**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:

**>> Chile: Chacabuquito 26 MW Run-of-River Hydropower Project**
Version 1
Version Date: Sept 6, 2006.

### A.2. Description of the project activity:

>> The Chacabuquito Project consists of a run-of-river power plant of 26 MW capacity that utilizes the waters of the Aconcagua river. It produces an average annual generation of 175 GWh gross (160 GWh net and 0.77 plant factor). The project connects to the 5$^{th}$ Region's at a 110 KV sub-system within the Central Interconnected System (SIC) and energy is delivered to industrial and residential consumers in the area. In addition, it is important to note that the plant does not consider a dam.

This plant is in cascade with two other upstream existent plants, Los Quilos and Aconcagua, which have been successfully operated since 1939 and 1994 respectively. In addition, there is a fourth project of similar characteristics on the same river, being also submitted under carbon credits financing. The project is being developed by Hidroeléctrica Guardia Vieja (HGV), a subsidiary of Grupo Matte.

The project uses well-proven technologies for run-of-river power generation. The design consists of a diversion weir, a system of channels and tunnels, a penstock and a powerhouse with four turbine-generator kits. In addition, the project construction costs are about US$ 37.0 million including contingencies but without financing charges. Of this, US$ 34.0 million corresponds to the cost associated with the hydro electric plant and related equipment and US$ 3.0 million is required for the expansion of the current transmission lines that connects Los Quilos and Aconcagua plants.

This project contributes to sustainable development in Chile through:

- Use of local renewable energy resources (small hydro) to displace coal and natural gas thermal power generation in the SIC.
- Increased commercial activity through clean and renewable source of power.
- Employment generation in the 5$^{th}$ Region where the project is located.

Furthermore, domestic and local environmental and socio-economic benefits are summarized in table 1.

Table 1: Domestic and local benefits

| "Issue" Area | Explanation |
|---|---|
| **Local environmental benefits** | - The project will contribute with clean energy for the Central Interconnected System of Chile, displacing thermal generation<br>- 18 hectares of reforestation with locally native trees. |
| **Socio-economic benefits** | - The project will allow the 5th Region to exploit its significant economic potential.<br>- Two new bridges and new access roads for semi-isolated villages in the region.<br>- Job creation during the construction period and also during the operation<br>- Economic activity during the construction period and also during all of its lifetime |
| **Capacity building** | - Extensive pre-negotiations consultations have been carried out and a Post-negotiations workshop communicating the lessons learned from the project design and implementation. |
| **Technology transfer** | - Introduction and demonstration of environmentally friendly power production techniques for the 5th Region is an explicit objective of the project.<br>- The demonstration that ERs from renewable energy can earn additional income and the introduction of CDM know-how is expected to raise environmental awareness and may create interest in low carbon energy technologies. |
| **Environmental Impact Assessment (EIA)** | - An EIA has been carried out in accordance with Chilean law and Executive Summary is being made available with other documentation for the Validation process. A more detailed impact assessment is available on request from the project operator. World Bank safeguard policies were applied as part of the detailed project design. Typically, small scale run-of-river hydropower projects have very limited environmental impacts. |

**A.3. Project participants:**

>> See Table 2 below for a list of Project Participants

**Table 2: Project Participants**

| **Name of Party involved (*):** | **Private and/or public entity(ies) Project Participants(*)** | **Does the Party involved wish to be considered as project participant?** |
|---|---|---|
| Chile (Host Party) | Hidroelectrica Guardia Vieja S.A. | No |
| State of the Netherlands | International Bank for Reconstruction and Development (IBRD) as the Trustee of the Prototype Carbon Fund (PCF) | Yes |
| Government of Canada | International Bank for Reconstruction and Development (IBRD) as the Trustee of the Prototype Carbon Fund (PCF) | Yes |
| (*) 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. | | |
| Note: *When the PDD is filled in support of a proposed new methodology (forms CDM-NBM and CDM-NMM),* at least the host Party (ies) and any known project participants (e.g. those proposing a new methodology) shall be identified. | | |

Source: World Bank

Please see Annex 1 for detailed contact information on the project participants.

**A.4. Technical description of the project activity:**

**A.4.1. Location of the project activity:**

>> The project will be located in the 5th region of Chile, in the Aconcagua river, near the city of Los Andes, at 100 Km north-east form Santiago, Chile.

**A.4.1.1. Host Party(ies):**

>>**Chile**

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

>>**5th Region**

**A.4.1.3. City/Town/Community etc:**

>>**Los Andes**

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

>> Los Andes is located 100 km north from Santiago (capitol of the country). The hydro power plant is located in a small valley surrounded by mountains (Aconcagua Valley). The Chacabuquito plant is in cascade with two existing upstream hydropower plants (Aconcagua of 81 MW and Los Quilos of 39 MW).

The location of the project activity is illustrated in Figure 1.

