean government for energy and power supply for Easter Island using renewable energies as part of Chilean strategic plan to improve access to basic services in isolated areas by exploiting alternative sources of energy and transferring applicable knowledge. *5G Consultants* provide consultation and management services to Government of Chile and Local authority of Isla De Pascua for this project. The concept of this project can be found in Appendix 1.

5G Consultants' main goal is to create public preference oriented project, which will integrate education, infrastructure and energy into independent system of renewable energy production combined with environmental awareness. *5G Consultants* are proposing experimental models of infrastructure and energy which are coordinated by *Centro Educacional para el fomento de las energías Renovables,Ecoturismo y Conservación del Patrimonio(CEREC)* that serves the local community from social, energy, environmental, infrastructure and economics perspective.

Overview of the Project

In order to fulfill the final target:

- *Provide Easter Island with continuous electricity and hot water supply using renewable energies*
- *Transfer technology to the local public, and create employment opportunities*
- *Contribute to the island's development and improve local public's living quality*

The project addresses three objectives:

- *Three renewable energies are planned to be used in Easter Island, which are geothermal, biogas and thermal solar, in order to get the best solution for local economy, energy demand, population growth and natural resources.*
- *Technology transfer in order to achieve the maximum value of local human resources and natural resources and educate the islanders with environmental management and renewable energy technology, cultural changes and preserving of tradition, and create additional employment opportunities.*
- *Associated infrastructure as the accessory for energy transportation and distribution is planned in this project to provide the end-users' energy demand.*

The project framework is attached in the Appendix-2 as GANTT Chart.

Detail Planning and Schedule

1. ***Education***

Education, as the first step of the whole project, holds the obligation to reduce resources and social risk and to ensure the fulfillment of the project. Technology transfer as one part of the education fulfills the obligation to help islanders make some product locally in order to reduce investment and cost for backup equipment and operation. The measurement steps are explained below and the detailed explanation is attached in the Appendix-3.

- Adaptation Measurement is the initial stage for information collection and technology settlement.
- Adaptability Enhancement is to build “Know How” system and to educate islanders to build their own better island.

2. ***The Choice of Renewable Energy***

The choices of the renewable energy are based on a comprehensive comparison. The contents include the local information, which is studied from the Tender for the Government of Chile, the current market situation, cost, risk, environmental impact, the technology developing stage, the advantage and disadvantage of each energy, and the feasibility based on social and environmental reasons. The five candidates are: Wind Energy, Solar thermal Energy, Biogas Energy, Geothermal Energy and Wave and Tidal Energy. The table of comparison is in Appendix-4. *The final choices are:*

- *Thermal Solar energy for hot water supply in Easter Island*
- *Biogas for islanders' cooking resource*
- *Geothermal Energy for power supply in Easter Island*

3. ***Overview for Renewable Energy Supply***

The settlement of renewable energy supply will be divided into two steps.

– The First Step: supply hot water by install Solar Thermal Collector into houses and public buildings. This phase considers a part of the education program, and it would last for two years for the whole island. In the mean time, the current thermo-electric plants will keep running for the electricity supply and propane gas will still be used as cooking resources in the island.

– The Second Step: Twenty wastewater treatment plants and biogas plants will be built in the city of Hanga Roa, integrated in the neighborhoods pyramids. The biogas will be used as cooking resource. A six MW geothermal energy plant appears as the best choice for electricity supply. Building works for the plant will take three years, and they will be based on previous research. In this stage, the application of thermo-electric plant and propane gas will be progressively decreased.

4. ***The Description of Energy Supply***

- *Hot Water Supply*: Considering the advantaged climate in Easter Island, together with the mature technology and low cost, the **thermal solar system** is the best choice for the hot water supply in the local place. *The solar hot water system is easy to install and operate. Householders are free to participate on the educational program and build their own collector system, or buy a “ready to install” one.* The final installation and inspection will be done by technicians. Description of thermal solar system in Appendix-5.

Technology: Indirect water heating system (2 water circuits). Plane collectors with glass cover.
The Total Cost for all the houses: 2,158,000 USD

- *Cooking:* The absence of wastewater treatment system in Easter Island has a high potential in polluting underground water (drinking water source in Rapa Nui). *The build of biogas plant with a wastewater treatment plant can solve both cooking resource and the water pollution problems.* The biogas will be bottled and distributed in the same way it is done now. Description of biogas plant is in Appendix-5.

Energy Source: Human waste and animal waste, mainly using cow waste
Technology: Anaerobic digestion
Total Cost: 1,200,000 USD (60, 000 USD per plant)
Capacity: 98100Kg/year

- *Electricity:* The local geothermal resource is hot liquid with temperatures greater than about 200 ° C (World Energy Council, 2001) and the temperature is suitable for power plant. Moreover, considering the high potential of geothermal in local place, the geothermal energy is decided to be the electricity supplier in Easter Island. Description of geothermal power plant and detailed costs are in Appendix-5.

Technology: binary plant, based on kalina cycle
Capacity: 6 MW
Total Cost: 6,024,000USD (includes research, design, exploration, development and construction)
Approximate Oil Saving: 98%

5. *The Upgrade for Local Infrastructure*

Associated local infrastructure system is necessary for the future application of renewable energy. The upgrade of infrastructure system is listed below. *However, firstly the possibility of using current infrastructure will be studied as one part of education.* Moreover the wastewater treatment plant was considered as one part of infrastructure, which services to reduce pollution and provide raw material for biogas digester.

– *For Thermal Solar Energy*: Installing hot water solar collectors, reinforce the roofs of local houses, hot water supply system rebuilding in single house
– *For biogas plants*: Wastewater transportation system upgrade, the build of wastewater treatment plant, and the transportation of biogas to the local families
– *For geothermal power plant*: rebuilding power lines and appropriate safeguard for potential environmental impact from geothermal plants and other infrastructures

Description of upgrade local infrastructure is attached in Appendix-6.

Project Finance Management Plan

According the Project planning Finance Management Plan is made. The first stage in project implementation is establishment of *Centro Educacional para el fomento de las energías Renovables,Ecoturismo y Conservación del Patrimonio(CEREC)*. The next stage is development of infrastructure and energy part (see Appendix- 2).

Chose strategy for Project Finance Management Plan is portfolio - financing mechanism.
Chilean government has set strategic targets to be achieved with assistance of World Bank. Therefore as coherent is chose to use UNDP and GEF mechanism Special Purpose Fund in order to manage the found made form Risk Capital, Mezzanine finance and Consumer Finance (UNEP, 2004). Risk Capital approach

is used if equity investment comes from strategic investors - equipment and material manufacturers (44% from total portfolio). Mezzanine finance instrument is used in developing countries and groups together financing package characterized as "high risk/high upside equity position and the lower risk/fixed returns debt position" (47% from total portfolio). Consumer Finance approach involves risk sharing at the local and institutional levels (9% from total portfolio).

Risk management

Chosen risk management approach for Energy and Power System supply for Easter Island is risk diversification through portfolio effect and risk sharing arrangements. In order to 'smoothing' cash flow Revenue / Income Protection mechanisms are considered as necessary.

The risks can be divided in four groups:

- To deliver the project to society and minimize risk that the project will be not accepted, vast education programme is foreseen as part of the project.
- To minimize the risk of interrupted power supply, the Energy and Power Supply System in Easter Islands is proposed to be organized as follows: hot water supply for single housing and public service is based on solar thermal hot water system; cooking from biogas energy. Standby power supply is ensured from geothermal electricity – generation plant. Industrial and public facilities receive power supply from geothermal electricity – generation plant and for primary importance objects alternative power supply is ensured.
- Technology dependent risks and means of mitigation are listed in Appendix-7**.**

Financial risk management instruments adapted for Renewable Energy Technology are Alternative Risk Transfer products, particularly, Finite Risk and Contingent Capital Programs. As a risk management measure, mitigation against possible adverse external events Chilean Government has selected the Deferred Draw-down Option (Chile CSA, 2005).

Project Cost Benefit and Feasibility Analysis

The total physical input for the Easter Island project is 9 384 326 USD.
The cost benefit analysis and feasibility studies for business sector and society see in Appendix 8 and 9(A,B). Feasibility studies show that the project will increase communities' economic welfare. (MNDP, 2005) Project creates social benefits greater than social costs (soc-ec. benefits 3,7 Mil $ and soc-ec. costs 1,6 Mil $).

