CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
(Version 02 - in effect as of: 1 July 2004)

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Lihir Geothermal Power Project
Version number: Version 2
Date: 7 November 2005

A.2. Description of the project activity:

Purpose of the Project Activity

The Project Activity involves the construction of a Geothermal Power Plant (LGPP) on Lihir Island, Papua New Guinea (PNG). This project is to take place at the Lihir Gold Mine, which is owned by Lihir Gold Limited. The mine is managed by Lihir Management Company Ltd (LMC), a 100% subsidiary of Lihir Gold Limited.

The PNG Government has given a high priority to the task of establishing an environment that encourages the uptake of renewable energy technologies through the process of developing renewable energy and rural electrification policies. However, there is still a reliance on expensive and highly pollutant fossil fuel based sources of energy.

Like many of the island nations within the Pacific islands, PNG is subject to substantial volcanic and seismic activity which provides an abundance of geothermal energy resources which can be used as an alternate source of energy. However, a large-scale geothermal power project has yet to be developed in this country. It is within context that LMC undertook a 6 MW pilot geothermal installation in 2003. This installation served as a test case for a larger scale geothermal project with an ultimate nominal capacity of 55MW (52.8MW net capacity), which is the subject of this Project Design Document (PDD). This project will be implemented incrementally, with an initial nominal capacity of 33MW (31.7MW net capacity), followed by the development of an additional 22MW (21.1 net capacity) in 2007.[1]

Geothermal control is an integral part of the standard operations of the Lihir Gold Mine. Geothermal discharge wells and shallow steam-relief wells have been drilled at the Lihir Gold Mine site to decrease geothermal hazards due to steam pressure build up, and to depressurise residual steam or gas pockets in the vicinity of the mine. Therefore the geothermal resources used by the power plant are a co-product of the mining operations that would have otherwise been emitted into the atmosphere and wasted.

By utilising the existing geothermal resources of Lihir Island to generate electricity, this project will displace most of the existing diesel generation on the island driven by the combustion of carbon-intensive heavy fuel oil (HFO). The geothermal energy source will offset diesel generation utilised by both the Lihir Gold Mine which comprises an open pit gold mine and carbon-in-leach processing facility, and the local village communities based on Lihir Island.

[1] The 6MW pilot geothermal installation will continue to be used independent of this expansion. It is not included in the total 33MW of the first phase of construction.

It is expected that the power plant will ultimately generate an average of 411 GWh per year, assuming a total net capacity of 52.8 MW. This will result in a displacement of 411 GWh of HFO. Expected average emission reductions at this capacity are approximately 279 kt CO_2 per annum.

Contribution of the Project Activity to Sustainable Development

The Government of PNG is committed to the principles of sustainable development and to the implementation of a national sustainable development strategy. The Department of Environment and Conservation (DEC) is the Government of PNG's agency responsible for the implementation of conservation and environmental management policies of the Government. The concept of sustainable development is enshrined in PNG's National Constitution under the 4th National Goal of its 5 National Goals and Directive Principals. The 4th National Goal specifically states that PNG "*declares their fourth goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all and be replenished for the benefit of future generations*."

Whilst there is no specific policy on Sustainable Development it is commonly cited and promoted in all specific policies and plans. The Government's main plan for the period 2003-2007 (the Medium Term Development Strategy), which is yet to be formally recognised, cites sustainable development as the main output of its core development strategy.[2]

The project makes a number of contributions to the sustainable development of Lihir Island specifically, and PNG more generally. Apart from its benefits on the global environment, further environmental benefits will be achieved though the reduction of air-based pollutants, such as oxides of nitrogen, oxides of sulphur, carbon monoxide and fine particles, being emitted into the atmosphere due to the reduced combustion of fossil fuels. The power plant will also be environmentally sustainable by using a currently wasted resource, steam, which is released from the ground during the course of mining operations. Additionally, the proposed Project Activity has the potential to contribute to the long term general economic and social development of Papua New Guinea by demonstrating the use of renewable energy alternative technology that could be applied on a larger scale throughout the Pacific. By encouraging the use of renewable energy sources, rural access to electricity could be improved in the future, one of the objectives of PNG's Government's Rural Electrification Policy.[3]

Currently about 85% of the population in PNG lives in rural areas and electrification rates in these areas are still very low. As at 2000 the total installed power capacity in PNG was 451.3 MW with this sourced from hydro (42%) and thermal (58%). Currently small diesel generators provide power in most rural towns and villages for at least a few hours each day. Although this is the first major geothermal development to be undertaken within in PNG, there is significant potential to replicate the LGPP within other areas of the country and substitute existing diesel generation with geothermal sources. In 1995, the South Pacific Applied Geoscience Commission (SOPAC) conducted a survey of the geothermal resources in five Pacific Island nations, including PNG, to assess its scope as an alternative source of energy. This study determined that there are more than 28 known thermal systems in existence in PNG and there are at least seven geothermal sites that could be developed as an energy resource. Economic and social development of PNG will also take place through technology transfer, the development of skills and expertise of Lihirians and other PNG nationals, and increased employment opportunities for locals. These issues are addressed in further detail in section A.4.3.

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[2] Gwen Sissiou, PNG Department of Environment and Conservation pers. com. March 2004

[3] APEC Energy Overview 2002. Available online at
http://www.ieej.or.jp/aperc/2002pdf/APEC_Energy_Overview_2002_Final_Version.pdf

A.3. Project participants:

Please refer to the Table A.1 below:

Table A1 Parties Involved in the Project

Name of Party Involved (*) ((host) indicates a host Party)	Private and/or Public Entity(ies) Project Participants (*) (as applicable)	Kindly Indicate if the Party involved wishes to be Considered as Project Participant (Yes/No)
Papua New Guinea (host)	Lihir Gold Ltd	No
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Papua New Guinea

A.4.1.2. Region/State/Province etc.:

New Ireland Province

A.4.1.3. City/Town/Community etc:

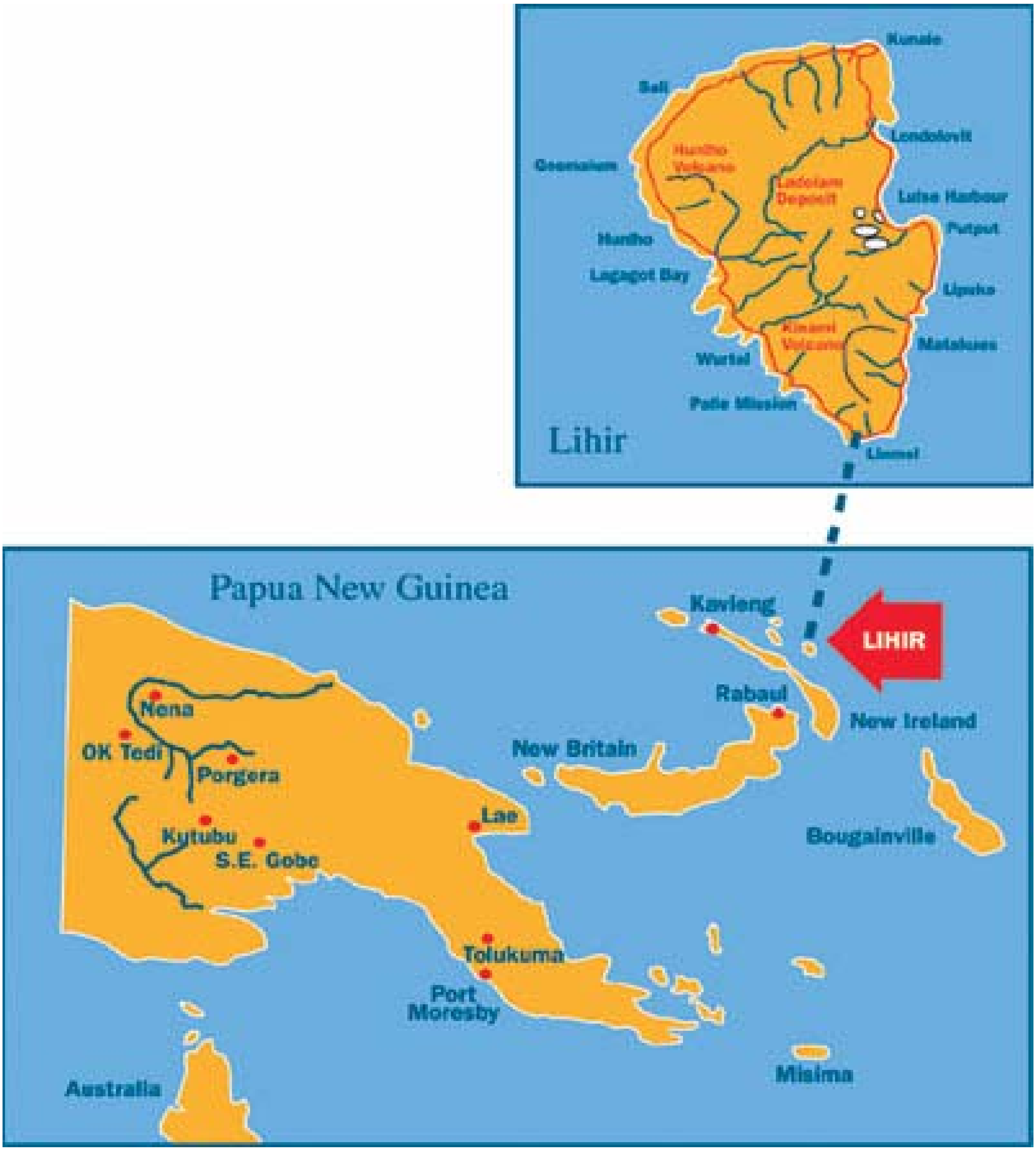
Lihir Island

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

The Project Activity is to be located within the Lihir Gold Mine site on Lihir Island. Lihir Island is situated in the Bismarck Archipelago approximately 50 kilometres off the northeast coast of the New Ireland province of Papua New Guinea and 900 kilometres north east of Port Moresby at a latitude 3º07' S and longitude 152º38 W.