**Figure 1a: Chacabuquito Project Location. Geographic position**

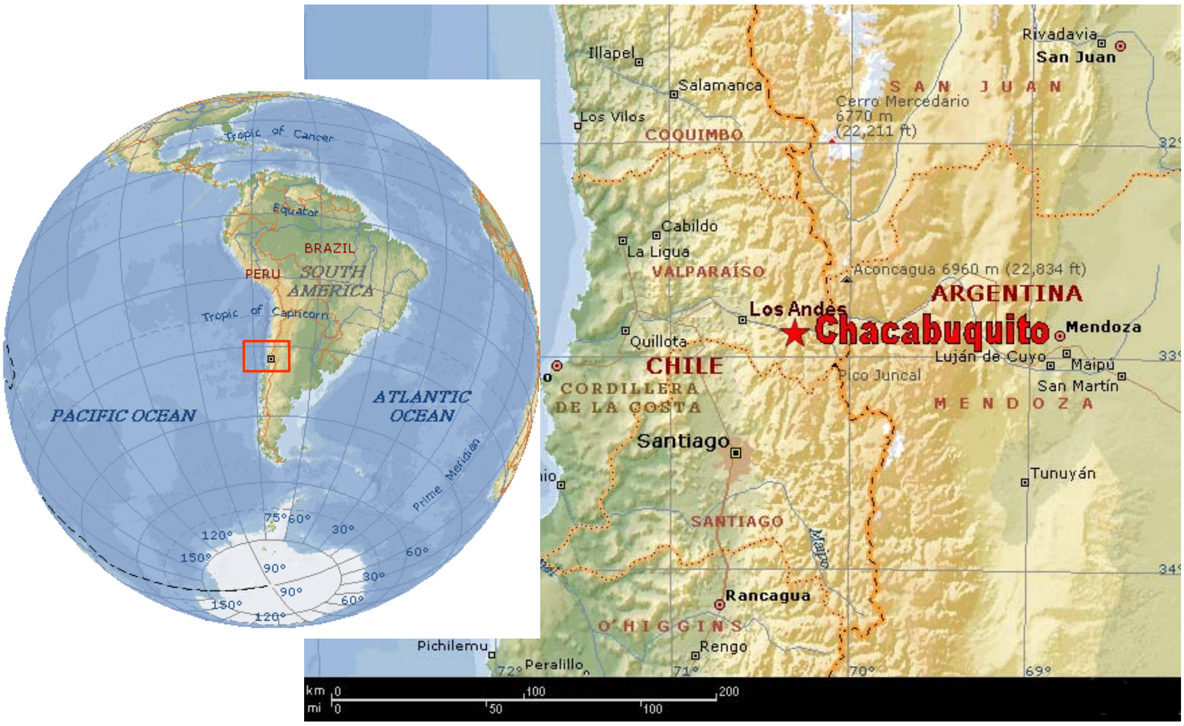



**Figure 1b: Chacabuquito Project Location. Road Map**

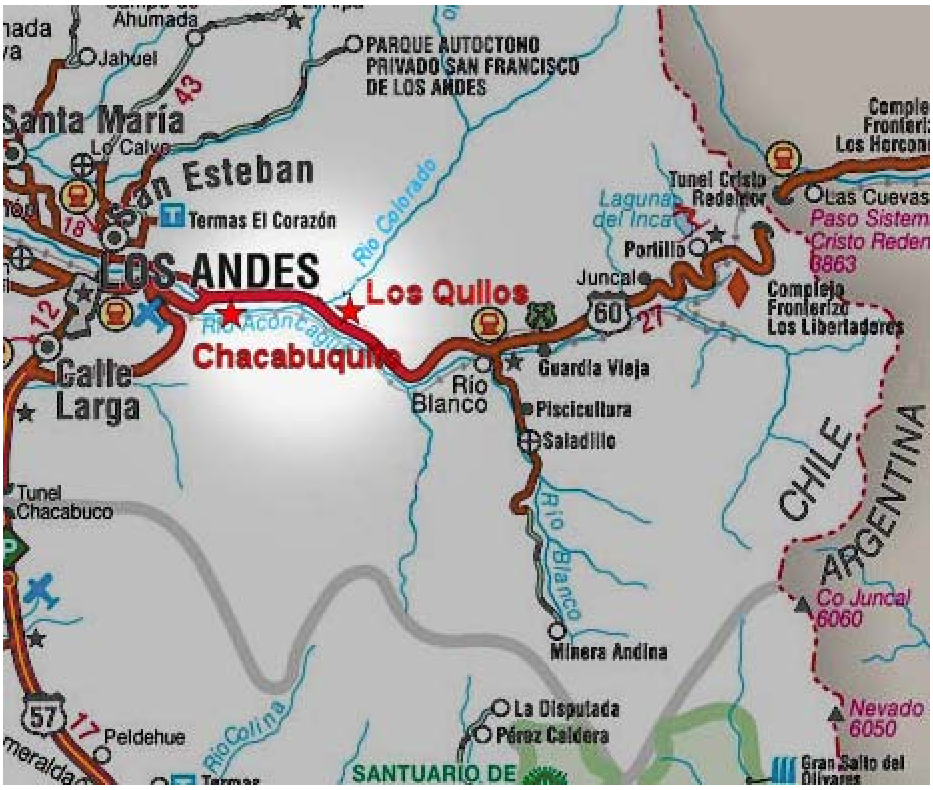


**Figure 1c: Chacabuquito Project Location. Satellite Panoramic View**

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

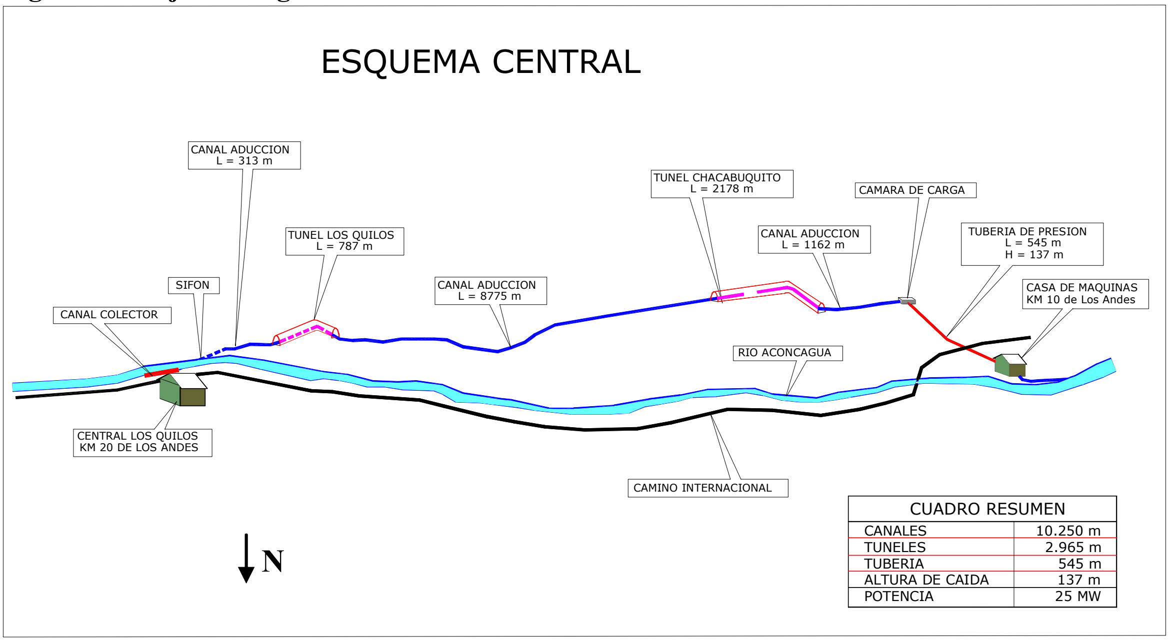
>> The Chacabuquito project falls into:

Scope number: 1
Sectoral Scope: Renewable Energy, Run-of-River Hydropower

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

>> The Chacabuquito project uses a simple layout and well proven technologies in Chile and worldwide and used in other HGV power plants. It consists of a diversion weir, a system of channels (11 km) and tunnels (3 km), a pressure penstock, water fall of 137 m, a powerhouse and a high voltage line, and upgrade of existing transmission system. HGV has demonstrated a successful experience of construction, setting up and operating similar plants. Figure 2 shows the project design.

**Figure 2: Project Design**




Canals and tunnels and the penstock will take the 21.5 $m^3$/sec from the Los Quilos plant through a series of canals and tunnels over a distance of approximately 10 km to a 440 m long and 137 meter head penstock to the 25 MW Chacabuquito power house. From the power house, the 21.5 $m^3$/sec will be discharged back to the Rio Aconcagua at Chacabuquito to meet the project's water right requirement to supply 18 $m^3$/sec to a downstream existing hydro plant and to satisfy irrigation users.

### 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:

*How the anthropogenic GHG emissions are to be reduced*

The Project will reduce emissions by displacing electric energy generated from fuel-based power plants. The electric energy generated by the project is produced using renewable energy with zero emission to the atmosphere associated with its operations.

The relevant system grid for the Chacabuquito Project boundary is the Central Interconnected System (or SIC in Spanish), which its generation mix capacity comprises of 60% hydroelectric generation, 30% combine cycle gas turbines (fired with natural gas most of the time, but also diesel recently), and the remainder from coal, diesel, petcoke, and cogeneration.