Table 1: Investment Issues and Total Cost

Investment Issues	**Amount (USD)**
Total	**9 384 326**
Education & research institute	300 000
Upgrading of the Rural Area Single Family Houses as Single Systems	326 040
Upgrading of the Base Neighborhoods and Construction of 20 Pyramids	2 668 286
Geothermal electricity – generation plant	6 054 000
Research and consultancy	36 000

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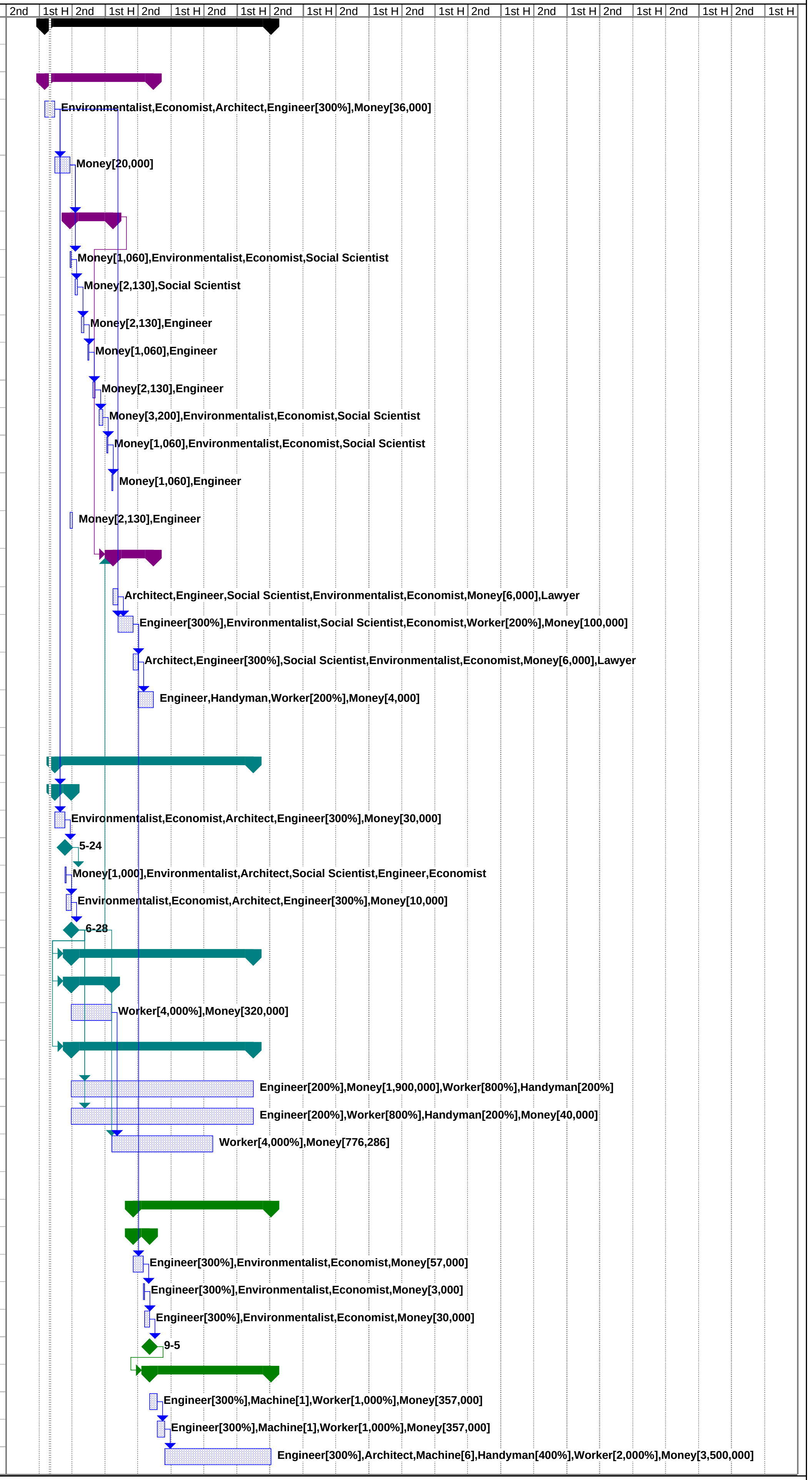
APPENDIX 2 Rapa Nui GANTT Chart

ID		Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		**Rapa Nui Project**	**895 days**	**Wed 05-2-2**	**Tue 08-7-8**		
2							
3		**Education**	**430 days**	**Wed 05-2-2**	**Tue 06-9-26**		
4		Baseline Research Project for Infrastructure and Energy and enhance the public awareness towards the project	2 mons	Wed 05-2-2	Tue 05-3-29		Environmentalist,Economist,Architect,Engineer[300%],Money[36,000]
5		Establishing the CEREC for Renewables, Preservation of Cultural Heritage and Eco-tourism	3 mons	Wed 05-3-30	Tue 05-6-21	4	Money[20,000]
6		**Sustainability Seminars and Training for the Local Community**	**170 days**	**Wed 05-6-22**	**Tue 06-2-14**	**5**	
7		Seminar on the Concepts of Sustainability	1 wk	Wed 05-6-22	Tue 05-6-28	5	Money[1,060],Environmentalist,Economist,Social Scientist
8		Seminar on Cultural Changes and Preserving of Tradition	2 wks	Wed 05-7-20	Tue 05-8-2	7FS+15 days	Money[2,130],Social Scientist
9		Seminar on Hot Water Collector Systems	2 wks	Wed 05-8-24	Tue 05-9-6	8FS+15 days	Money[2,130],Engineer
10		Seminar on Photovoltaic Collectors Systems	1 wk	Wed 05-9-28	Tue 05-10-4	9FS+15 days	Money[1,060],Engineer
11		Seminar on Renewable Energy Systems	2 wks	Wed 05-10-26	Tue 05-11-8	10FS+15 days	Money[2,130],Engineer
12		Seminar on Saving Water and Energy	3 wks	Wed 05-11-30	Tue 05-12-20	11FS+15 days	Money[3,200],Environmentalist,Economist,Social Scientist
13		Seminar on Green Sign Product Consumption	1 wk	Wed 06-1-11	Tue 06-1-17	12FS+15 days	Money[1,060],Environmentalist,Economist,Social Scientist
14		Seminar on Grey Water Treatment Systems	1 wk	Wed 06-2-8	Tue 06-2-14	13FS+15 days	Money[1,060],Engineer
15		Seminar on Wastewater Treatment Systems	2 wks	Wed 05-6-22	Tue 05-7-5		Money[2,130],Engineer
16		**Research Projects, Monitoring and Evaluation**	**160 days**	**Wed 06-2-15**	**Tue 06-9-26**	**28,6**	
17		Public Participation	1 mon	Wed 06-2-15	Tue 06-3-14		Architect,Engineer,Social Scientist,Environmentalist,Economist,Money[6,000],Lawyer
18		Research project for the location of the Geothermal plant	3 mons	Wed 06-3-15	Tue 06-6-6	17,4	Engineer[300%],Environmentalist,Social Scientist,Economist,Worker[200%],Money[100,000]
19		Review of the Strategy Project for Energy and Infrastructure project	1 mon	Wed 06-6-7	Tue 06-7-4	18	Architect,Engineer[300%],Social Scientist,Environmentalist,Economist,Money[6,000],Lawyer
20		Research and Monitoring project for installated hot-water collectors	3 mons	Wed 06-7-5	Tue 06-9-26	19	Engineer,Handyman,Worker[200%],Money[4,000]
21							
22		**Infrastructure**	**785 days**	**Wed 05-3-30**	**Tue 08-4-1**		
23		**Strategy Project for Infrastructure**	**65 days**	**Wed 05-3-30**	**Tue 05-6-28**	**4**	
24		Design of the Project	2 mons	Wed 05-3-30	Tue 05-5-24	4	Environmentalist,Economist,Architect,Engineer[300%],Money[30,000]
25		First Version of the Project	0 mons	Tue 05-5-24	Tue 05-5-24	24	
26		Public Participation	1 wk	Wed 05-5-25	Tue 05-5-31	25	Money[1,000],Environmentalist,Architect,Social Scientist,Engineer,Economist
27		Review of the Project and Final Decision	1 mon	Wed 05-6-1	Tue 05-6-28	26	Environmentalist,Economist,Architect,Engineer[300%],Money[10,000]
28		Final Version of the Project	0 mons	Tue 05-6-28	Tue 05-6-28	27	
29		**Construction Phase**	**720 days**	**Wed 05-6-29**	**Tue 08-4-1**	**28**	
30		**Upgrade of Single Family Houses (rural area**	**160 days**	**Wed 05-6-29**	**Tue 06-2-7**	**28**	**Money[273,700],Architect,Engineer,Handyman[500%],Machine[1],Worker[1,200%]**
31		Installing Hot Water Solar Collector System	32 wks	Wed 05-6-29	Tue 06-2-7		Worker[4,000%],Money[320,000]
32		**Upgrade of Base Neighborhood and Constructing Pyramid**	**720 days**	**Wed 05-6-29**	**Tue 08-4-1**	**28**	**Architect,Engineer[300%],Handyman[2,000%],Machine[6],Worker[4,000%],Money[1,825,000],Craftsman[2,000%]**
33		Constructing the Pyramids (biogas and wa	36 mons	Wed 05-6-29	Tue 08-4-1	28	Engineer[200%],Money[1,900,000],Worker[800%],Handyman[200%]
34		Wastewater Pipelines	36 mons	Wed 05-6-29	Tue 08-4-1	28	Engineer[200%],Worker[800%],Handyman[200%],Money[40,000]
35		Upgrading of Single Family Houses (Hanga Roa)	20 mons	Wed 06-2-8	Tue 07-8-21	28,31	Worker[4,000%],Money[776,286]
36							
37		**Energy**	**545 days**	**Wed 06-6-7**	**Tue 08-7-8**		
38		**Strategy Project for Energy**	**65 days**	**Wed 06-6-7**	**Tue 06-9-5**		
39		Design of the Energy Strategy Project	2 mons	Wed 06-6-7	Tue 06-8-1	18	Engineer[300%],Environmentalist,Economist,Money[57,000]
40		Public Participation	1 wk	Wed 06-8-2	Tue 06-8-8	39	Engineer[300%],Environmentalist,Economist,Money[3,000]
41		Review of the Project and Final Decision	1 mon	Wed 06-8-9	Tue 06-9-5	40	Engineer[300%],Environmentalist,Economist,Money[30,000]
42		Final Version of the Project	0 mons	Tue 06-9-5	Tue 06-9-5	41	
43		**Geotermal Plant**	**480 days**	**Wed 06-9-6**	**Tue 08-7-8**	**42**	
44		Prospection Phase	6 wks	Wed 06-9-6	Tue 06-10-17		Engineer[300%],Machine[1],Worker[1,000%],Money[357,000]
45		Development Phase	6 wks	Wed 06-10-18	Tue 06-11-28	44	Engineer[300%],Machine[1],Worker[1,000%],Money[357,000]
46		Construction Phase	21 mons	Wed 06-11-29	Tue 08-7-8	45	Engineer[300%],Architect,Machine[6],Handyman[400%],Worker[2,000%],Money[3,500,000]