Lihir Island is approximately 197km^2 in area (20km long and 10km wide) and is formed around five extinct volcanoes. The proposed geothermal power plant will be located on the youngest volcanic feature of the island, the Luise Caldera on the east coast of Lihir (refer to white spots near Luise Harbour in Figure A1).

Figure A1: Lihir Island Locality Map



A.4.2. Category(ies) of project activity:

Type: Energy and power
Category: Energy generation, supply, transmission and distribution

A.4.3. Technology to be employed by the project activity:

The LGPP is anticipated to have an initial output of 31,650 kWe or 31.7 MW total net power (taking into account parasitic load). This output is expected to increase to a total net power of 52.8 MW by 2007.

Geothermal steam will be obtained from existing underground reservoirs accessed through three steam wells located over the 2 km^2 area of the Lihir basin. These steam wells have already been drilled as a component of mining operations in order to decrease geothermal hazards due to steam pressure build up and to depressurise residual steam or gas pockets in the vicinity of the mine. This steam is currently being vented into the atmosphere (Figure A2). As part of the LGPP the steam will be reticulated via a steam collection system that comprises the valves, piping, separation and scrubbing plant and controls required for delivering the geothermal steam from the geothermal wells to the turbine inlet.

Figure A2: Steam Being Vented to Atmosphere as a Component of Current Mining Operations

The two-phase fluids from each of the wells will be piped to a single separation plant located nearby to the Kapit village. The production wells will be manually set to meet or slightly exceed the power plant requirements. The separation plant removes the water from the two phase geothermal fluid, and allows steam to travel along a single phase steam line to a scrubber. The scrubber is required to remove the high levels of dissolved solids found in the water phase and thus provide the required steam quality at the turbine inlet. Steam pressure controls will be provided to maintain constant delivery pressure to the turbine.

In the initial stage of the project, the geothermal steam will drive 3 x 11MWe gross steam turbine-generator sets. An additional 2 x 11MWe gross steam generator sets will be commissioned when the project expands to its full capacity. Power generated by the project will feed into the existing 11kV distribution network that covers approximately one third of the island's perimeter, and used directly by the mine and other consumers connected to the island's grid. As part of the project, new underground cable will be installed to reduce the visual impact of transmission lines and to provide additional reliability.

Accessing and utilising the geothermal steam to generate power has a negligible impact on the environment over and above that of the mines existing operations. The technology employed will actually lead to a reduction in environment impacts due to the decreased quantity of HFO utilised on the Island.

Transferral of Technology

The pilot phase of this geothermal power plant (the 6 MW unit) was the first application of geothermal technology in PNG and has resulted in the development of an initial skill base in this field. PNG is on the Pacific "Ring of Fire" and has much geothermal potential. The continued development of local experience with geothermal power will reduce the risks associated with the subsequent development of geothermal projects in PNG.

Knowledge of the technology employed and in the operation and maintenance of the geothermal power station technology will be transferred to Lihirians and other PNG Nationals through LMC's localisation program which is in line with PNG Government objectives.

Locally employed mine staff have already been trained in diesel power station operations through LMC supported theory and practical training at the PNG Electricity Commission Training College in Port Moresby, as well as basic power station competency assessments conducted in-house. Trained staff have since been actively involved in the operation of the pilot 6 MW geothermal power station and this up-skilling process will continue during the implementation of the Project Activity with on-the job training programs being offered to LMC employees.

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

Reduction of Anthropogenic Greenhouse Gas Emissions

The project will displace electricity currently generated on Lihir Island through the combustion of HFO in diesel engines.

This project is expected to displace an average of 411 GWh of HFO generated power per year assuming a total net capacity of 52.8MW.

Refer to section E for further details on the quantification of GHG emission reductions associated with this project.

Why Emission Reductions Will Not Occur in the Absence of the Project Activity

In the absence of the LGPP electricity generation on Lihir Island would be produced by the continued consumption of HFO. It is highly unlikely that geothermal energy projects would be developed in the absence of the Project Activity due to unfavourable financial conditions and the existence of significant market barriers for such projects, with the exception of the already existing 6MW geothermal plant, which was a pilot plant for this project.

To date, there has been limited development of renewable energy projects in PNG and no development of geothermal energy. This has been recognised by the Pacific Islands Energy and Policy Plan (PIEPP)[4] in which the Government of PNG participates. PIEPP was initiated in recognition of the slow progress in the development of renewable energy in PNG and other Pacific countries as a result of a number of policy, technical, financial, management, institutional and awareness barriers. The key barriers for the development of renewable energy, including geothermal energy, as cited by PIEPP include "a lack of technical expertise and weak institutional structures to plan, manage and maintain renewable energy programmes; the absence of clear policies and plans to guide renewable energy development; a lack of successful demonstration projects; a lack of the renewable energy resources potential; a lack of confidence in the technology by the policy makers; a lack of local of financial commitment and support to renewable energy; and continuing reliance on aid-funded projects."

The UNDP and Global Environment Facility (GEF) have also initiated the Pacific Islands Renewable Energy Project (PIREP)[5], in an attempt to reduce implementation costs and barriers to project development of renewable energy. This further demonstrates that commercialisation of renewable energy technologies in PNG will not occur without external assistance and the provision of financial incentives.

A.4.4.1 Estimated amount of emission reductions over the chosen crediting period:

Estimated emission reductions over the chosen crediting period are shown in Table A2.

4 Pacific Islands Energy Policy and Plan (2002) at http://www.spc.org.nc/coastfish/reports/crga/PIEPP%20October%202002.pdf

5 Addressing the Barriers to the Development and Commercialization of Renewable Energy (2003) in the Pacific Islands at http://www.sidsnet.org/archives/energy-newswire/2003/msg00019.html

Table A2 Estimated Emission Reductions Over the Crediting Period

Year	Annual Estimate of Emission Reductions (tonnes of CO_2)
2006	114,687
2007	286,537
2008	286,537
2009	286,537
2010	286,537
2011	286,537
2012	286,537
2013	286,537
2014	286,537
2015	286,537
2016	95,512
Total estimated reductions (tonnes of CO_2)	2,789,037
Total number of crediting years	10 years
Annual average over the crediting period of estimated reductions (tonnes of CO_2)	278,904

A.4.5. Public funding of the project activity:

This project will be financed by private sources and as such no public funding will be required to undertake this Project Activity.

SECTION B. Application of a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the project activity:

According to the UNFCCC's Drafting Group on Technical Issues text on CDM (Mechanisms) (Decision-/CP.7 Article 12, Paragraph 48) a project must select a baseline approach relevant to the activity. For this project, the approved consolidated baseline methodology, ACM0002, *"Consolidated baseline methodology for grid-connected electricity generation from renewable sources"* has been selected for this activity.

A justification of the method's appropriateness given the project circumstances is given in Section B.1.1 below. A description of how the proposed methodology is applied for the specific project activity of the LGPP is provided in Section B.2.

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

The choice of baseline methodology, ACM0002, is justified for this project as the LGPP meets the applicability criteria as outlined in this baseline methodology namely:

- The LGPP project activity is a grid connected renewable energy power project that will generate electricity via a zero-emission renewable energy source, geothermal energy.
- The LGPP will displace electricity production currently driven by the combustion of heavy fuel oil.
- The geographic and system boundaries for the electricity grid on Lihir island can be clearly identified, and information on the characteristics of this grid is available

As a renewable energy project it is appropriate to follow Paragraph 48 of Marrakech Accords and use existing actual or historical emissions, since the project activity will serve to reduce actual emissions. On this basis the conditions for applying ACM0002 are met.