*Why the emission reductions would not occur in the absence of the proposed project activity*

In a centrally planned system, such as Chile, the baseline scenario can be determined on the basis of the least cost expansion and operation of the electric grid as defined by the planning authority. In Chile there is no central planning for expansion of power facilities. However, the National Energy Commission (CNE) prepares an indicative plan, to determine regulated prices (node prices).

Investors are free to choose the projects they want to develop and base their decisions regarding: market prices, investments costs and operation of plants on their own perception of the market. Consequently the baseline, for the purpose of *estimating* emission reductions prior to their actual generation, should be determined as the most likely scenario of capacity additions and generation private investors and plant operators would choose on the basis of demand projections, node and spot prices, investment costs of candidates for capacity expansions and expected price of fuels. Thus, the baseline scenario consists of the current power plants in the SIC plus the projected capacity expansion and including the generation pattern in the SIC as it occurs in the absence of the generation of the CDM project.

The CNE indicative expansion plan and the price competition of individual investors makes it clear that potential candidates for capacity expansions are mostly thermal options: coal fuelled steam plants (SP), gas fuelled combined cycle plants (CC) and gas fuelled open cycle turbines (GT), as shown in table 7 in section B.3. (More information can be obtained from CNE's web site: www.cne.cl)

At the moment of Chacabuquito's investment decision, new hydro power units where not likely to be developed following the introduction of imported natural gas from Argentina in 1996. Since the gas introduction there was a significant change in the electricity sector's structure, with high growth in the lower capital cost and shorter payback period combined cycle natural gas plants, resulting in significant reductions in node prices periodic fixations, increasing the barriers to hydroelectricity and other renewable energy technologies with higher capital cost of investments.