Project: Rapa Nui Project
Date: Sat 05-2-26

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

The Comparation of Different Renewable Energy

	Wind Energy	Solar Energy (Solar thermal energy)	Biomass/Biogas Energy	Geothermal Energy	Wave and Tidal Energy
Resource Siutaion in Easter Island	The average annual wind speed is around 4m/s, and the monthly peak is 19.2m/s.	400-500W/m2	Available resources include sewage sludge, waste water and animal waste	The Island has a high geothermal potential from the non-active volcanoes.Based on the research for Chile, The type of resource should be high temperature hot water	Energy capacity 30-40 kW/m
Advantage	1.Green power, no hazardous emissions, and no adverse environmental impacts. 2.The energy is free and locally available	1.Green energy,clean and without emissions to the air. 2.Solar energy is free. 3.If possible, the existing pipes still can be used for hot water in single house.	1. Systems can be heat only, electricity only or both. 2.The daily waste can be used locally and improve the local sanitation situation and decrease the ground water pollution from infiltration of black water.	1.Reduce emission of green house gases and minimal land use. 2.Locally available – reduce reliance on fossil fuel. 3.Reliable because it can supply power 24 hours.	Different system types will have different advantage. The main advantage for the off-shore system is the operation of the plant is easy and has little visual impact.
Disadvantage	1.Expensive as compared to conventional source of electricity,especially as hot water supply resource is extremely expensive. 2.Wind is intermittent and it does not always blow when electricity is needed, thus needs energy storage devise or back up system.	The technology has the shortages like depending on the weather,especially the sunlight intensity , hot water is not available during the night.	1. The emission can not be avoided but can be offset against reduced need for energy generation.The emission is lower than the conventional energy plant.	1.High initial investment cost and sometimes difficult task to reach the source, but different based on local situation. 2.Release of hydrogen sulfide and disposal of geothermal fluid affect human health, and thus good air quality has to be maintained in the plant.	1. High initial investment cost 2.For the on-shore system, the visual impact should be considered and for the off-shore system, the operation is much more diffcult. For both systems, the suitable location for wave and tidal energy plant is rather rare and civil engineering work is difficult on a wave-exposed shore.
Environmental Impact (Visual Impact)	Mostly they are noise and visual effects from the wind turbine. Impacts on terrestrial ecosystems , may not be that much considerable as the Island doesn't need large wind farm. Other impacts are affecting birds life,high accidents and interference with electromagnetic communication systems.	The environmental impact was considered very small. The materials used are those of everyday buildingand plumbing. Solar collectors can have a small visual impacton house, but can be avoided by using new product.	Energy recovered is renewable and can offset non-renewable sources and contributes to reducing anthropogenic sources of greenhouse gases.It contributes to sustainable waste management. Moreover, nutrients can be returned to the land and the effect to the farm will be lower and in the mean time, it help to improve soil structure due to the application of organic matter. Because the plant we considered is underground, so there is no visual impact.	The impacts show as deposition of wastesoil and drill mud, and steam and spray can have a small adverse effect on the local vegetation with trees and grass being scalded, small subsidence and increased microseismic activity, and small release of hydrogen sulfide and disposal of geothermal fluid, and also mminimal emissions of CO_2 . The plant is not considered with high visual impact.	Wave and Tidal Energy are green energy, but they still have some environmental impacts.The sheltering effect is the one should be considered and also the effect to the local fishing industry. The main environmental impacts of tidal energy are due to the changes of water levels which modify currents, and sediment transport and deposit. On-shore system has large visual impactthe off-shore system has little visual impact.
Technology Developing Stage	Wind energy has matured, but it is far from being a mature technology.	Solar thermal applications have been proven to be durable and reliable and therefore can be considered as a fairly mature technology.It is a proven technology for domestic water heating (household and large scale), and for swimming pool heating.	Technologies for digester of sewage sludge, industrial sludges and waste water are fully commercialised.	1. Heat exchange technology and heat pumps are widely available. 2.Hot Dry Rock technology is still in an early research and development phase. In this project, the type of resources is hot water.	The variability of real ocean waves represents a problem for wave energy utilization. The effect between different basin in tidal system make the efficiency of turbines much lower than the design efficiency.
Current Market Situation	Wind energy has shown strong growth over the last 5 years.	Domestic water heating for households is the main application around the world. Today's marketplace offers high quality products and the installation of reliable systems.	The highest current development rates are currently in Asia.	For hot waters extracted from aquifers at moderate temperatures, in the range 50°C to 150°C, can be used for heating purposes including district heating. Higher temperatures of 150°C+ allow electricity to be produced.	1.Many wave energy devices remain at the research and development stage and have not yet to enter the market. 2.Several tidal barrage sites is studied worldwide,but these studies have not led to industrial implementation,plus the planning and construction times for tidal are typically long at 5 to 10 years.So the current market situation is not satisfied.
Total Cost in Easter Island Project	16.95Million USD	1.082 Million USD	1.2 Million USD	6.0 Million USD	61.2 Million USD
Risk	1.Uncertainty in the power purchase price is one risk. 2.Plant life and reliability is low. 3.Uncertainties in the resource is another problem.	1.The technology has been proven to be reliable, therefore technical risk is low.	1.This area of risk needs to be addressed on a country by country basis due to varying circumstances. 2.The current uncertainty in markets for the digestate represents a commercial risk which impacts on the technology's costs.	1.Regarded as a high risk investment relative to other forms of energy production. 2.Technologies which attract a high risk premium are difficult to finance without insurance policies. In this project, the reource is high potential and the information was proved by specialist.So the risk could be lower,	1.Many current uncertainties on cost and performance make the technology with high risk. 2.Most wave energy technologies have yet to develop a proven track record. 3.Tidal energy projects require very high capital expenditure at the outset, and so have relatively long construction periods and low load factors, leading to long payback periods.
Limitations in Easter Island Project	Need detailed investigation at daily and hour wind speed data to determine its feasibility. Currently, no sufficient data is available.	The data of daily sunlight intensity should be provided.Currently,the result of energy capacity and cost is based on the annual average temperature. The cost result will have small changes.	No technology limitation in this currently.	Need further research on type of resources and detail exploration report.	Need much more detailed wave and tidal data.
Feasibility	The average annual wind velocity is not so encouraging for efficient and economical reasons in Easter Island Project.	The solar thermal system for heating water is a good choice when considering the local reourses situation, with low risk and low cost.Solar thermal electricity technology and PV cell technologies are not currently considered in this project due to the high cost,low efficiency and large land use.But it is considered in the concept of housing part and the detailed information will be available after researching in Easter Island. It is feasible in this project.	The low cost,ease to operate and without technology limitation in this project make the biogas energy become a good choice in current stage. In this project, the biogas was considered as low risk. Biogas is feasible in this project.	Geothermal can be used in Easter Island due to the high potentiality,but further research are strongly supported.	The effect to fisher men must be considered and the initial cost is higher than the other renewable energy. Many uncertainties make the wave energy not feasible in this project.