B.2. Description of how the methodology is applied in the context of the project activity:

Description of the context of the project activity

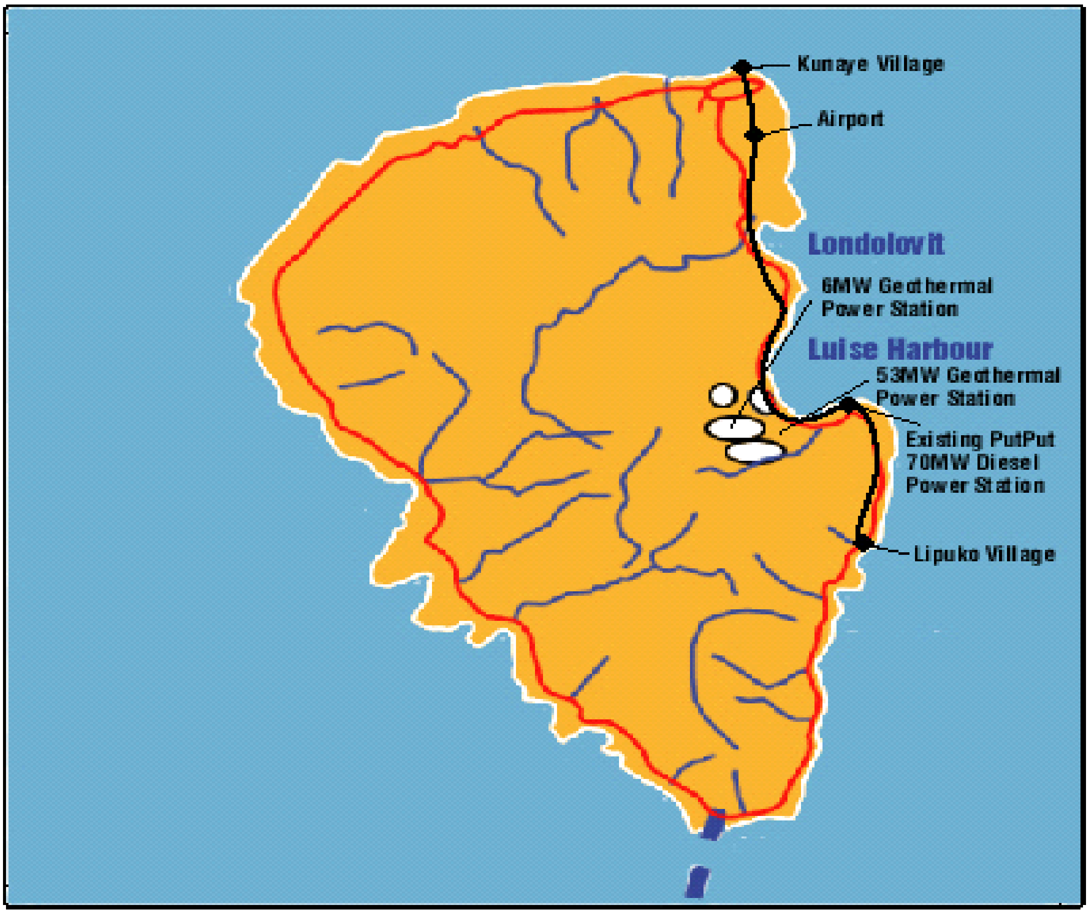
The LGPP is a 52.8 MW thermal power plant (at its total net capacity) using steam coming from geothermal resources released by the Lihir Gold Mine. Lihir has a stand-alone electricity network of 80 MW total installed capacity and is not connected to any other grid. The main power source at the Lihir electricity network is the diesel fired Putput Power Station, which has an installed capacity of 70 MW.

This station provides most of the electricity generation on the island. There is a 4 MW diesel power station located at Londolovit running as a backup generator during shutdown periods of the diesel fired Putput Power Station. As a pilot project, the 6 MW Geothermal Power Station was added to the grid. This 6 MW Geothermal Power Station has been included in the baseline scenario, as it would have continued operation even if the decision had been made not to go ahead with the full-scale geothermal power plant. The LGPP is intended to run as a base load plant and offset the amount of diesel fuel

consumed at the Putput Diesel Power Station. It will be connected to the grid via 4 underground 11kV transmission circuits.

The extent of the electricity network on the island can be seen on the map in Figure B1. It runs to Kunaye village and the Airport in the north and Lipuko village in the south, and supplies the mine site, villages and other loads along the east coast between these two sites.

Figure B1: Existing Electricity Network and the LGPP on Lihir



The electricity grid and the power stations are owned and operated by the LMC under license from the PNG electricity authority. Information on electricity production and fuel consumption used in the baseline scenarios has been supplied by LMC.

Application of methodology ACM0002 in the context of the project activity

Applying the methodology ACM0002 "*Consolidated baseline methodology for grid-connected electricity generation from renewable sources*", the implementation of the Lihir project will reduce on average 278,904 tCO_2 per annum. The defaults used for the calculation of calorific values for fuel types and fuel oxidization factors, come from the IPCC GHG Gas Inventory Reference Manual (IPCC 1996).

Emissions reductions for the project are based on the baseline scenario, established as the likely future scenario based on the most recent expansion of the system, the Build Margin, as provided for in ACM0002. The ACM0002 consolidated methodology provides four options to calculate the Operating Margin. For the proposed project activity, option (a), simple Operating Margin, has been chosen. Dispatch data analysis has not been used as there is only one significant power generation source on the island, therefore a true dispatch scenario does not exist.

The Operating Margin is therefore calculated as the generation-weighted average emissions per electricity unit (tCO2/MWh) of all generating sources serving the grid, not including low-operating cost and must-run power plants. There are only two other plants connected to the grid on the island, the diesel fired Putput Power Station, and the 6 MW pilot Geothermal Power Station. The Londolovit backup generator is excluded because it is simply a backup unit for occasions when the Putput Power Station is shut down, and its total contribution to electricity generation is very small (the generation capacity is 4MW). The simple Operating Margin methodology can only be used where "low-cost" or "must run" resources constitute less than 50% of the total grid generation. The Putput Power Station is neither "low-operating cost" or "must-run", while although the 6MW pilot Geothermal Power Station is a "low-operating cost" and "must-run" resource, it constitutes less than 50% of total grid generation. The simple Operating Margin method can therefore be used.

The data used for the calculation of the Build Margin and Operating Margin is shown in Annex 3 of this document.

Emission Reductions are calculated using the formula:

$$ER_y = BE_y - PE_y - L_y$$

Where:

ER: Emission reduction (t CO_2e);
BE: Baseline emissions (t CO_2e);
PE: Project Emissions (t CO_2e);
L: Leakage emissions (t CO_2e); and
y: a given year.

Baseline Emissions:

The baseline emission factor calculations are based on a combined margin consisting of the Operating and Build Margins. The Operating Margin will be calculated using the "Simple Operating Margin", option (a) of the ACM0002, according to the following formulae:

$$BE_y = GEN_y * EF_y$$

Where:

BE: Baseline emissions (t CO_2e);
GEN: Electricity supplied by the project to the grid (MWh);
EF: Baseline emission factor (tCO_2e / MWh); and
y: a given year.

Where:

$$EF_y = \omega_{OM} * EF\_OM_y + \omega_{BM} EF\_BM_y$$

Where:

EF: Baseline emission factor (tCO_2e / MWh);
ω_{OM}: Operating Margin weight, which is 0.5 by default;
EF_OM: Operating Margin emission factor (tCO_2e / MWh);
ω_{BM}: Build Margin weight, which is 0.5 by default;
EF_BM: Build Margin emission factor (tCO_2e / MWh); and
y: a given year.

and

$$EF_{OM,simple,y} = \frac{\sum_{i,j} F_{i,j,y} \cdot COEF_{i,j}}{\sum_{j} GEN_{j,y}}$$

Where:

$F_{i,j,y}$ is the amount of fuel *i* (in a mass or volume unit) consumed by relevant power sources *j* in year(s) *y*;
j refers to the power sources delivering electricity to the grid, not including low-operating cost and must-run power plants, and including imports to the grid;
$COEF_{i,j\ y}$ is the CO_2 emission coefficient of fuel *i* (tCO_2 / mass or volume unit of the fuel), taking into account the carbon content of the fuels used by relevant power sources *j* and the percent oxidation of the fuel in year(s) *y*; and
$GEN_{j,y}$ is the electricity (MWh) delivered to the grid by source *j*.

The CO_2 emission coefficient $COEF_i$ is obtained as:

$$COEF_i = NCV_i * EF_{CO2,\ i} * OXID_i$$

Where:

NCV_i is the net calorific value (energy content) per mass or volume unit of a fuel *I*;
$OXID_i$ is the oxidation factor of the fuel (default values from page 1.29 in the 1996 Revised IPCC Guidelines are used); and
$EF_{CO2,i}$ is the CO_2 emission factor per unit of energy of the fuel (Default values from IPCC 1996 are used).

The Simple Operating Margin emission factor is calculated using data based upon a 3-year average, utilising the most recent statistics available at the time of PDD submission, of all operational Power Stations providing electricity to the grid.
According to ACM0002, project participants can choose between two given options of how to calculate the Build Margin for the project. In this case, option 1 has been chosen (i.e. calculate the build margin

emission factor based on the most recent information available on plants already built at the time of PDD submission).