For investment projects following the baseline methodology, the appropriate method to determine the additionality of a project is to compare the proposed project with the least cost means of generating power in the SIC among the potential generation capacity addition options. This is done below as part of the application of the Tool for the demonstration and assessment of additionality.

It can be shown that the least cost expansion plan for the SIC does not include the Chacabuquito project. The Baseline Study (see section B.5) shows that fossil fuel thermal power generation options are available to private investors in Chile at lower kWh costs than Chacabuquito. The Baseline Study concludes that the proposed project is an unlikely candidate for system expansion investment in Chile.

The proposed project employs a non-GHG emitting technology (hydropower). In the absence of this project, the same level of demand for electricity would mostly be met by fossil fuel thermal power generation with associated GHG emissions. The methodology to monitor and determine the replaced generation and the associated emission reductions is obtained from the consolidated monitoring methodology for zero-emissions grid-connected electricity from renewable sources, ACM002, approved in September 2004.

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

>> Chacabuquito's emission reduction is calculated as a combined margin emission factor (CM), consisting of the weighted average of an operating margin (OM) and a Build Margin (BM) as stated in ACM002

The OM emission factor from the project activity is calculated using the Simple Adjusted OM, and will depend on the actual generation data for the SIC. The generation data, to be provided by the Economic Dispatch Center (CDEC-SIC), will conclusively indicate the type of generation displaced by the addition of Chacabuquito in the generation mix in the SIC. The monitoring and verification plan for the project utilizes the data provided by CDEC-SIC.

The BM emission factor will be determined in an ex-post basis as the generation-weighted average emission factor (tCO2/MWh) of the latest 20% capacity added to the SIC.

The estimates of emission reduction are provided to facilitate evaluation of emission reduction from the project. The total estimated emission reduction to be achieved by the project is about 1,6 millions tons of $CO_2$ over 21 years (i.e. during three seven-year crediting periods). This is approximately 76,700 $tCO_2e$ per year.

Table 3: Estimated amount of emission reductions during the First Crediting Period

| Years | Annual Estimation of emission reductions in tonnes of CO2e |
|---|---|
| 2002 (from July 1, 2002) | 44.052 |
| 2003 | 90.568 |
| 2004 | 71.966 |
| 2005 | 76.700 |
| 2006 | 76.700 |
| 2007 | 76.700 |
| 2008 | 76.700 |
| 2009 (until June 30, 2009) | 38.150 |
| Total Estimated Reductions First Crediting Period (tonnes of CO2e) | 551.536 |
| Total number of crediting years | 7 |
| Annual average over the crediting period of estimated reductions (tonnes of $CO_2e$) | 78.791 |

#### A.4.5. Public funding of the project activity:

>> No public funding is involved in the project activity.

## SECTION B. Application of a baseline methodology

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

>>ACM002, Version 6: "Consolidated Baseline Methodology for zero-emissions grid-connected electricity from renewable sources". This methodology also refers to the "tool for the demonstration and assessment of additionality"

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

>>

The project activity is a grid connected run-of-river hydropower project, it does not involve switching from fossil fuels and the grid's geography and system boundaries are explicit and characteristics are readily available through CNE and CDEC-SIC.

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

This methodology requires an OM to be calculated using one of the following options:

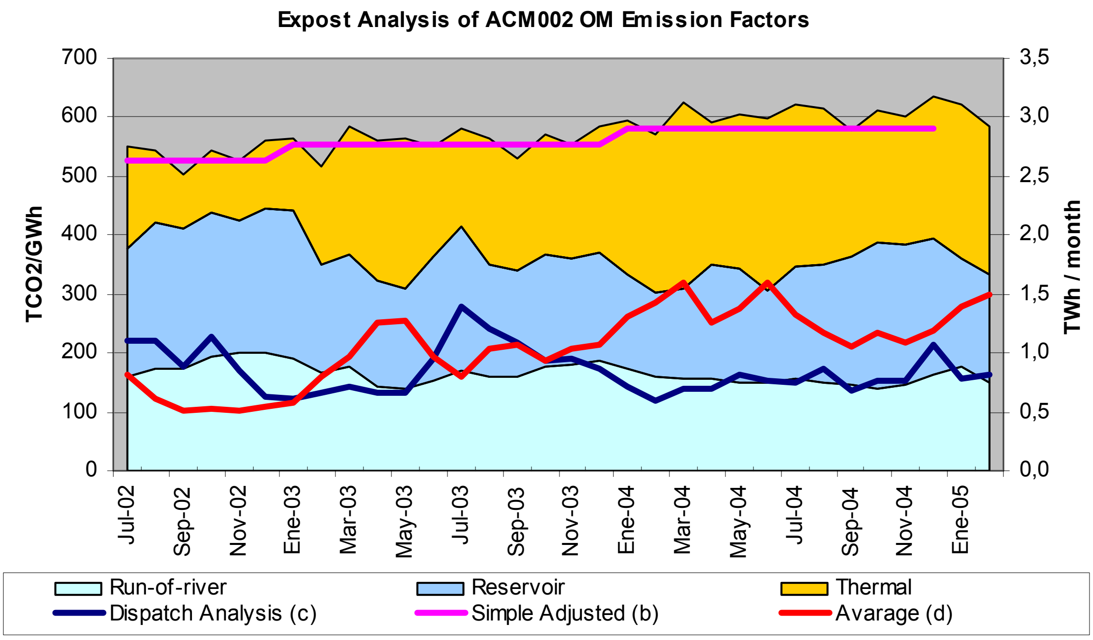
- **Dispatch Data Analysis OM**. This OM is calculated using detailed (hourly) dispatch data from various power stations, considering the top 10% of the grid system dispatch order. This is the preferred option by the EB. However, this 10% also accounts energy from hydro reservoir units that should not be considered for ER abatement. The share or reservoir capacity in the margin distorts the Dispatch Data Analysis estimation in the relevant system boundary (SIC). Even if the reservoir energy is present in the top 10% dispatch order in a strict way, the annual energy generation of reservoirs follows a similar behavior of run-of-river power units when confronted to hydrological variations. Also, it can be effectively demonstrated from real dispatch data and system model analysis in the Central Interconnected System (SIC), that reservoir hydro power generation is not affected by capacity additions on the system, such as thermal power, hydro power, CDM power plants or even other reservoir units. In other words, CDM power additions to the system should directly translate into thermal energy displacement. Thus, the Dispatch data Analysis method, as stated in ACM0002, is not appropriate for calculating the real emission displacement and the OM from the SIC, because it would consistently overestimate the share of reservoir hydropower for the emission factor calculation (this is demonstrated in the Figure below).
- **Simple OM.** It is generation-weighted average emissions per electricity unit ($tCO_2$/MWh) of all generating sources serving the system, excluding low operating cost and must run power plants. It can be used where low cost / must run resources constitute less than 50% of total grid generation, which is not the case for Chile.
- **Simple Adjusted OM**. This separates low-cost / must run power sources (from other power sources) to consider their impact on emission factor, if they operate on margin also. It requires plotting load duration curve and contribution from low-cost power sources. This method is the most appropriate in the case of CDM Chacabuquito Project and Chile's SIC grid among ACM002 alternatives, as explained below.

- **Average OM.** It can be used only if low cost/ must run resources constitute more than 50% of the total grid generation and detailed data in unavailable. It is calculated as the average emission rate of all power plants. This method can only be used if the detailed data to use the Simple Adjusted OM is not available – which is not the case for Chile's SIC grid.

Historical data has been registered from July 2002 to February 2005 in order to calculate ACM002 Operating Margins Emission Factors for 3 different alternatives proposed by the methodology: Dispatch analysis, Simple Adjusted and Average options. The figure below shows the generation mix from July 2002 to February 2005 and the resulting OM emission factors following the three indicated methods. The figure shows an increasing share of thermal generation from July 2003 to February 2005 due to dryer hydrological conditions. However, as shown in the figure, the Emission Factor that results from using the Dispatch Analysis method decreases during the same period. This is because during dry seasons, reservoir hydropower is dispatched at higher marginal cost, moving its ranking upward in the dispatch merit order, and having a higher share of the margin to follow up system demand fluctuations. By other hand, the simple adjusted OM method follows the same trend of thermal share dispatch, justifying its election as the most appropriate method for this case.

It is clear that the Dispatch Analysis, as stated on ACM002, underestimates the OM emission factor, resulting in estimations that are even lower than the average option. Further, the Dispatch Analysis option behaves in a contradictory manner when dryer seasons appear, decreasing OM emission factor estimation, precisely when more thermal units are dispatched in the system and higher emissions are expelled to the atmosphere.

Figure 3




Considering the above arguments, the Chacabuquito project will use the Simple Adjusted method for OM estimation. This method, apart from being a much more simple, transparent, easy to implement and audit method than the Dispatched Data Analysis, represents the most consistent model from all the other ACM002 options for estimating emission displacement in the Chilean SIC electric system.

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

>>The proposed methodology determines the baseline emissions by observing the actual power dispatch data from CDEC-SIC and the official expansion plan provided by CNE.

The baseline emission factor of the project activity is calculated as a combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors according to the following steps:

**Step 1. Calculation of the Operating Margin for each hour of the crediting period**

ACM0002 calculates the emission factor for the operating margin (OM) by observing actual dispatch data of all generating units in the system, following the Simple Adjusted Method.

The Emission Factor of the operating margin is calculated as follows.

$$EF_{OM,y} = \left(1-\lambda_y\right)\cdot\frac{\sum_{i,j} F_{i,j,y}\times COEF_{i,j}}{\sum_{j} GEN_{j,y}} + \lambda_y\cdot\frac{\sum_{i,k} F_{i,k,y}\times COEF_{i,k}}{\sum_{k} GEN_{k,y}} \qquad \textbf{(f1)}$$

where,

$F_{i,j,y}$ is the amount of fuel *i* (mass or volume) consumed by relevant power sources *j* in years *y*, j refres 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 $CO_2$ emissions coefficient of fuel *i* ($tCO_2$/mass or volume) , taking into account the carbon content of the fuels used by relevant power sources *j* and percent of oxidation of fuel in year *y*

$GEN_{j,y}$ is the electricity (in MWh) delivered to the grid by source *j*

$\lambda_y$ and is calculated as the number of hours for which low cost/must-run sources are on the margin divided by 8760 hours per year

The Semi-annual Node Price Report and the IPCC Good Practice Guidance provide all the information to calculate the emission factors for all the power plants within the Chilean grids, including future plants projected in the expansion plan. Node Price Reports inform about the specific fuel consumption for every power plant, which are used together with the carbon content of the different fuels as reported by the IPCC.