Main Data Source: 1.Home of BEER(2003) Renewable Energy accessed on 19-02-2005 http://www.arch.hku.hk/research/BEER/renew.htm

Education Methodology

Objectives

- Baseline research as the foundation of the fulfillment of the project in renewable energy resources and social-economy field
- Technology education transfer based on the project's need and local public's willingness to learn
- Generate public interest and support together with culture- economy knowledge transfer

Barriers

Based on the initial communication with Georgia Lee, Ph.D. & Easter Island Foundation and Jo Anne Van Tilburg, Ph.D. & Director of Easter Island Statue Project, and the current investigation, this project addresses the potential technology and social barriers in *Table 1*.

Approach

Due to the high risk of the project and in order to ensure the success of it, *Centro Educacional para el fomento de las energías Renovables,Ecoturismo y Conservación del Patrimonio (CEREC)* will be established in Easter Island working on conquering the barriers. The approach methods and measurements are listed in *Table 1*.

Future Directions

- Continued renewable research and its application and contribution in local economy
- Transfer cultural heritage and preserving of tradition, sustainability and environmental protection knowledge to Easter Islanders

Table 2: Local Barriers and Approach Processes

Barriers		Approach Method and Measurements
Technology Barriers	Insufficient renewable energy resources information	At the beginning, a serial of researches will be processed in order to find the best location for the geothermal plant and detailed local climate condition to ensure the accuracy of the chosen technology.
	Construction land use and building permission	Different measurements will be taken based on whose land will be used for the plants. To reach these targets, negotiations with local public, local companies and meetings with people involved are very necessary.
	Shortage of local construction code and standards	Chile's construction code and standards will be used as the first reference. Other successful projects' code and standard will be considered as secondary reference in similar islands.
	Unknown Current situation of applicable public infrastructure	Investigation on local infrastructure is to find out the best solution for wastewater transportation, electricity lines and best location for biogas plants. The possibility of using the current system will be considered.
	Undeveloped technology leads to most of the project equipment depending on oversea support.	Providing technology support and cooperating with local companies to maximize the local technology conditions are the initial steps to achieve product localization, in order to reduce transportation cost, long term investment on thermal solar equipment and supply of spare product.
Social and Human Resource Barriers	Lack of public support and awareness	A serial of poll and activities will be taken in local communities to generate public support and interest in renewable energy. Private meetings, seminars, negotiation and financial support will be used.
	Lack of skillful local labors serving for the project	Firstly transfer technology including construction, installation, operation, and management to skilled locals, which are needed in infrastructure and energy projects. Then majority of then were paid to work for the project, and others transfer information and technology into communities.
	Lack of environmental management technology	Enhance the awareness of environmental protection. Provide waste and wastewater handling technology and saving energy and water measurements.

<u>Note</u>: Education time line can be found in project framework (*Appendix 1*).

The Description of Energy Supply System

a) THERMAL SOLAR ENERGY - *Hot water Supply*

Table 3 The Local Climate Description (Without data showing cloudy days):

Average Temperature, Precipitation, & Humidity												
Temp (° *C*)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Temp	26	27	26	24	24	20	20	20	20	22	23	23
Min Temp	19	19	20	18	17	16	15	15	15	15	17	18

The average temperature in Easter Island is 18 ° *C.*

2. The Hot Water System for Family Houses:

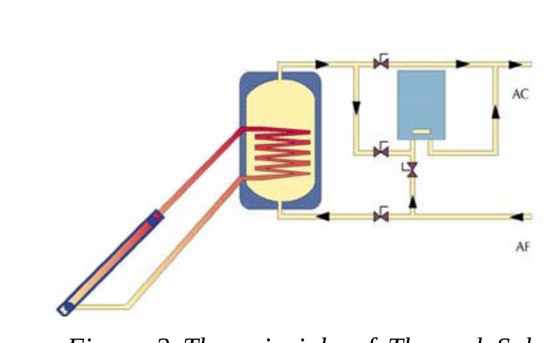


Figure 2 The principle of Thermal Solar

The solar hot water system is used for sanitary hot water (home use). The specifications of the system are natural flow of water (no pumps needed), plane collectors with glass cover and indirect heat exchange with 2 circuits (the water used is not the water that circulates through the collector). This set up is preferred here although the efficiency is lower. Water is heated as it circulates through solar collectors, which are located on the roof of the house. The heated water is then stored in an insulated storage tank. An auxiliary biogas boiler is also included in the system, to boost water temperature on days when solar energy may be insufficient to meet all your hot water requirements.

Specifications of Single House System: **175 litre** tank that yields to **2.5 m^2** of collector surface.

Average efficiency: between 45-55 %

Number of people	1-2	3-4	5-6
Hot water load	Small load	Average load	Large load
Daily capacity	80 - 120 liters	120 - 200 liters	More than liters

Table 4: System Size

Based on the correlation used by the PROSOL program (Spain 2005) the reference price of such system is:

FINAL PRICE = RPIN + RPW

RPIN = RPIB · TF + RPIB · E + RPIB · IF · TF ; RPW = 0.1 · RPIB

RPIB	Base reference investment price	1299.98 USD
TF	Type of installation factor	1,12
E	Efficiency factor	0,12
E	Integration factor	0,07
RPIN	Reference price of investment	1732.67 USD
RPW	Reference price of warranty	173.25 USD
TOTAL PRICE (1 house)		**1905.91 USD**

Table 5 The Reference price

This is the price for one single installation. Considering that we have 1416 houses, the price will be lower. If the collectors are built by the locals, as a part of the educational program, a reduction factor of 0.8 can be applied:

Total Price for family houses = 0,4 * 1905 * 1416 = 1.082 Million USD

3. The Hot Water System for Hotel and Public Services Use

Considering the tourism in the island, we can calculate the hot water volume as:

26,28 minifamilies/day * 2,5 people/minifamily * 40 l/person = 2628 l.

Relating to the previous price, the cost will be 22891.75 USD

4. The installation Time: Installing the system in a single house: 1 week. 40 technicians working in parallel on 13 houses at the same time will install the hot water supply system in 2 years for the whole island.

b) BIOGAS – ***Cooking resources***

Facts	Population	Agriculture	Cattle	Wastewater & Sewage
Values	3790 inhabitants	1.968Km2	Cows: 3152, Sheep: 80, Goats:97, Pigs:30, Chicken:1914	4000lt/day of wastewater generated

Table 6 Local Nature Resources Description (Based on the local data from Tender for the Government of Chile)

2. The Principle of Biogas System in Easter Island

Due to the potential danger from infiltration of black waters to the ground water, the drinking water resource in Easter Island, the human waste and animal waste should be treated in order to provide a sanitary living condition to locals. The planning treating system includes: waste collectors, waste water treatment plants, and anaerobic digestion plants. The water treatment plants and the digestion plants are integrated in the neighborhood pyramids. The biogas will be mainly used on cooking in local place, and it will be supplied in the same way than propane is supplied now.

3. The Sspecifications of the System

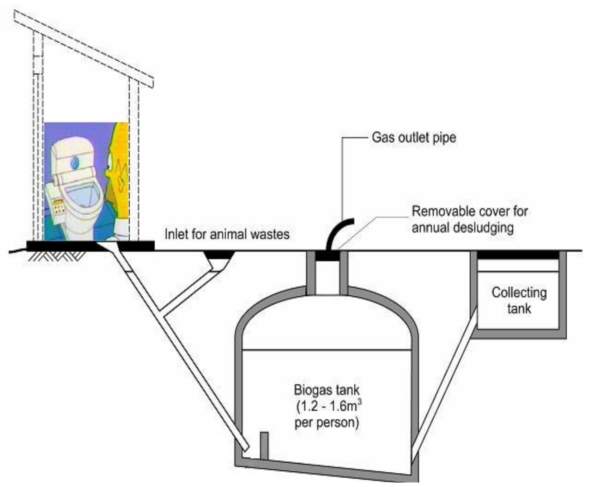


Figure 4 The Principle of Biogas System

Heating Power:

Propane: 11103.6 Kcal/Kg = 4.6413e+004 KJ /Kg

Methane: 11974.4 Kcal/Kg = 5.0053e+ 004 KJ/Kg

Biogas: 60 % methane (weight) = 3.0032e+004 KJ/Kg

And one cow = 2.7273 kg natural gas/day (One cow model)

Based on previous project results (Rwanda prisons in 1999), we can say that from the people in the city we can obtain biogas for 350 people. Considering this, our need for gas is now becoming 358, 52 Kg biogas per day, which is equal to 135 cows. We consider 200 cows in our project, which produce 10900 Kg/day of manure, in order to take over the future population growth.

4. The collection methods

To collect the solid waste, 2 trucks and 2 drivers are required. And to collect the animal waste, 20 to 30 containers for the farmers will be provided.

c) GEOTHERMAL ENERGY -***Electricity Supply***

1. The General Description of Local geothermal resources:

Easter Island and Chile are located in the Nazca Plate. Based on the research from the Global Volcanism Program, the Volcano type in Chile belongs to hydrothermal field, where the geothermal resource is usually high temperature hot water. The high temperature reservoirs are the ones suitable for, and sought out for commercial production of electricity. Based on the information given in the tender, which write like “geothermal has high potential, non- active volcanoes", the geothermal energy seems to be the best choice for electricity production.