Under option 1 there are two alternatives to select the sample group, of which the one with the sample with the largest annual generation should be chosen. The first consists of taking the five power plants that have been built the most recently. The second consists of taking the power plant capacity additions in the electricity system that comprise 20% of the system generation (MWh) that have been built the most recently. For the first alternative, since only three power plants have been built and connected to the grid in Lihir, these have been selected for the Build Margin. The Londolovit backup generator has no significant power generation and thus has not been included in the calculations. In the second alternative, the sample group would include the Putput Power Station and the 6MW Geothermal Power plant. In effect, both samples for calculation the built margin comprise of the same power plants (refer to the Build Margin calculations in Annex 3).

Thus the Build Margin is calculated as:

$$EF\_BM_y = \frac{\sum_{i,m} F_{i,m,y} * COEF_{i,m}}{\sum_{m} GEN_{j,y}}$$

Where:

EF_BM: Build Margin emission factor (tCO_2e / MWh); and

m: refers to last additions power sources delivering electricity to the grid.

The CO_2 emission coefficient $COEF_i$ is obtained as:

$$COEF_{i,n} = NCV_i \cdot EF_{CO2} \cdot OXID_i$$

Where:

NCV_i is the net calorific value per mass or volume of fuel;

$OXID_i$ is the oxidation factor of of the fuel; and

EF_{CO2} is the CO_2 emission factor per unit of energy of fuel i.

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity:

The determination of project scenario additionality is done using the CDM consolidated tool for demonstration of additionality, which follows the following steps:

Step 0. Preliminary screening of projects based on the starting date of project activities

The crediting period starts at the date of registration.

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations

Sub-step 1a. Define alternatives to the project activity:

The following alternatives to the project have been considered:

- Alternative 1 - the proposed 55MW LGPP not undertaken as a CDM project.
- Alternative 2 - the continuation of the current situation, where the existing Put-Put power station would have supplied the power.

Sub-step 1b. Compliance with applicable laws and regulations:

All the alternatives to the project activity comply with the applicable laws and regulatory requirements for electricity generation in Papua New Guinea and all relevant permits are in place.

Step 2. Investment Analysis

Sub-step 2a. Determine appropriate analysis method

The option chosen to prove additionality is Option III – "Benchmark Analysis", since the choices between the plausible alternatives represent a choice between the proposed project and continuation of business as usual. No other investment has been considered.

Sub-step 2b. Option III – Apply Benchmark Analysis

The financial indicator chosen as most suitable for the project type and decision context is the Net Present Value. The most plausible benchmark to compare the project NPV has been derived from government bond rates. As a reference the average rate of the government 182 day-Treasury Bill rate has been chosen. For the first half of 2003 this was 18.5%.[6] The consolidated tool for additionality states that for use as a benchmark, "the government bond rates shall be increased by a suitable risk premium to reflect private investment and/or the project type". There is considerable private investment risk, risk related to geothermal resource uncertainty, and technology performance risk, which could be valued at 3%. Nevertheless to be conservative, a discount rate of 18.5% has been chosen.

Sub-step 2c. Calculation and comparison of financial indicators

The next step is to calculate the NPV for the proposed CDM activity. A cash flow analysis model has been used to analyse the cash flow with and without the expected CDM revenues of the project. This analysis consists of confidential information and therefore the details of the financial analysis have only been made available to the DOE.

The assumptions made in the analysis include:

- the project will operate 8,000 hours per year. The extension from 31.7 MW to 52.8 MW will come on line in early 2007;
- the project will avoid an equal amount of electricity otherwise to be generated with HFO;
- the HFO price is based on the price of 2003;
- capital costs associated with the construction and operation of the power plant have been included in the financial model;

[6] Based on the average of the published January and June rates in the Treasury Economic Monitoring. See http://www.treasury.gov.pg/tem/march_2004.pdf

- resource analysis costs involving the drilling of twenty medium depth geothermal wells for the assessment of the intermediate depth resource have been included in the financial model;
- project development costs related to steam field definition drilling have been included in the financial model;
- costs associated with the ongoing maintenance of deep and medium depth wells have been included in the financial model; and
- the Putput Power Station will be retained as a backup installation, and the costs of care and maintenance of the plant have been included.

The results of the NPV analysis for the LGPP project are presented in Table B1 below.

Table B1: Project NPV

Description	Value
NPV of LGPP without CDM (US$)	-17,596,570
Benchmark discount rate	18.50%

The comparison indicates that the project is not viable compared to the government lending rate even without any corrections to reflect private investment. If the bond rate is corrected with technological, steam resource and private investor risks, the NPV of the LGPP project would be even more negative.

Based on the information provided above, it is clearly demonstrated that the Lihir Geothermal Power Project without CDM cannot be considered as financially attractive.

Sub-step 2d. Sensitivity Analysis

A sensitivity analysis was conducted by altering the following parameters:

- the amount of energy generation (plus and minus 10%);
- the discount rate (plus and minus 3%);
- the HFO price (plus and minus 10%); and
- project capital and operational costs (plus and minus 10%).

Financial analyses were performed altering each of these parameters and assessing what the impact on the project NPV would be, which is presented in Table B2 below. As it can be seen, the project NPV remains negative even in the case where these parameters change in favour of the project.

Table B2: Project NPV Using Alternative Project Parameters

Scenario	Parameter change	Project NPV
Base case		-17,596,570
Electricity generation	Plus 10%	-11,842,107
Electricity generation	Minus 10%	-23,351,034
HFO price	Plus 10%	-11,842,107
HFO price	Minus 10%	-23,351,034
Discount rate	Plus 3% (=21.5%)	-23,468,620
	Min 3% (=15.5%)	-8,740,165
Capital and operational costs	Plus 10%	-25,515,097
	Minus 10%	-9,678,044

After the completed investment comparison analysis, it has been clearly demonstrated that the proposed CDM project activity is unlikely to be considered as a financially attractive course of action, therefore Step 3 – Barrier Analysis is not required.

Step 4. Common Practice Analysis

4a - Other activities similar to the LGPP
There are currently no other geothermal power projects in Papua New Guinea. This has been verified by interviews of various government officials. Indeed, this will be the first geothermal power project in the South Pacific region.

4b – Discussion of similar options that occur

No similar activities are observed in Papua New Guinea.

Step 5. Impact of CDM registration

As shown in Step 2 and 4 above, the LGPP project is not a financially attractive project. If the project developer was able to sell certified emission reduction (CERs) from the project activity, the additional revenue generated by carbon sales would make the project more attractive. The financial analysis indicated that the CDM revenue has a discounted NPV of over US$10.8 million if the credits will be sold at a price of 6.0 Euro/CER. CDM will thus considerably alleviate the financial hurdle facing this project.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

Figures B2 and B3 present the flow diagrams of the proposed LGPP and of the baseline situation in accordance with the project boundary definition as presented in the Baseline Methodology ACM0002.