**Setp 2. Calculation of the Build Margin**

The emission factor for the build margin for each crediting period is calculated based on the latest 20% of capacity added to the grid (Option 2 for Build Margin Calculation of ACM-0002).

$$EF_{BM} = \frac{\sum_{i=1}^{L} EF_{BM,i} * Gen_{BM,i}}{\sum_{i=1}^{L} Gen_{BM,i}} \qquad \textbf{(f2)}$$

Where:

L Group of electricity generation plants that compromise 20% of the system generation (in MWh) and that have been built most recently. Power plant capacity additions registered as CDM project activities should be excluded from the sample group L.

$EF_{BM,i}$ Emission factor of $i^{th}$ electricity generation plant in the build margin, expressed in $tCO_2/MWh$.

$Gen_{BM,i}$ Projected generation for the $i^{th}$ electricity generation plant included in the build margin, expressed in MWh.

$$EF_{BM,i} = SFC_{BM,i} * CEF_{BM,i} * Oxid_i \qquad \textbf{(f3)}$$

Where,

$SFC_{BM,i}$ Specific fuel consumption of the $i^{th}$ electricity generation plant, expressed in ton of fuel /MWh or TJ of fuel /MWh. The data shall be taken from published data of electricity regulatory authority.

$CEF_{BM,i}$ $CO_2$ content of fuel used in $i^{th}$ electricity generation plant, expressed as $tCO_2$/(ton of fuel or TJ of fuel).

$Oxid_i$ Fuel oxidation factor, expressed as fraction.

For the first crediting periods, the $EF_{BM}$ will be updated annually ex-post for the year in which actual project generation and associated emissions reductions occur. For subsequent crediting periods, $EF_{BM}$ should be calculated ex-ante, as described in Option 1 for the Build Margin Calculation of ACM0002

**Step 3. Project Emissions**

The combined emission factor for the proposed Chacabuquito project, according to ACM002, is calculated with the weighted average for both the Operating Margin (OM) and the Build Margin (BM) as follows:

$$EF_y = w_{OM} * EF_{OM,y} + w_{BM} * EF_{BM} \qquad \textbf{(f4)}$$

where,

$EF_{OM,y}$ Emission factor for operating margin power generation sources, in $tCO_2/MWh$

$w_{OM}=0.5$ Weight for operating margin emission factor.

$EF_{BM}$ Emission factor for build margin power generation sources, in $tCO_2/MWh$

$w_{BM}=0.5$ Weight for build margin emission factor.

The baseline emissions for the project are calculated as follows:

$$BE_y = EF_y * Generation_y \qquad \textbf{(f5)}$$

where,

$EF_y$ Baseline emission factor, in $tCO_2$/MWh
$Generation_y$ Electricity generated by the proposed CDM Project in year y (in MWh).

Finally, the project mainly reduces $CO_2$ emissions through substitution of power generation supplied by the existing generation sources connected to the grid and likely future additions to the grid. The emission reduction ($ER_y$) by the project activity during year $y$ is equal to the Baseline Emissions. Since the Chacabuquito project consists of a hydro power plant, there are no Project Emissions ($PE_y$). Additionally, no leakage was identified for this project activity. The emission reduction can be expressed as follows:

$$ER_y = BE_y - PE_y - L_y = BE_y \quad \textbf{(f6)}$$

The following table provides information and data used to determine baseline emissions