2. The Specifications of the System

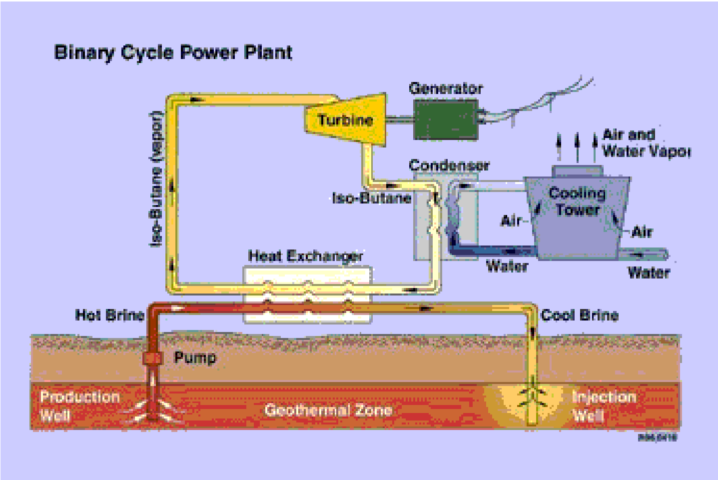


Figure 4 The Principle of Geothermal System

From the calculation, the total consumption in current stage is equal to 3932, 64 MWh/year. Considering that the geothermal station working time efficiency is 90 %, the power needed right now is equal to 0.4988 MW. Moreover, considering an electric consumption growth rate of 8 % for 30 years, the power needed for the electricity plant is equal to 5.0313 MW

$(0.4988 * (1+0.08)^{30} = 5.0313MW)$.

So the final design power is 6 MW. It is preferred to build the whole 6 MW plant now, to avoid future upgrades, which will lead to high transport and construction costs due to the island location. Moreover, 6 MW is the average power for common geothermal wells.

A binary plant will be used, based on the kalina cycle consisting in a water-ammonia work fluid circuit, and a water circuit. By using of this, the cost can deduce 25% of the total cost. The advantage of the Binary Cycle plant is that they can operate with lower temperature waters. They also produce no air emissions. (Renewable Energy Power for a Sustainable Future,1998). In this project, one production well and one re-injection well will be developed, since the average power for one product well is 6MW.

3. Cost of the plant.

Research and design: 60000 USD

Prospecting: 2 wells of 700 m. * 170 USD/m = 238000 USD

Development: 2 wells of 700 m * 170 USD/m = 238000 USD

Power plant construction: Building, turbines, offices, piping system, and others 3.5 Million USD

Factor applied due to transport costs (shipping) and risk insurance: 1.5

TOTAL PRICE: 6 024 000 USD

4. The employment:

Two engineers, six technicians and ten workers are the expected employees from that plant.

5. Landscape

The land use is only 23 acres, and the visual impact is much lower than with other technologies. The accurate location will be decided after sufficient research in the island.

6. The Cost of Operation and Maintenance

The total cost for operation and maintenance of the plant is around 10.3 USD / MWh produced. This value can be considered 45% for steam fields and 55% for the plant itself.

The value considered is fairly high, but future increases of costs along the working life of the plant are included in that way.

7. The CO_2 Emission

In a geothermal plant using the binary cycle technology, 90.91 Kg of CO_2 are produced for each 1000 MWh obtained in the plant.

The Upgrade of Associated Infrastructure

General Description

With upgrade of infrastructure on Rapa Nui we considered to apply biogas production, hot water solar collectors, solid and water waste management, methods as trash pre-sort, composting, recycling of waste.The goals of upgrading are turning toward energy saving technology, more efficient use of energy, finding possibilities to produce renewable energy in the house, creating advanced waste management systems and forming symbiosis or coexistence between the traditional ways of life of the islanders and new technologies. There are three ways of upgrade depending on tenant preferences and the position of the house on the island, upgrading the single family houses as single systems for houses that are far from Hanga Roa, upgrading the base neighborhoods and constructing pyramids in Hanga Roa and constructing of new sustainable neighborhoods (see *Appendix 1*).

System	No.	Associated Infrastructure	Methodology
Thermal Solar System	1	The installation of thermal solar collectors	Collector will be installed on a concrete platform on house's roof. Before the installation, safeguard should be considered to ensure the installation don't effect the house structure and carrying capacity.
	2	Water supply system	Although the annual temputerature is high enough,the attemperator will be considered to reduce the heat lose along the water supply pipes. Pipes will be installed in a stable way and fixed on the wall.The choice of pipe material will combine the local sunlight and intensity, economy capacity, sanitation requirement and hot water temperature.
Biogas Plant	1	Solid waste collection	See Energy Appendix-4.
	2	Wastewater transportation system	In currect stage and based on the sustainable concept in this project, 70 houses were considered as a community. Each community will have its own pyramid, which combine wastewater treatment plant and biogas plant.First step, the current wastewater transportation system will be studied and found out the possibility to rebuild. Second step, when there are no possibility to use the current one, the upgrade new system will be built. The end of the community pipe system is the pyramid.In construction period, reduce the effect to local society, suitable raw material and stable installtion will be considered as principles. Due to the lack of construction code, other substitutes is mentioned in education part. The basic sanitation equipment will be considered to update in order to save water and energy with consideration of the local economic capacity and the islanders' need.
	3	Wastewater treatment plant	Based on the technology process of biogas, most of the wastewater will be used as raw material for biogas plant.The extra wastewater will be treated in this plant. Due to the lack of information, the quality of the input water is unknown. But in general, the wastewater is considered mostly as human waste. Obeying the design code in P.R.China, the treatment grade will be biochemistry treatment process. The end products will be treated water and solid waste. The treated water will be processed by particular treatment and reached safe standard to drain into rivers. The solid waste will be used as raw material for produce biogas.
	4	Biogas Transportation	As mentioned in energy description,the biogas will be bottled and distributed in the same way it has been done now. 2 Trucks (one for use and one for substitute)will be used as transportation equipments.
	5	Water supply system	The new plants' water supply system will be joined with local water supply system.
Geothermal Plant	1	Power Line	The possibility of using current power grid will be studied first. The rebuild of the transportation and distribution power line will consider the capacity of the need of current consumption and future use. The rebuild of the system will based on the principle of safety and reducing effect to the local environment, animals and farming land.The rebuild of the distribution system will be combining with the future local urban planning and reduce visual impact in cities.The end users include local families, hotels, other public service constructions, future biogas plants and geothermal plant itself.
	2	Wastewater treatment system	The after-use geothermal hotwater will be re-injected into the ground to avoid the impact to ground water. The measurements were mentioned in energy Appendix-4.
	3	Water supply system	The new plants' water supply system will be joined with local water supply system.

To attract investments to Chile it is important to record current Risks and Creditworthiness and other issues that are taken into consideration during decision - making process.

As World Bank and Insurance Company stated, Chile represents low risks because of exposure is low, development management capacities are strong, and the track record of achieving development impact is high. The country possesses strong institutions and has followed consistent and prudent policies (Chile CSA).