Figure B2: Project Delivery System of the LGPP

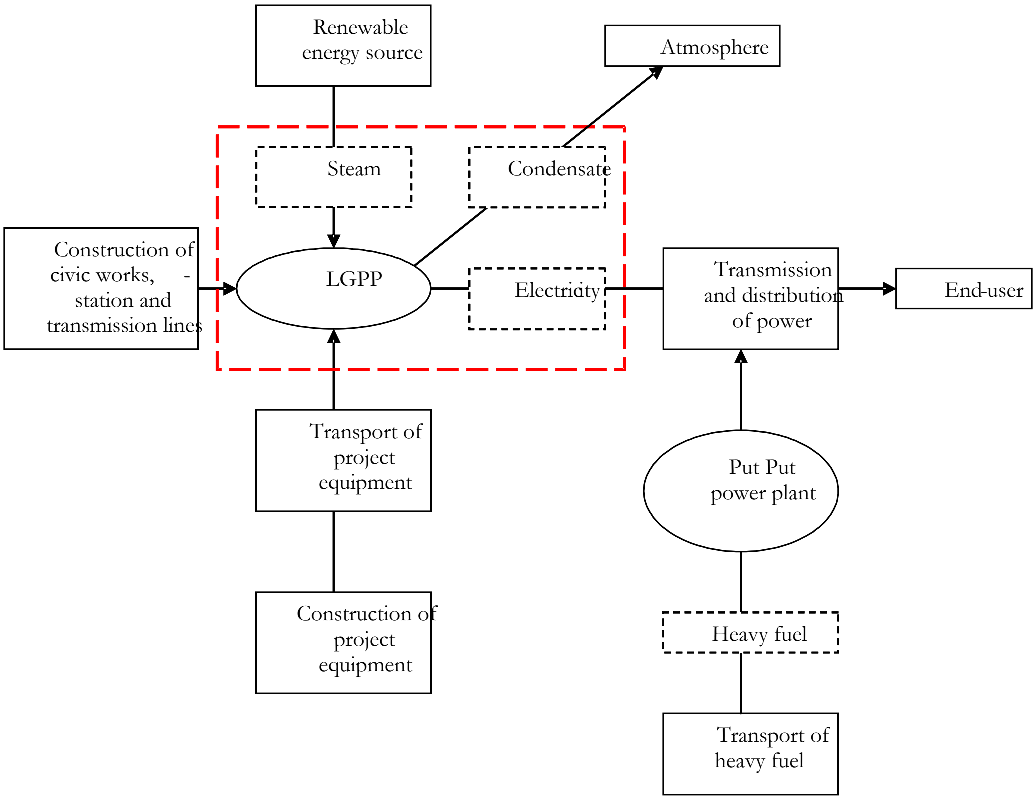
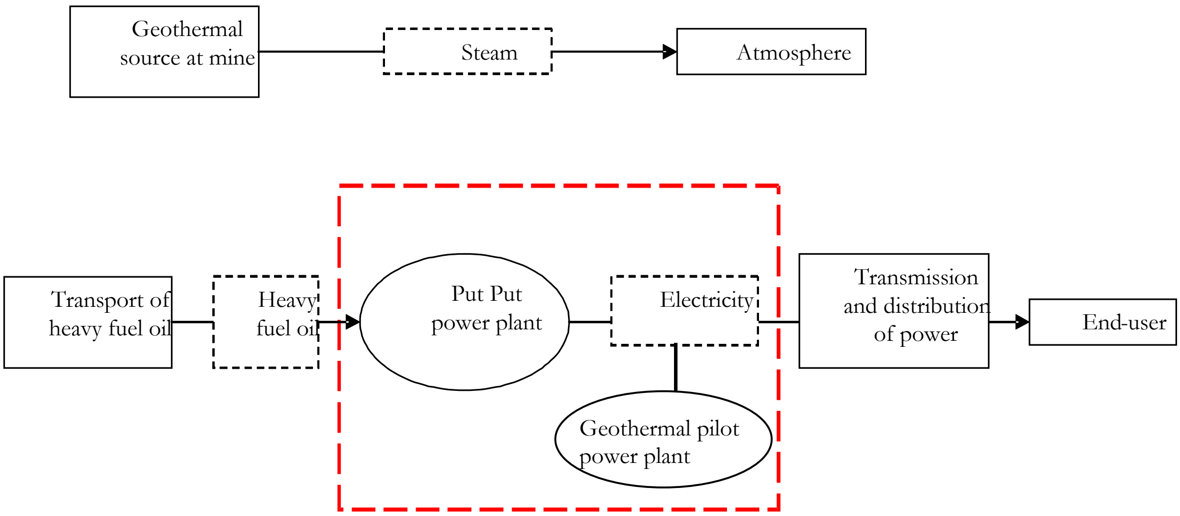


Figure B3: Current Delivery System



In the baseline methodology applied to the LGPP project, only the direct on-site emissions of the project are included in the system boundary. This means that the emissions related to the construction of the project and transport of project equipment are ignored. Additionally, emissions related to transmission

and distribution losses, emissions related to mining processes, and emissions related to the transport of materials to the project site are also excluded in the baseline scenario.

This approach is justified as emissions related to the construction of renewable power plants are excluded in the methodology ACM0002. There is no reason to assume that emissions during construction would be significant in the case of the LGPP.

The steam coming from the geothermal well contains non-condensable gases. A study of these gases[7] shows that the non-condensable gas content in the steam after separation is 2.5 to 5.0 % by weight, with an estimated average of 3%. Of this, 98.8% is CO_2 and 0.25% is CH_4. Based on projections of steam to be vented as a component of mining operations and the steam demand of the potential power outputs of the LGPP, it is envisaged that the mining operations will release sufficient steam to power the 31.7 MW and 52.8 MW potential net capacity of the LGPP[8]. It is therefore expected that no additional steam venting holes will have to be drilled; therefore the project will not increase the emission of non-condensable gases including CO_2 and CH_4 to the atmosphere. However, some uncertainty does exist over whether this upper 52.8 MW net capacity can be reached using the steam released during mining operations. Due to this, and the fact that projections of steam to be released by the mining operations are highly uncertain, there is the possibility that LMC may have to drill more holes to source additional steam for the LGPP. In that case the non-condensable gases in the steam coming from these additional wells will have to be counted as project emissions under ACM0002. For this reason LGPP will monitor the amount of steam released by the mining operations, the amount of steam consumed by the LGPP, the drilling of new wells specifically for the LGPP, and the quantity of greenhouse gases in the steam (see Section D.2.1).

As mentioned previously, Lihir has two existing diesel power stations: the 70 MW Putput Power Station and the 4 MW Londolovit Power Station. As the Londolovit Power Station is only used as a back-up generator, we have only incorporated the emissions associated with the Putput Power Station as an emission source. The emissions associated with the Londolovit station have been determined as insignificant and have thus been ignored.

Table B3 below contains a summary of the system and project boundaries for the LGPP.

[7] Grant, M.A. (MAGAK) , K. Brown (GEOKEM), Bixley, P. (LMC), 2003: "Lihir 30MW Development: Geothermal resource", LMC, 11 February 2003.
[8] Industrial Research Limited 2003: "Modelling the Luise Geothermal System", Industrial Research Limited Report No 1487, December 2003.

Table B3: Summary of System and Project Boundaries

Emissions	Project case	Baseline scenario
Direct on-site	• Emissions from activities related to the construction of the project - considered insignificant. • Possible emissions from extra drilling activities to generate steam to meet capacity.	• Emissions related to the consumption of fuel sources for electricity generation at the project site - non-existent.
Direct off-site	• Transportation of equipment to the project site - excluded • Distribution and transmission losses - excluded.	• Transport of HFO to the site – excluded. • Distribution and transmission losses - excluded.
Indirect on-site	• Use electric output net of parasitic loads.	• Use electric output net of parasitic loads.
Indirect off-site	• The indirect off-site emissions related to displaced power plants is a baseline issue and treated as direct on-site emissions for the baseline scenario. Other indirect off-site GHG emission sources are excluded.	• Indirect off-site emissions related to transport of heavy fuel oil or mining/processing of the HFO are excluded.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

This baseline was completed on 29 June 2005.

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SMEC-HGM is the lead entity for all communication with regards to this CDM Project Design Document.

SECTION C. Duration of the project activity / Crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

Project construction commenced in May 2004. The 31.7 MW net capacity plant became operational in June 2005. The LGPP's capacity will be expanded to a total net capacity of 52.8 MW by early 2007.

C.1.2. Expected operational lifetime of the project activity:

The Lihir Geothermal Power Plant will be operational for approximately 30 years.

C.2 Choice of the crediting period and related information:

A fixed crediting period has been selected for this project.

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

Not applicable

C.2.1.2. Length of the first crediting period:

Not applicable

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

The starting date for the first crediting period is 05/06/2006.

C.2.2.2. Length:

Length (max 10 years): 10 years

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

Approved consolidated monitoring methodology ACM0002, *"Consolidated monitoring methodology for zero-emissions grid-connected electricity generation from renewable sources"* has been selected as the appropriate monitoring methodology for this project.

D.2. Justification of the choice of the methodology and why it is applicable to the project activity:

The LGPP meets the applicability criteria as outlined in the consolidated monitoring methodology ACM0002 (and which are in line with the applicability criteria of the consolidated baseline methodology ACM0002). Specifically, electricity generation from the LGPP will be monitored and data on the fugitive carbon dioxide and methane emissions and carbon dioxide emissions from combustion of fossil fuels required to operate the LGPP will be calculated.

The project will monitor its net electricity production from the project activity using on site metering equipment at the substation (interconnection facility connecting the LGPP to the grid). The meter reading records will be made accessible to the auditors, and calibration tests records will be maintained.

As mentioned in Section B4, LMC may have to drill additional holes to source additional steam for the LGPP. In that case the non-condensable gases in the steam coming from these additional wells will have to be counted as project emissions. For this reason LGPP will also monitor the amount of steam released by the mining operations, the amount of steam consumed by the LGPP, the drilling of new wells specifically for the LGPP, and the quantity of greenhouse gases in the steam. Section D2.2 specifies how this monitoring will be conducted.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1. Wi	Well	LMC	Number of wells	M	daily	100%	Electronic	Only condensable gases will be monitored from steam from wells specifically drilled for the LGPP
2. MS, y	Quantity of steam produced during year y	LMC	t	M	daily	100%	Electronic	See note 1
3. $w_{Main,CO2}$	Fraction of CO_2 in produced steam	LMC	tCO_2 / t steam	M	Every 4 months	100%	Electronic	See note 2
4. $w_{Main,CH4}$	Fraction of CH_4 in produced steam	LMC	tCH_4 / t steam	M	Every 4 months	100%	Electronic	See note 2
5. M_{ty}	Quantity of steam generated during well testing	LMC	t	M	daily	100%	Electronic	See note 1
6. $w_{t,CO2}$	Fraction of CO_2 in Steam generated during well	LMC	tCO_2 / t steam	M	Every 4 months	100%	Electronic	See note 2

	testing							
7. $w_{t,CH4}$	Fraction of CH_4 in steam produced during well testing	LMC	tCH_4 / t steam	M	Every 4 months	100%	Electronic	See note 2
8. $F_{i,y}$	Amount of fossil fuels used for the operation of the geothermal plant	LMC	Mass or volume	M	Monthly	100%	Electronic	
9. $COEF_i$	CO_2 emission coefficients of fossil fuel types I used for the operation of the geothermal plant	LMC	tCO_2 / mass or volume unit	M	As required	100%	Electronic	IPCC Default value used

The following specific notes apply to the table.