Table 5. Summarized Data to Calculate the Baseline Emissions

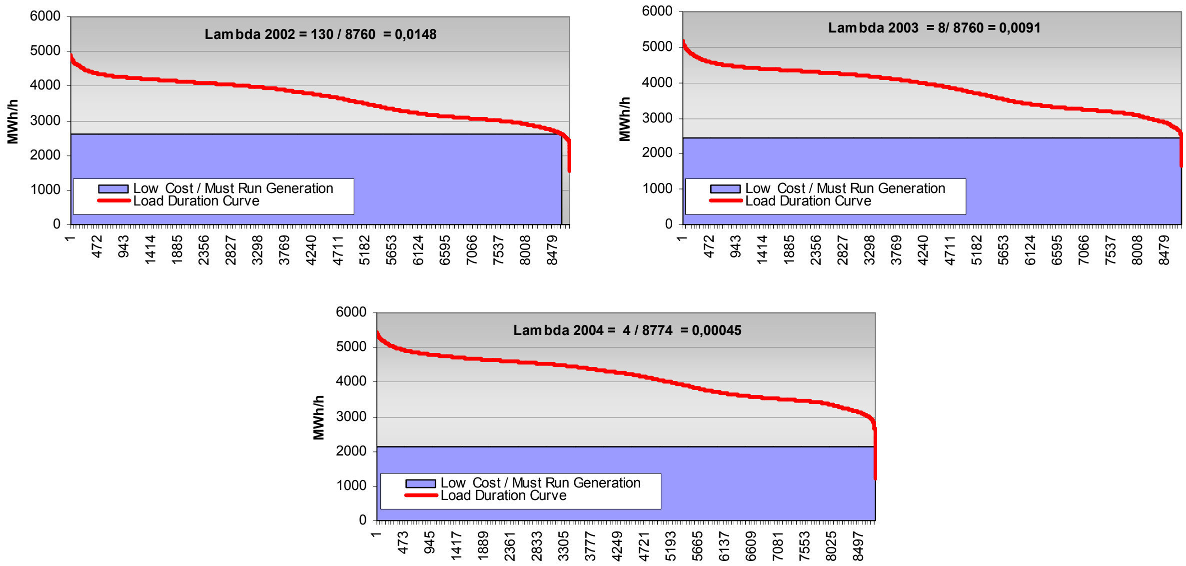
| Variable | Value | Data source |
|---|---|---|
| $EF_{OM,\,y}$ ($tCO_2e$/GWh) | 554.6 | Calculated using CDEC-SIC real dispatch data from 2002 to 2004 and IPCC manual |
| $EF_{BM,\,y}$ ($tCO_2e$/GWh) | 404.1 | Average $EF_{BM}$, from 2002 to 2004, calculated using CDEC-SIC real generation data and IPCC manual |
| $EF_y$ ($tCO_2e$/GWh) | 479.4 | Combined Margin result (**f4**) |
| $Generation_y$ (GWh/year) | 160 | Average net generation |
| $BE_y = ER_y$ | 76,696 | Calculated |

$EF_{OM}$ has been estimated using simple adjusted average OM for years 2002 to 2004. The lambda factor for each of these years has been calculated following ACM002 steps.

Table 6. OM Emission Factor calculation

| Year | Thermal EF | Low Cost Must Run EF | Lambda | $EF_{OM}$ |
|---|---|---|---|---|
| 2002 | 535,9 | 0 | 0,01484 | 528,0 |
| 2003 | 554,6 | 0 | 0,00091 | 554,1 |
| 2004 | 581,9 | 0 | 0,00046 | 581,7 |
| | | | **Avg** | **554,6** |

Figure 4. Lambda determination for years 2002, 2003 and 2004




| **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 baseline scenario for the Chacabuquito Project is the continuing operation of the existing and future power plants without the Chacabuquito electricity generation to meet the actual electricity demand. In the project scenario the same electricity demand is met with the Chacabuquito generation dispatched in the base load displacing the generation from existing power plants and future power developments. Because the project uses renewable sources to produce electricity, there are no additional emissions from the project activity and the emissions reductions are generated by the displaced generation.

The following steps are used to demonstrate the additionality of the project.

**Step 0. Preliminary screening based on the starting date of the project activity.**

The Chacabuquito Project started its operations on July 1st, 2002 and began its construction around one year before. Before its implementation HGV submitted this project to the Prototytpe Carbon Fund of the World Bank (PCF) seeking for additional funding from the Emissions Reductions generated by the project. In March 2001 HGV and the PCF signed a Letter of Intent for the purchase of Emissions Reductions; in April, 2001 the Government of Chile endorsed the project for the purpose of the Article 12 of the Kyoto Protocol; and in February 2002 an ERPA was signed, reflecting what was originally agreed in the Letter of Intent. Therefore, the CDM was seriously considered before the start of the project and the expected revenues from the CDM component of the project and the PCF as buyer were crucial for the investment decision.

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

The CNE establishes for every Node Price Report the Optimal Expansion Plan of the SIC, and uses it to calculate the regulated prices. The expansion plan consists of successive iterations of comparing different options of system expansion that minimizes the net present cost of the energy supply, which includes the sum of the net present value of investments, operation and maintenance, and shortage cost for a period of ten years (see the Formula 10 below). Therefore, the model picks the technologies and projects that minimize the objective formula, assuring the minimum economic cost for the expansion and operation of the system.

$$Min\left\{\sum Investment + O\&M + VarC - \mathrm{Re}\,sid\right\} \quad \textbf{(f8)}$$

The effective report at the time was the Node Price Report of April 2001 and thus, the one that impacted on the investment decision; it is thus the relevant report to test the additionality of the Chacabuquito Project. The following table shows the expansion plan from that report (page 5 of Annex 5 of the Report).

| Power Plant | Capacity [MW] | Commissioning Date | Chilean Region |
|---|---|---|---|
| **Optimal Plan** | | | |
| Taltal combined cycle | 360.0 | Jan.2003 | Third |
| SIC-SING Interconnection | 250.0 | Jan.2004 | Third |
| Combined cycle 1 | 372.6 | Apr.2004 | Fifth |
| Combined cycle 2 | 372.6 | Apr.2005 | Fifth |
| Combined cycle 3 | 372.6 | Apr.2006 | Fifth |
| SIC-SADI Interconnection | 400.0 | Jan.2007 | Metropolitan |
| Combined cycle 4 | 372.6 | Apr.2007 | Fifth |
| Neltume hydro | 400.0 | Jan.2008 | Tenth |
| Combined cycle 5 | 372.6 | Apr.2008 | Fifth |
| Combined cycle 6 | 372.6 | Jan.2009 | Fifth |
| Combined cycle 7 | 372.6 | Apr.2009 | Fifth |
| Combined cycle 8 | 372.6 | Apr.2010 | Fifth |
| **Plants under construction** | | | |
| Ralco hydro | 570.0 | Jul.2003 | Eighth |

As shown above, the least cost alternative for the expansion of the SIC are combined cycle natural gas fired power plants and two hydro dams called Ralco (570 MW, 2003) and Neltume (400 MW, 2007). The Ralco hydro dam is under construction and it was expected to start generating electricity by July 2003. There are no run-of-the-river hydroelectric power plants picked by the model.