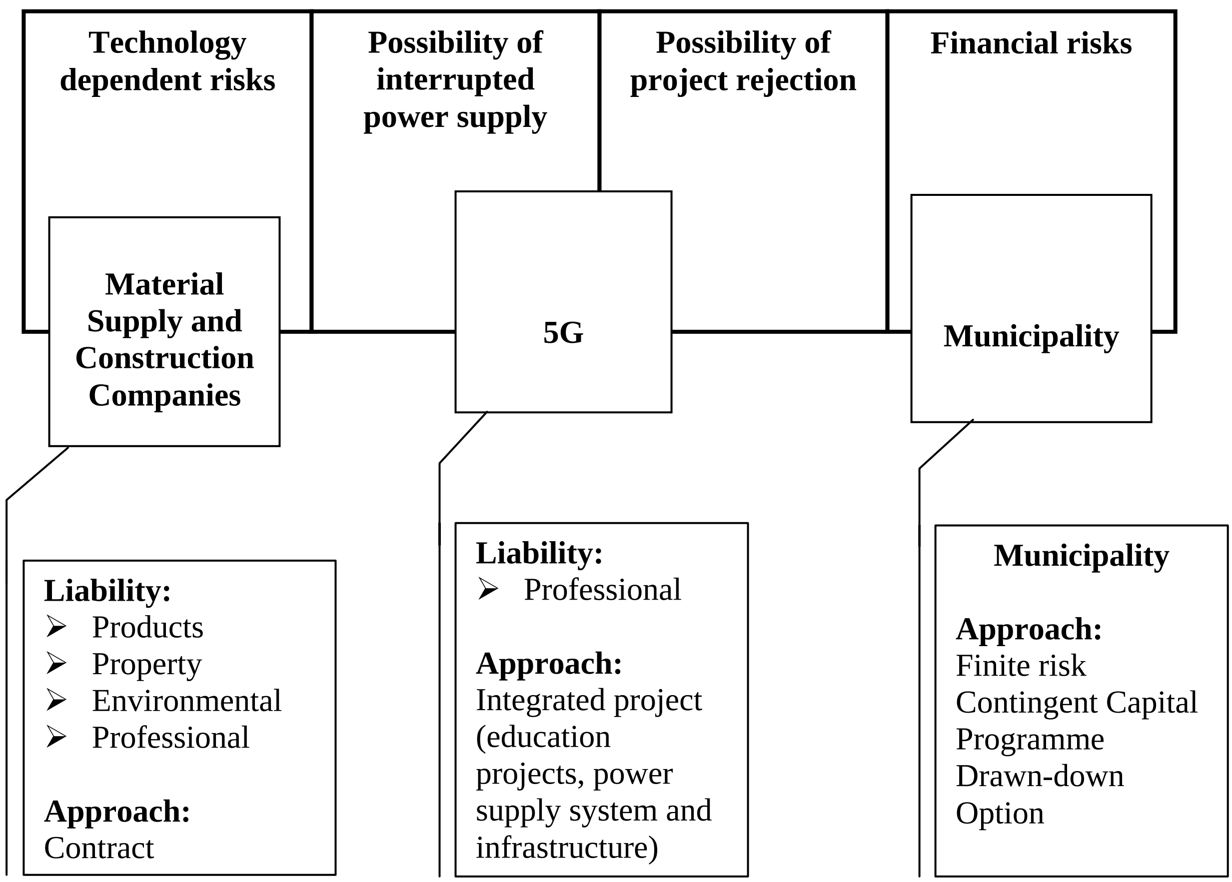
As a risk management measure, mitigating against possible adverse external events from available World Bank instruments, the Chilean Government has selected the Deferred Draw-down Option (Chile CSA).

Financial risk management instruments adapted for renewable energy technology are Alternative Risk Transfer products, particularly, Finite Risk and Contingent Capital Programs (*Marketplace Realities and Risk Management Solutions. Global Perspectives 2003*).

Finite risk is a multi-year risk financing technique that blends elements of pure financing with risk transfer to smoothes out volatility of events that adversely impact earning/cash flows. Finite risks include risks such as E&O, General Liability, Products Liability, Environmental Liability and Property, Completed Operations exposures for large residential contractors. Finite risk policy is addressed towards risk that losses occur faster than expected.

Contingent Capital Programme complements Finite risk approach. A Contingent Capital Program is insurance policy basic principle is an arrangement where a company purchases an option to issue securities (either debt or preferred shares) to an insurance company upon the occurrence of a predefined event. The event can be an insurance loss or other measurable event (such as economic downturn) that has the potential to cause excessive financial harm. The program is intended to guarantee availability of capital at a time when the company may be financially stressed. Finite risk policy is addressed towards risk that any contingent event that suddenly damages the capital structure of a project (*Marketplace Realities and Risk Management Solutions. Global Perspectives 2003*).

Figure 5 risk management principle scheme



The major risks and mitigation means

Major risk	Means to mitigate
Delays	Not relevant
Solar thermal hot water	
Fabrication damages/losses	Insurance and performance guarantee; Solar thermal equipment supply company carry all risks and relevant cost
Transport damages/losses	
Installation damages/losses	
Construction damages/losses	
Operation damages/losses	
Weather damage	
Biogas	
Technology	Supply company carry all risks and relevant cost; Long – term contracts
Operation	
Resource quantity and quality	Strict safety procedures are needed, as are loss controls such as fire fighting equipment and services. High rate of amortization
Planning opposition associated with odour problems	
Geothermal electricity – generation plant	
Drilling expenses and associated risk	Limited experience of operators and certain aspects of technology in different locations
Exploration risk	Contingencies
Critical component failure	
Long lead times	

(Financial Risk Management Instruments for Renewable Energy Projects United Nations Environment Programme)

Cost -Benefit Analysis

Costs and benefits	**Upgrading / Biomass / biogas and Geothermal power supply Project**
Direct benefit	**1,947,117**
Revenue from the sales of energy (estimating community's willingness to pay)	720,000
Selling CO2 *	
Value attributed to lesser dependence on energy from broad	1,227,117
Physical inputs	**9,384,326**
Education & research institute	**300,000**
Establishment	20,000
Operation	96,000
Materials	12,000
Personnel	84,000
Sustainability Seminars and Training for the Local Community	16,000
Research Projects, Monitoring and Evaluation	168,000
Upgrading of the Rural Area Single Family Houses as Single Systems	**326,040**
Design and permit obtaining process	6,000
Construction & Transport	320,040
Hot water solar collector system	320,040
Upgrading of the Base Neighbourhoods and Constructing Pyramids (20)	**2,668,286**
Design	10,000
Construction&Transport	51,100
Ground works	3,700
Concrete works	10,100
Stonemason works	1,800
Carpenter works	2,100
Installation of equipment	3,400
Wastewater pipelines (50-70 houses)	30,000
Materials	43,000
Biogas digester	30,000
Additional equipment	3,000
Wastewater pipelines (50-70 houses)	10,000
Neighbourhood house upgrade	776,286

Costs and benefits	Upgrading / Biomass / biogas and Geothermal power supply Project
Geothermal electricity – generation plant	**6,054,000**
Design	90,000
Construction and Materials	5,250,000
Exploration	357,000
Development	357,000
Research and consultancy	**36,000**
EIA	36,000
Socio – economic costs	**1,591,840**
Externalities (negative)	1,591,840
Additional net costs for local authorities to connect a new plant to existing transport infrastructure	100,000
Increase in public facilities costs	3,000
Due to opening of building sites	291,640
housing	17,640
*historical/ cultural heritage ****	
Raw material and land (loss to society by diversion)	4,000
productive/ service functions	270,000
Environmental	1,197,200
costs of measures necessary to neutralise possible negative effects on environment driven from project	12,000
loss of land, which could be used for agriculture	14,000
visual impact	144,000
Anthropogenic load	1,027,200

Costs and benefits	Upgrading / Biomass / biogas and Geothermal power supply Project
Socio – economic benefits	**3,358,200**
Additional employment (additional income generated by job creation; accounted for direct and indirect net output resulting from the project)	2,956,200
Increase in demand for residences and hotels	168,000
Decreasing costs for heating	190,000
Waste management	44,000
Other Implementation costs	1,200,000
Consulting	1,200,000
Financial planning/analysis	
Economic rate of return (ERR)	0.13
Economic net present value (ENVP)	17,519,079
% payment	8,184,263

*** Income not included due to insignificance for particular project**

***** on this position will be not costs**

NPV and IRR for business sector

Costs&income /Years		%	1 year of Project		2 year of Project		3 year of Project		4 year of Project		5 year of Project		10 year of Project		15 year of Project	
			$	executed %	$	executed %	$	executed %	$	executed %	$	executed %	$	executed %	$	executed %
Investment	7,787,550		340,800		336,000		3,073,350		2,249,900		696,600		957,000		133,900	
Risk Capital	3,270,771	42		0.00		0	1,646,900	50	1,097,933	34	132,600	4	393,338	12		
Consumer Finance	700,880	9	30,000	0.92	30,000	4	208,000	30	234,000	33	30,000	4	168,880	24		
Mezzanine finance	3,815,900	49	310,800	8.14	306,000	9	1,218,450	37	917,967	28	534,000	16	394,783	12	133,900	4
Costs	7,787,550		340,800	4.38	336,000	4	3,073,350	39	2,249,900	29	696,600	9	957,000	12	133,900	2
Education & research institute	300,000	3.85	30,000	10.00	30,000	10.00	30,000	10.00	30,000	10.00	30,000	10.00	150,000	50.00		
Upgrading of the Single Family Houses as Single Systems	664,300	8.53	7,800	1.17	39,000	6	39,000	6	39,000	6	132,600	20	273,000	41	133,900	20
Upgrading of the Base Neighborhoods and Constructing Pyramids	2,670,000	34.29	267,000	10	267,000	10	534,000	20	534,000	20	534,000	20	534,000	20		
Geothermal electricity – generation plant	4,117,250	52.87					2,470,350	60	1,646,900	40						
Research and consultancy	36,000	0.46	36,000	100.00												
Maintanance costs											57,333		274,000		274,000	
Capital costs					857,154		857,154		857,154		857,154		4,285,772		4,285,772	
Income					1,621,400		3,150,400		3,239,190		2,585,836		13,478,565		27,097,901	
Balance	0	100	-73,800		1,018,400		77,050		132,135		974,748		7,961,793		22,404,229	

The Net Present Value for Project is 17 519 079 USD (10% sicount rate) and the Economical Reate of Retur - 13%

The income is calculated by taking into account power and gas consumption. The current average costs per households are 52 USD/month. In case of project implementation, the cost will decrease to 37 USD

The income from tourist amount increase is added to income form facilities fees. The assumptions are - 5% increase per year and from total income 40% will be used for balancing cash flow.