Note 1: Steam flow rate, power plant
The steam quantity discharged from the geothermal wells will be measured with a venture flow meter (or other equipment with at least the same accuracy). Measurement of temperature and pressure upstream of the venture meter will define the steam properties. The calculation of steam quantities will be conducted on a continuous basis and based on international standards. The measurement results will be summarized transparently in regular production reports.

Note 2: Non-condensable gases in geothermal steam
Non-condensable gases (NCGs) in geothermal reservoirs usually consist mainly of CO_2 and H_2S. They also contain a small quantity of hydrocarbons, including predominantly CH_4. In geothermal power projects, NCGs flow with the steam into the power plant. A small proportion of the CO_2 is converted to carbonate / bicarbonate in the cooling water circuit. In addition, parts of the NCGs are reinjected into the geothermal reservoir (please note that this does not occur at Lihir due to mining operational requirements). However, as a conservative approach, this methodology assumes that all NCGs entering the power plant are discharged to atmosphere via the cooling tower. NCG sampling will be carried out in production wells and at the steam field-power plant interface using ASTM Standard Practice E1675 for Sampling 2 - Phase Geothermal Fluid for Purposes of Chemical Analysis (as applicable to sampling single phase

steam only). The CO_2 and CH_4 sampling and analysis procedure consists of collecting NCG samples from the main steam line with glass flasks, filled with sodium hydroxide solution and additional chemicals to prevent oxidation. Hydrogen sulphide (H_2S) and carbon dioxide (CO_2) dissolve in the solvent while the residual compounds remain in their gaseous phase. The gas portion will then be analyzed using gas chromatography to determine the content of the residuals including CH_4. All alkanes concentrations will be reported in terms of methane. The NCG sampling and analysis will be performed at least every three months and more frequently, if determined necessary. Accuracy of data monitoring and collection will be in line with the ASTM Standard Practice E1675.

All archived data will be kept until two years after the last issuance of CERs for this project. The electricity generated by the LGPP will be measured with energy meters with an accuracy of within 1%. The Utilities Superintendent of LMC will be responsible for the monitoring and storing of this data. Data will be archived in LMC's existing information storage system on a monthly basis.

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Formulae used to estimate the project emissions for the project activity are as outlined in Section B2.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
10. EGy, power plant	Electricity supplied to the grid by the project	LMC	MWh	M	Continuous	100%	Electronic	Results can be cross checked with sales receipts of power consumption data

11. EFy	CO_2 emission factor for the grid	LMC	tCO_2/MWh	c	Yearly	100%	Electronic	Calculated as a weighted sum of the OM and BM emission factors.
12. EFOM, y	CO_2 operating margin emission factor for the grid	LMC	tCO_2/MWh	c	Yearly	100%	Electronic	Calculated based on the simple OM methodology in ACM0002
13. EF BM,y	CO_2 build margin emission factor for the grid	LMC	tCO_2/MWh	c	Yearly	100%	Electronic	Calculated as $[\sum_i F_{i,y} * COEF_i] / [\sum_m GEN_{m,y}]$ over recently built power plants defined in the baseline methodology
14. Fi,y	Amount of fossil fuel consumed by each power plant	LMC	Mass or volume	m	Yearly	100%	Electronic	Obtained from LMC who operate the baseline grid connected power plants
15. COEFi	CO_2 emission coefficient of each fuel type i	IPCC	tCO_2e/ mass or volume unit	m	Yearly	100%	Electronic	IPCC 1996 default value used
16. GENj/k/ n, y	Electricity generation of each power plant j, k or n	LMC	MWh/ year	m	Yearly	100%	Electronic	Obtained from LMC who operate the baseline grid connected power plants
17.	Identification of power plant for the OM	LMC	Text	e	Yearly	100%	Electronic	Identification of plants j, k, or n to calculate operating margin emission factors
18.	Identification of power plant for the BM	LMC	Text	e	Yearly	100%	Electronic	Identification of plants m to calculate build margin emission factors

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Formulae used to estimate the project emissions for the project activity are as outlined in Section B2.

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

Not applicable

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

D.2.3. Treatment of leakage in the monitoring plan

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

Not applicable, since leakage is determined as negligible, and does not have to be considered, according to ACM0002

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

>>

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

Formulae used to estimate the emission reductions for the project activity are as outlined in section B.2.

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored

Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
Table D.2.1.3; 11, 14, 15, 16	Low	QA/QC procedures are planned for these data as these data will be directly used for calculation of emission reductions. Sales record to the grid and other records are used to ensure the consistency.
Others	Low	QA/QC procedures are planned for these data as these data as default data (for emission factors) are used to check the local data.

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

LMC propose to appoint a CDM Monitoring Officer within the External Affairs and Sustainability Development department to monitor emission reductions. As identified previously no significant sources of leakage are expected.

D.5 Name of person/entity determining the monitoring methodology:

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SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

The estimated anthropogenic emissions of the LGPP by sources of greenhouse gases within the project boundary are determined by the following formula:

$PE_y = PES_y + PEFF_y$.

Where PES_y = the project emissions due to the release of carbon dioxide and methane from the produced steam during the year *y*; and

PEFFy = the project emissions from combustion of fossil fuels related to the operation of the geothermal power plants in tons of CO_2.

Based on projections of steam to be vented as a component of mining operations and the steam demand of the potential power outputs of the LGPP, it is envisaged that the mining operations will release sufficient steam to power the 31.7 MW and 52.8 MW potential net capacity of the LGPP[9].

Thus $PES_y = 0$.

However, some uncertainty does exist over whether this upper 52.8 MW net capacity can be reached using the steam released during mining operations. Due to this, and the fact that projections of steam to be released by the mining operations are highly uncertain, LMC may have to drill additional holes to source additional steam for the LGPP. In the event that extra drilling is necessary, the non-condensable gases in the steam resulting from these additional wells will be counted as project emissions. LMC will monitor the amount of steam released by the mining operations, the amount of steam consumed by the LGPP, the drilling of new wells specifically for the LGPP, and the quantity of greenhouse gases in the steam in order to determine project emissions if wells in excess of those required the mining operations are necessary.

Emissions associated with fuel combustion and transport of equipment for the LGPP are likely to be offset by emissions related to the transport of the HFO in the baseline situation. Similarly emissions related to the construction of the LGPP are likely to be less than emissions associated with construction of the baseline power plant. Given that the net balance of both emission sources are likely to be insignificant compared to the direct emission sources related to the burning of HFO it is justifiable to exclude them from the project emission calculations.

Thus $PEFF_y = 0$.

Total project emissions for geothermal activities are determined by:

$$PE_y = PES_y + PEFF_y$$

On this basis, project emissions PE_y associated with the LGPP = 0.

E.2. Estimated leakage:

[9] Industrial Research Limited 2003: "Modelling the Luise Geothermal System", Industrial Research Limited Report No 1487, December 2003.

No significant sources of leakage are to be expected for the LGPP. A possible source of leakage might be emissions during the construction phase of the LGPP – however this is unlikely to be greater 1% and therefore considered to be insignificant.
Thus $L_y = 0$.

E.3. The sum of E.1 and E.2 representing the project activity emissions:

The sum of PE_y and L_y is expected to be zero.

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

Following the methodology ACM0002, the estimated anthropogenic emissions for the Putput Power Station for the crediting period is calculated using the following formula:

$$BE_y = EG_y * EF_{BL}$$

Where the baseline emissions (BEy in tCO_2) are the product of the baseline emissions factor (EF_{BL} in tCO_2/MWh) times the electricity supplied by the project activity to the grid (EG_y in MWh).

The total emissions generated in the baseline situation determined by the project using the above formula is 2.789 $MtCO_2$ (see Annex 3 for further detailed calculations).

Electricity Generated Emissions Reductions	**Per Year**	**Crediting Period (10 years)**
Estimated Simple Operating Margin Emissions Factor (EF_OM_y in tCO_2/MWh)	0.704	-
Build Margin Emissions Factor (EF_BM_y in tCO_2/MWh)	0.653	-
Baseline Emissions Factor (EF_y in tCO_2/MWh)	0.678	-
Electricity generated by Project (*EG* GWh)	411	4,111
Baseline Emissions (*BE* $ktCO_2$)	**279**	**2,789**

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity:

The project is ultimately expected to generate an average of 411 GWh of electricity per year (assuming a total net capacity of 52.8 MW) during the crediting period. The total emission reductions are expected to be 2.789 $MtCO_2$.

2.789 – 0 = 2.789 MtCO2e.

E.6. Table providing values obtained when applying formulae above:

The emission reductions resulting from the project activity during the first crediting period are shown in Table E1 below.

Table E1 Project Activity Emission Reductions During the First Crediting Period

Year	Estimation of project activity emission reductions (tonnes of CO2 e)	Estimation of baseline emission reductions (tonnes of CO2 e)	Estimation of leakage (tonnes of CO2 e)	Estimation of emission reductions (tonnes of CO2 e)
2006	0	114,687	0	114,687
2007	0	286,537	0	286,537
2008	0	286,537	0	286,537
2009	0	286,537	0	286,537
2010	0	286,537	0	286,537
2011	0	286,537	0	286,537
2012	0	286,537	0	286,537
2013	0	286,537	0	286,537
2014	0	286,537	0	286,537
2015	0	286,537	0	286,537
2016	0	95,512	0	95,512
Total	0	2,789,037	0	2,789,037

SECTION F. Environmental impacts

F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

PNG legislation does not require an environmental assessment to be undertaken for the implementation of this Project Activity.

An assessment of the environmental impacts of the Lihir Gold Mine by way of an *Environmental Plan* was undertaken and submitted to the PNG Department of Environment and Conservation prior to the construction. This Environmental Plan was prepared on a voluntary basis pursuant to Section 46 (6) of the *Environmental Planning Act*, Chapter 370, to inform the PNG Government of the project and its environmental effects, and to document an environmental management and monitoring plan. The Environmental Plan was approved by the PNG Government in 1995.

A number of environmental investigations were undertaken during this the course of this assessment process including an evaluation of the mine's impacts on the marine environment, air quality, and terrestrial ecology. Socio-economic effects of the project were also considered at this time. If required, a copy of the Final Environmental Plan prepared for the Lihir Gold Mine is available upon request.

The addition of a geothermal power plant to the mine is not expected to result in any significant environmental impacts and advice from the PNG Department of Environment and Conservation confirms that an additional environmental assessment of impacts associated with the construction and operation of the LGPP is not required under the PNG Government's environmental legislation. Discharges and emissions arising from the geothermal project will fit under the existing environmental permits of the mine. Therefore no additional environmental assessment is required to undertake the Project Activity.

LMC has also been working closely with the PNG Government to ensure that the operational environmental impacts of the mine are minimised. LMC has involved the PNG Government in the implementation of its environmental management and monitoring plan for the specific purpose of ensuring that the company fulfils its environmental obligations under PNG environmental legislation. Additionally LMC demonstrates its commitment to the environment through the preparation of annual Community and Environment Reports. The scope of these initiatives will be expanded to include the operation of the LGPP.

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

Not applicable. Impacts are not considered to be significant by the project participants or the host Party.

SECTION G. Stakeholders' comments

G.1. Brief description how comments by local stakeholders have been invited and compiled:

The LGPP is located entirely within the boundaries of the Lihir Gold Mine and all emissions and discharges associated with this Project Activity are similar to those of the baseline scenario. There are no additional stakeholders directly affected by the LGPP – either within its pilot project phase or the current Project Activity. Regardless of this, stakeholders have been extensively consulted during the planning phases of both the 6 MW pilot plant and the LGPP.

The various elements of stakeholder consultation have included:

- involvement of local and national authorities in the planning and design phases of the project;
- consultation with land owners;
- publicity via local media;
- facilitation of community consultation events; and
- sending surveys inviting comment regarding the CDM component of the LGPP.

Each of these activities is discussed in detail below.

Involvement of local and national authorities in the planning and design phases of the project

In line with environmental assessment procedures of PNG, the construction of both the pilot project and the LGPP has been discussed with national and local government authorities. In March 2004 meetings were also held with representatives from DEC, Department of Energy, Ministry of Justice, the Prime Minster's Department, and National Planning and Rural Development where the relationship between the project and the CDM were discussed.

Consultation with land owners

The Lihir Gold Mine has a lease over the land on which the mining operations and associated activities (including power generation) are taking place. Under current arrangements the land will be returned to the local land owners by LMC after mining ceases operations in 2041. As the construction of the pilot plant and LGPP will occur on land owned by the local land owners, they have been consulted with regarding the implementation of the two projects accordingly.

Publicity via local media

Articles describing the construction of the pilot project and the planned implementation of the LGPP have been included in several publications. These include *Lihir Direct*, a quarterly magazine distributed on Lihir, specific information sheets (*Toksari*), and a monthly community magazine (*Komuniti Niusleta*). Press releases have also been issued to various national press agencies.

Facilitation of community consultation events

The 6 MW pilot project was officially opened in April 2003 by the Minister of Mining. Nearly 100 people attended the opening including representatives from:

- PNG National Government: Hon Sam Akoitai, PNG Minister for Mining, and Hon Bart Philemon PNG Minister for Treasury;
- Local Government: Ambrose Silul, President, Nimamar Local Level Government;
- the Lihir Mining Area Landowners' Association: Marc Soipang, Chairman; and
- the local community.

During the official opening, information was provided to attendees regarding not just the pilot project but the potential development of the LGPP as well. An exhibition tent was set up as a part of the event to provide further details to the local community via posters and brochures. LMC staff also further explained the concept of geothermal energy. Guided tours were also given by LMC staff around the pilot power plant site to attendees.

A workshop was also held in 2004 with local government representatives. During this workshop, the proposed LGPP was presented and the relationship of the project with global warming and the CDM outlined.

Sending surveys inviting comment regarding the CDM component of the LGPP

Surveys were sent to two key stakeholders that were not able to be interviewed inviting their comments on the CDM component of the LGPP.

G.2. Summary of the comments received:

One issue raised during consultation with land owners during the planning stage of the pilot plant was related to the steam venting process. The geothermal plant redirects the steam from vents at

the mine site to the power plant site. Objections were raised against the initial design due to the fact that steam would be vented directly onto a sacred rock.

Specific feedback received from the attendees of the opening of the 6 MW pilot project held in April 2003 was in general very positive and included the following points:

- The islanders were excited by the idea that geothermal energy could provide a long term source of power to the island even after completion of the mining operations.
- The project has been positively received at the Government level with the replication potential of the geothermal power in other parts of PNG being identified. Also the operation of this first power plant will create local capacity in operating and managing geothermal energy.
- The islanders perceive the reduction of potential pollution from heavy fuel oil burning of the geothermal plant as a positive influence to their environment.
- As a new technology the geothermal plant raised questions about how energy was derived from the steam. The amount of steam vented by the plant especially impressed some people. This issue was addressed by highlighting the fact that the geothermal plant does not generate steam by itself but rather uses steam released from the mining operations.
- Community members were satisfied with the re-direction of the steam from the geothermal power plant.

During a more recent meeting with representatives of the local government held in March 2004, the following issues were raised by stakeholders and the responses given:

- A question was asked when the remainder of the island would be electrified. Although this issue is not directly related to the development of the LGPP, by expanding the capacity on the island the LGPP creates the possibility of providing power to a wider area. The expansion of the electricity grid is an item which will be further discussed between LMC and the local community. A key impediment for electrification is that the low load on the other side of the island makes it very expensive to extend the power grid. Electrification with decentralised energy systems such as solar home systems may be a more attractive alternative.
- Queries were made with regards to greenhouse gas emissions and why they were a problem for the planet and in particular for Lihir. A brief explanation of the greenhouse effect and its potential impacts was given.
- Two remarks were made that the CDM of the Kyoto Protocol appears to be loophole to assist industrialised countries avoid decreasing GHG emissions within their own countries. In response, a brief explanation was given on the pros and cons of emission trading under the Kyoto Protocol. Reference was also made to the fact that the Government of Papua New Guinea ratified the Kyoto Protocol in 2000 and that the LGPP will need to seek host country approval from the Government of Papua New Guinea; and
- Various questions on the operation of geothermal power were also raised and were addressed by technical experts.

Feedback from surveyed stakeholders was also positive with comments including recognition of the contribution of the Project Activity to the sustainable development of PNG, as well as the contribution that could potentially be made to PNG's 'energy plans for the future' if the LGPP is replicated within other parts of the country. It was also felt that this Project Activity would encourage the finalisation of PNG's renewable energy policy and attract foreign investment to the country.

G.3. Report on how due account was taken of any comments received:

In response to objections raised against the initial design due to the fact that steam would be vented directly onto a sacred rock, LMC adjusted the design of the piping associated with the venting process so that the steam would be redirected away from this rock.