NPV and IRR for society

Costs&income /Years	1 year of Project implementation	2 year of Project implementation	3 year of Project implementation	4 year of Project implementation	5 year of Project implementation	10 year of Project implementation	15 year of Project implementation
	$	$	$	$	$	$	$
Investment	30,000	30,000	208,000	234,000	30,000	168,880	0
Consumer Finance	30,000	30,000	208,000	234,000	30,000	168,880	
Costs	906,911	1,795,265	1,795,265	1,795,265	1,568,187	8,264,589	10,725,781
Capital costs		857,154	857,154	857,154	857,154	4,285,772	4,285,772
Costs for public facilities *	*899,111*	*899,111*	*899,111*	*899,111*	521,100	3,431,817	6,032,108
Upgrading of the Single Family Houses as Single Systems	7,800	39,000	39,000	39,000	132,600	273,000	133,900
Mainance					57,333	274,000	274,000
Income	1,411,200	3,212,400	4,267,200	4,341,600	4,954,560	12,955,440	17,000,400
Additional employment (additional income generated by job creation; accounted for direct and indirect net output resulting from the project)		1,364,400	1,910,160	2,728,800	3,274,560	3,547,440	5,912,400
Increase in income form increasing tourists	1,411,200	1,848,000	2,357,040	1,612,800	1,680,000	9,408,000	11,088,000
Balance	504,289	1,387,135	2,263,935	2,312,335	3,356,373	4,521,971	6,274,619

The Net Present Value for Project is 12 741570 USD (10% discount rate)

* during first four years current costs will remain

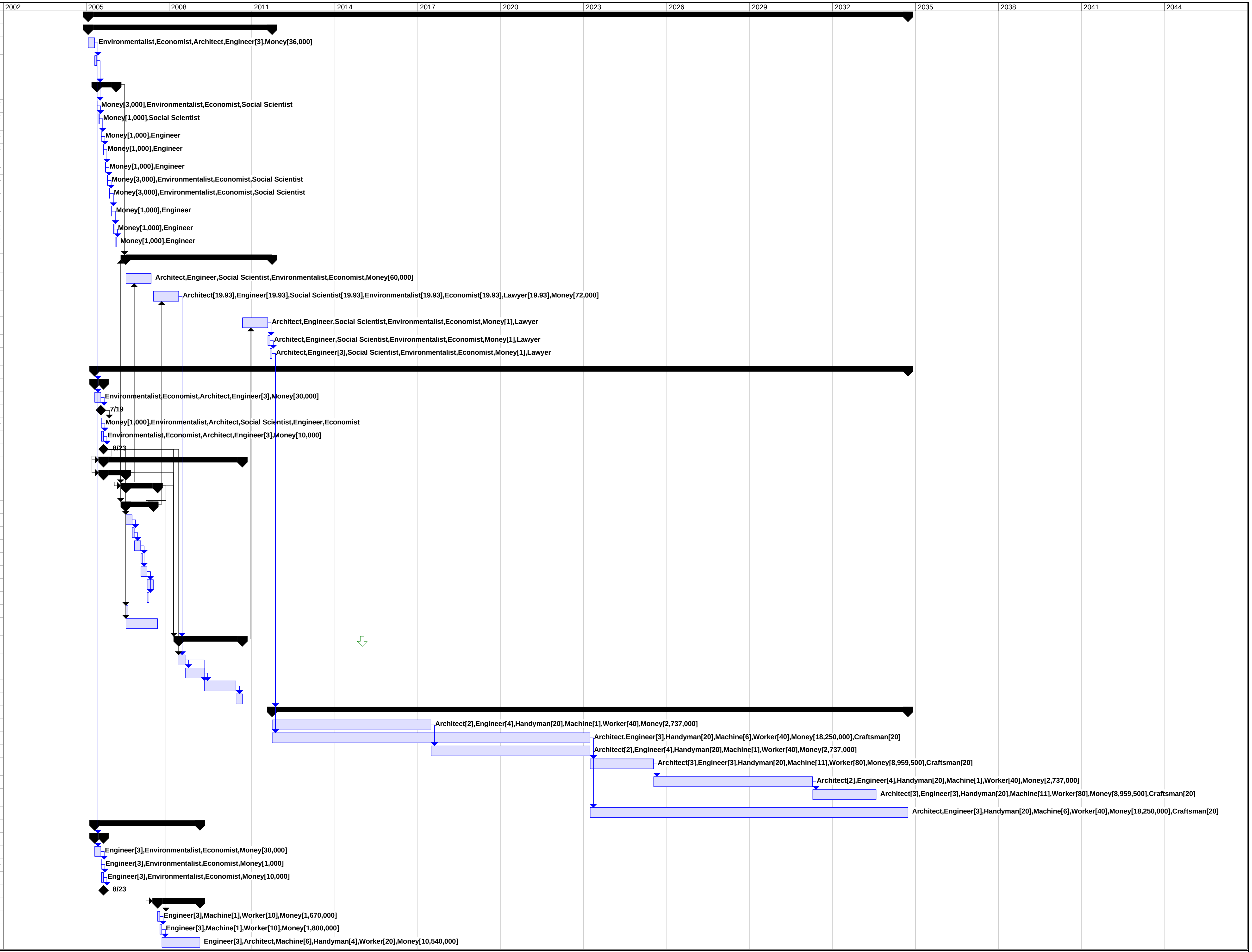
Footnote:

We needed to make changes,
and created simplified view report.

I am adding the original Gantt chart
and the infrastructure appendix
which was left out.

TŽS

ID	Task Name	Duration
1	**Rapa Nui Project**	**7735 days**
2	**Education**	**1735 days**
3	Baseline Research Project for Infrastructure and Energy	3 mons
4	Establishing the Education Center for Renewables, Preservation of Cultural Heritage and Eco-tourism	1 mon
5	**Sustainability Seminars and Training for the Local Community**	**185 days**
6	Seminar on the Concepts of Sustainability	1 wk
7	Seminar on Cultural Changes and Preserving of Tradition	1 wk
8	Seminar on Hot Water Collector Systems	1 wk
9	Seminar on Photovoltaic Collectors Systems	1 wk
10	Seminar on Renewable Energy Systems	1 wk
11	Seminar on Saving Water and Energy	1 wk
12	Seminar on Green Sign Product Consumption	1 wk
13	Seminar on Grey Water Treatment Systems	1 wk
14	Seminar on Urine Separation Systems	1 wk
15	Seminar on Wastewater Treatment Systems	1 wk
16	**Research Projects, Monitoring and Evaluation**	**1380 days**
17	Research, Monitoring and Evaluation of the Upgrade of Single Family Houses Project	12 mons
18	Research, Monitoring and Evaluation of the Upgrade of the Base Neighborhood and Constructing Pyramid Project	12 mons
19	Research, Monitoring and Evaluation of the New Sustainable Neighborhood Project	12 mons
20	Public Participation	1 mon
21	Review of the Strategy Project for Infrastructure	1 mon
22	**Infrastructure**	**7675 days**
23	**Strategy Project for Infrastructure**	**85 days**
24	Design of the Project	3 mons
25	First Version of the Project	0 mons
26	Public Participation	1 wk
27	Review of the Project and Final Decision	1 mon
28	Final Version of the Project	0 mons
29	**Construction Phase**	**1310 days**
30	**Upgrade of 10 Single Family Houses**	**210 days**
37	**Upgrade of Base Neighborhood and Constructing Pyramid**	**300 days**
38	**Constructing the Pyramid**	**260 days**
39	Design of the Pyramid Project	3 mons
40	Ground Works	1 mon
41	Concrete Works	3 mons
42	Stonemason Works	1 mon
43	Carpenter Works	3 mons
44	Installations of Equipment	3 mons
45	Additional Costs	1 mon
46	Wastewater Pipelines	1 mon
47	Upgrading of 50 Single Family Houses	15 mons
48	**Construction of New Sustainable Neighborhood**	**600 days**
49	Design of the Housing Project	3 mons
50	Constructing the Pyramid	9 mons
51	Constructing of 50 Housing Units	15 mons
52	Additional Construction Works	3 mons
53	**Construction Phase**	**6000 days**
54	Upgrade of 100 Single Family Houses	1500 days
55	Upgrade of 10 Base Neighborhoods	3000 days
56	Upgrade of 100 Single Family Houses	1500 days
57	Construction of New Sustainable Neighborhood	600 days
58	Upgrade of 100 Single Family Houses	1500 days
59	Construction of New Sustainable Neighborhood	600 days
60	Upgrade of 10 Base Neighborhoods	3000 days
61	**Energy**	**995 days**
62	**Strategy Project for Energy**	**85 days**
63	Design of the Energy Strategy Project	3 mons
64	Public Participation	1 wk
65	Review of the Project and Final Decision	1 mon
66	Final Version of the Project	0 mons
67	**Geotermal Plant**	**400 days**
68	Prospection Phase	1 mon
69	Development Phase	1 mon
70	Construction Phase	18 mons