Detailed explanations addressing specific comments raised by stakeholders have been provided throughout the development process.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2 – Information Regarding Public Funding

No public funding, either national or international, was sourced in order to undertake any aspect of this Project Activity. The LGPP was funded solely by private entities.

Annex 3 – Baseline Information

Data used in the calculation of the baseline emissions

Power plant information of the Lihir grid:

Plant Names	Must Run?	Year of Commission (date)	Fuel	Fuel Consumption (t/year)			Electricity Generation (MWh/year)		
				2002	2003	2004	2002	2003	2004
Put Put	No	1990	Heavy fuel oil	94,880	92,524	88,725	427,275	402,028	384,020
Geothermal (6MW)	Yes	2003	Geothermal	0	0	0	0	23,573	36,189
Total							427,275	425,601	420,209

Operating Margin				
	2002	2003	2004	3 Year Average
Heavy Fuel Oil	94,880	92,524	88,725	92,043
MWh/year	427,275	402,028	384,020	404,441
Heavy Fuel Oil Emission Factor (IPCC, 1996)	3.091 tonnes of CO_2/tonne of fuel			
tCO_2/MWh	0.69	0.71	0.71	
Average Emission Factor				0.704

Build Margin			
	MWh/Year	Emissions (tCO_2/Year)	Build Margin
Last 5 plants	420,209	274,268	0.653
Last 20%	420,209	274,268	0.653

Combined Margin	
Operating Margin EF (tCO2/MWh)	0.704
Build Margin EF (tCO2/MWh)	0.653
Combined Margin (tCO2/MWh)	0.678

Total Emissions

Total Emissions					
Year	Installed Capacity (MW)	Annual Operating Hours	GWh	$ktCO_2$/Year	$ktCO_2$/Cumulative
2006	2006	31.7	5,333	169	115
2007	2007	52.8	8,000	422	287
2008	2008	52.8	8,000	422	287
2009	2009	52.8	8,000	422	287
2010	2010	52.8	8,000	422	287
2011	2011	52.8	8,000	422	287
2012	2012	52.8	8,000	422	287
2013	2013	52.8	8,000	422	287
2014	2014	52.8	8,000	422	287
2015	2015	52.8	8,000	422	287
2016	2016	52.8	2,667	141	96

Annex 4 – Monitoring Plan

This plan aims to monitor on a regular basis the GHG emissions of the Lihir Geothermal Power Project from non-condensable gases and the power displaced from the Lihir electricity grid. Five main activities are to be performed within the monitoring process:

1. Calibration and maintenance of monitoring of equipment and instruments
2. Gathering of data from steam wells and power generation
3. Calculation of GHG emission reductions
4. Management and storage of data
5. Supervision of the quality of the monitoring process
6. Issuance of reports for internal and external verification

LMC propose to appoint a CDM Monitoring Officer within its Department for External Affairs and Sustainability Development who will be responsible for monitoring emission reductions.

Annex 4. Monitoring Procedures								
	Activity		Sub-Activity	Responsible		Periodicity	Performance Indicator	Report
1	Calibration and maintenance of monitoring of equipment and instruments	A	Calibrate sampling equipment and instruments	Manufacturer of equipment/ External Affairs and Sustainable Development department	Manufacturer of equipment/CDM Monitoring Officer	Every 12 months	Sampling will be conducted in accordance with ASTM E1675-83: Standard Practice for Sampling Two Phase Geothermal Fluid for the Purposes of Chemical Analysis at the frequency specified	LGP-CM-01
		B	Calibrate and maintain laboratory equipment and instruments	Manufacturer of equipment/ External Affairs and Sustainable Development department	Manufacturer of equipment/CDM Monitoring Officer	In accordance with guidelines specified by the National Association of Testing Authorities, Australia (NATA), or equivalent	Sampling will be conducted in accordance with AS ISO/IEC 17025-2005: General requirements for the competence of testing and calibration laboratories at the frequency specified	LGP-CM-01
		C	Calibration and Maintenance of electricity meter	Manufacturer of equipment/ External Affairs and Sustainable Development department	Manufacturer of equipment/CDM Monitoring Officer	In accordance with the manufacturers recommendations	LMC will ensure that a manufacturer's test certificate accompanies all purchased meters. Meters will be recalibrated in accordance with IEC standards	Manufacturers test certificates
2	Gathering of data from steam wells and power generation	A	Sampling steam from wells used by the project activity	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every three months	Sampling will be conducted in accordance with ASTM E1675-83: Standard Practice for Sampling Two Phase Geothermal Fluid for the Purposes of Chemical Analysis at the frequency specified	LGP -GD-01
		B	Analyse CO2 content of the steam	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every three months	Sampling will be conducted in accordance with ASTM E947-83: Standard Specification for Sampling Single Phase Geothermal Liquid or Steam for Purposes of Chemical Analysis at the frequency specified	

		C	Analyse CH4 content of the steam	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every three months	Sampling will be conducted in accordance with ASTM E947-83: Standard Specification for Sampling Single Phase Geothermal Liquid or Steam for Purposes of Chemical Analysis at the frequency specified	
		D	Report the findings of the chemical analysis	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every four months	Table D.2.1.1. on PDD	
		E	Read electricity generation data from meter	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	Table D.2.1.1. on PDD	LGP -GD-02
		F	Measure the steam flow	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	Table D.2.1.1. on PDD	
		G	Report the data from the readings and measure	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	Table D.2.1.1. on PDD	
3	Calculation of GHG emission reductions	A	Calculate the project activity emissions from CO2 and CH4 emissions from NCG discharged to the atmosphere due to the project activity	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	Sections D.2.1.2 and B.2 on PDD	-
		B	Calculate the CO2 and CH4 emissions offset from the grid	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	Section D.2.4	-
		C	Calculate the CO2 and CH4 emission reductions	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	Section D.2.4	

4	Management and storage of data	A	Archive data from steam wells	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every four months	Table D.2.1.1 and section D.4 on PDD	-
		B	Archive data from steam wells and power generation	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	Table D.2.1.1 and section D.4 on PDD	-
		C	Manage the data and information	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	Sections D.2.1 and D.4 on PDD	-
		D	Storage the data and information	External Affairs and Sustainable Development department	CDM Monitoring Officer	daily	The data and information should be storage two years after the crediting period has finished	-
5	Supervision of the quality of the monitoring process	A	Review all reports are being performed as mentioned in this plan	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every four months	Monitoring plan and Section D.3 on PDD	LGP -SMP-01
		B	Interview the monitoring personnel	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every four months		
		C	Performance evaluation of monitoring personnel	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every four months	Monitoring plan procedures and reports	
		D	Issue a evaluation report of the monitoring process	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every four months	Send the report on time to all clients	

		E	Assure the periodical training of personnel within the External Affairs and Sustainability Development department	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every six months	All personnel involved in the monitoring process is capable or performing their appointed tasks according with the "performance indicators" mentioned in this plan	LGP -SMP-02
6	Issuance of reports for internal and external verification	A	Produce a Monitoring Management report summarising the reports mentioned above	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every six months	Send the report on time to all clients	LGP -MM-01
		B	Produce a report of the GHG emission reductions	External Affairs and Sustainable Development department	CDM Monitoring Officer	Every four months	Send the report on time to all clients and according with section D on the PDD	LGP -GHG-01

Annex 4. List of Monitoring Reports				
Code	Name	Content	Issuer	Receiver
LGP -CM-01	Instruments and Equipments Calibration and Maintenance Report	List of equipments and instruments used in the sampling and laboratory chemical analysis which have been calibrated and maintained, mentioning the applicable international standards	CDM Monitoring Officer	General Manager Operations
LGP -GD-01	Non Condensable Gases (NCG) Sampling and Data Analysis Report	Description of sampling and data analysis process, including any problem faced an its solution.	CDM Monitoring Officer	General Manager Operations
		Present the result of the analysis in terms of the proportion of NCG found in the samples	CDM Monitoring Officer	General Manager Operations
LGP -GD-02	Power Generation Report	Electricity supplied to the grid (MWh) and daily power output (MW)	Technical Services Manager	General Manager Operations
LGP -SMP-01	Monitoring Auditing Report	Describe every anomaly found and the way the External Affairs and Sustainability Development department have proceeded to fix them.	Technical Services Manager	General Manager Operations
LGP -SMP-02	Trained Monitoring Personnel Report	Description of the training courses delivered to personnel from the Monitoring Department in the External Affairs and Sustainability Development including who attended and briefly describing the content of the course.	Technical Services Manager	General Manager Operations
		Letter certifying the sampling and laboratory staff has proper capacity to perform the samplings and analysis (the letter must be issued every year)	CDM Monitoring Officer	General Manager Operations
LGP -MM-01	Monitoring Management Report	Summarise all other reports	Technical Services Manager	General Manager Operations

LGP -GHG-01	GHG Report	Describe the GHG emissions of the project activity as well as the GHG emission reduction from the electricity displaced from the grid	Technical Services Manager	General Manager Operations