Project: Rapa Nui Project Date: Sat 3/5/05	Task		Split		Progress		Milestone		Summary		Project Summary		External Tasks		External Milestone		Deadline

In text

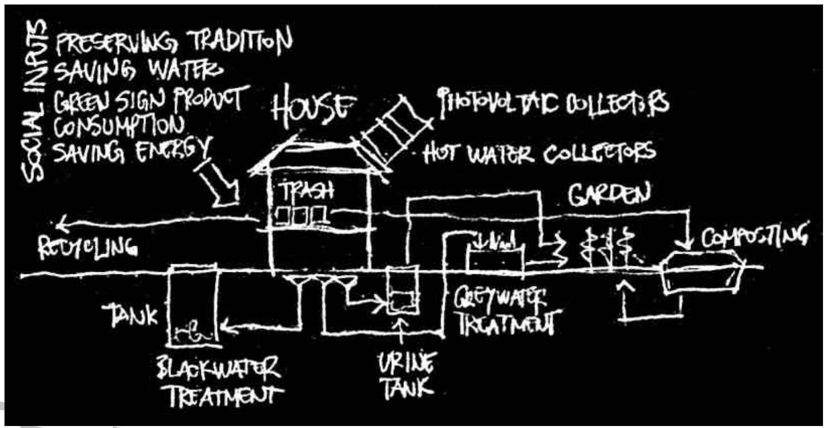
With upgrade of infrastructure on Rapa Nui we considered apply of technologies as photovoltaic collectors and hydrogen cells, biogas production, hot water solar collectors, solid and water waste management, methods as trash pre-sort, composting, recycling of waste, urine separation and grey and black water treatment combined with social programs for sustainable consciousness as water and energy conservation and preservation of culture heritage and local traditions. (Minderman et al. 2004)

The goals of upgrading are turning toward energy saving technology, more efficient use of energy, finding possibilities to produce renewable energy in the house, creating advanced waste management systems and forming symbiosis or coexistence between the traditional ways of life of the islanders and new technologies. There are three ways of upgrade depending on tenant preferences and the position of the house on the island, upgrading the single family houses as single systems for houses that are far from Hanga Roa, upgrading the base neighborhoods and constructing pyramids in Hanga Roa and constructing of new sustainable neighborhoods (see Appendix 7).

APPENDIX 7

Upgrading of the Single Family Houses as Single Systems

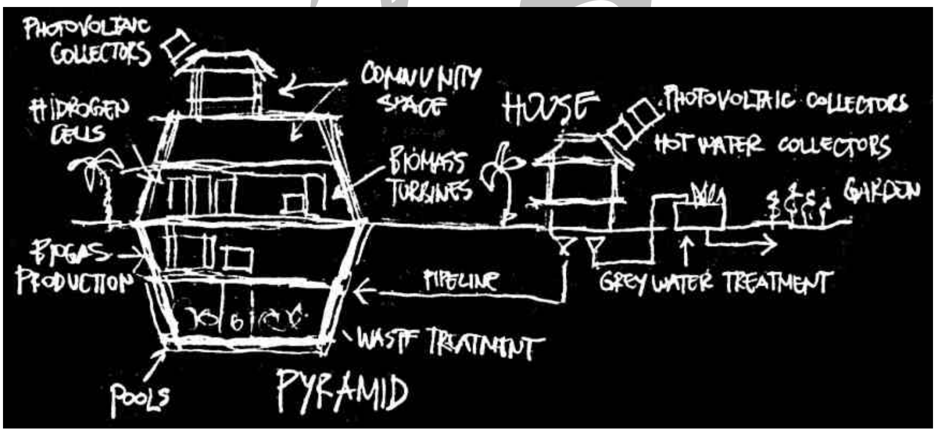
In this concept the goals are reached by tenant preferences. Tenants choose to apply the new technologies to save or produce energy and resources. The basic prerequisite for this upgrade is enabling access to sustainable technology and informed local community in the principles of sustainable housing. The tenants could find information about different sustainable housing techniques on media's, like TV or internet, or through programmes for education and training, like seminars or lectures.



Upgrading of the Base Neighborhoods and Constructing Pyramids

In 1947, Thor Heyerdahl and his five-person crew climbed aboard Kon-Tiki, an experimental balsa raft, and swept atop the Pacific's Humboldt Current from Peru to the Tuamotu islands - and into history. His achievement, Heyerdahl announced to the world, proved that New World mariners from the east might have sailed into Polynesia, contradicting the general assumption that it had been populated from the west.

Among the pyramids of Túcume, Peru, from 1988 to 1993, Heyerdahl found what he believed was proof of his original Kon-Tiki hypothesis: "Images of reed ships crewed by mythical men with bird heads" - symbolic motifs similar to others found in petroglyphs on Rapa Nui. (The Guardian, 2002)

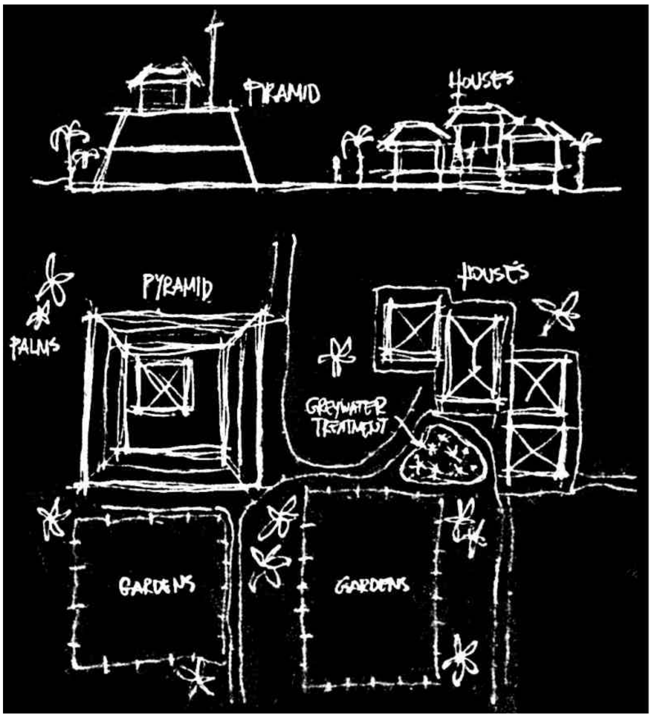


The second concept is inspired by Kon-Tiki voyage and traditional stone houses on Rapa Nui. We propose building of stone pyramids on the outskirts of the neighborhoods. The pyramids act as waste treatment plants, energy production and storage facilities and communal buildings. These cut-edge technology buildings need high skilled personnel which will coordinate with CEREC and their function depends on resolving number of problems that can occur on the field, like waste treatment odours, low efficiency of energy storage, lost of energy in the transformations, high costs of building and maintenance etc.

The first premise for this project is building an experimental model as a unity of education, infrastructure and energy that can be subject of research which will be conducted by CEREC. Our opinion is that the problems can be solved by the scientists with constant participation and help from Rapa Nui community. The experience from this project in that way can be used for communities in different places in Chile, Polynesia, South America and around the world.

Constructing of New Sustainable Neighborhoods

The new neighborhoods concept unites the elements of the first two, which means creating sustainable houses around the cut-edge technology pyramid. The proposed sustainable housing development for Rapa Nui includes 50-70 housing units that can accommodate 300 people, the population growth rate for 5-10 years.



The design of the sustainable neighborhoods project should is based on the next premises.

- ❖ Use of local building heritage and traditions
- ❖ Use of gardens
- ❖ Use of green or sustainable technologies in housing
- ❖ Flexibility of the housing units
- ❖ Tenant preferences

Polynesian architecture as local building heritage combined with the influence of South American continent is the main motif for the houses. That means preferably use of local building material and local craftsman skills.
Creation of private gardens is proposed for two reasons. The first is the traditional custom for the islanders to grow their own vegetable and fruits and the second is that the gardens are used for dumping the "environmental friendly" waste that is generated by the houses. That is why it is proposed that the housing units in the project should have own private gardens depends on the tenant preferences.
The use of green or sustainable technologies is important for the new neighborhood. The tenants should have basic information about using these technologies, but it should not be prerequisite. The level of use of these technologies should be compatible with the tenant interest.
Flexibility of the housing units is seen from the idea of easily changing the structure of the neighborhood. Because the project has the tenants as the center, there is possibility for creating of rigid housing structures, a concept not very favorable. The housing units should have the possibility to follow the development of the culture and technology in the island population for many generations.