**Step 2. Investment analysis / Substep 2b Option II. Investment comparison analysis**

The Official Expansion Plan elaborated by the CNE is the primary source to test the additionality. The methodology requires an extra test to confirm additionality. This test consists of running the expansion model again with the same information from the CNE but adding the project official data (hydrological data, construction cost and operation and maintenance cost), and comparing both results. The outcome of this comparison is shown below, annually and in net present value:

**Chacabuquito**
**Total Costs Comparison**

| Cost Item | Hydrological years (April-March) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2001-02 [MM USD] | 2002-03 [MM USD] | 2003-04 [MM USD] | 2004-05 [MM USD] | 2005-06 [MM USD] | 2006-07 [MM USD] | 2007-08 [MM USD] | 2008-09 [MM USD] | 2009-10 [MM USD] | 2010-11 [MM USD] |
| **Baseline scenario** | | | | | | | | | | |
| Generation | 157.8 | 182.7 | 186.3 | 205.1 | 239.9 | 281.7 | 328.6 | 371.8 | 444.1 | 517.9 |
| Unserved energy | 0.1 | 7.9 | 22.3 | 10.7 | 7.3 | 5.2 | 1.1 | 0.6 | 0.4 | 2.8 |
| **Total** | | | | | | | | | | |
| **Including Project** | | | | | | | | | | |
| Generation | 156.7 | 179.9 | 183.2 | 202.4 | 237.4 | 278.9 | 325.5 | 369.0 | 440.9 | 514.6 |
| Unserved energy | 0.1 | 7.5 | 21.0 | 10.1 | 6.8 | 4.9 | 1.0 | 0.6 | 0.3 | 2.5 |
| Project investment | 0.0 | 36.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Project O&M costs | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| **Total** | | | | | | | | | | |
| **Generation+Unserved** | | | | | | | | | | |
| **Cost difference** | | | | | | | | | | |

**Chacabuquito**
**Total Costs Comparison**

| Cost Item | Present Value* [M USD] |
|---|---|
| **Baseline scenario** | |
| Generation | 1773.8 |
| Unserved energy | 44.3 |
| **Total** | **1818.1** |
| **Including Project** | |
| Generation | 1756.1 |
| Unserved energy | 41.6 |
| Project investment | 33.1 |
| Project O&M costs | 1.8 |
| **Total** | **1832.6** |
| **Generation+Unserved** | **-20.4** |
| **Cost difference** | **14.5** |

**(*) As of April 2001**

| Project Data | |
|---|---|
| Investment [MUSD] | 37.0 |
| Commissioning date | June 2002 |
| Annual O&M costs [MUSD] | 0.32 |

| | |
|---|---|
| Annual discount rate | 10.00% |
| Monthly discount rate | 0.80% |

The above table shows the proposed CDM project has the following economic impact on the overall system:

- savings in the system operation cost of US$ 17.7 million (US$ 1,773.8 - US$ 1,756.1);
- savings in expected shortage of US$ 2.7 million (US$ 44.3 – US$ 41.6); and

- US$ 34.9 million of additional investment and maintenance and operation of the Project.

The overall outcome is US$ 14.5 millions of additional cost for serving the same energy demand.

Should be noted that the model and all the information is publicly available and could be run by independent experts. The model cannot be manipulated and the information added by sponsor is official (construction cost and hydrological data). The project data used by the model can be confirmed during the validation process.

Therefore, according to the investment analysis, the Project would be additional.

**Step 3. Barrier Analysis.**

The following barriers have been identified as the crucial barriers affecting the owners in undertaking the project activity.

**Sub-step 3a.** Identification of barriers that would prevent the implementation of type of the proposed project activity:

*Hydrological risk:*

Hydrology risk is perhaps the greatest risk facing run-of-river projects such as Chacabuquito. The Project does not consider a regulating reservoir, so there is no way the project can mitigate against drought and low inflow periods. Due to almost 100% exposure to meteorological and hydrological risk project returns are highly variable.

*Tunnelling risk:*

The project includes two tunnels for a total of 3 km to convey water from the intake to the surge shaft and penstock facility. Because of the very steep alpine terrain, it is not possible to convey the water through canals, which are much cheaper than tunnels. As a result, the rock conditions for tunneling are critical to final project cost. The construction company can only rely on surface mapping to base their cost estimates on, and hence there are considerable unknowns, such as underground water, geotechnical quality and presence of gases have to be taken by the Owner.

HGV has considered 5% of cost contingencies in the financial analysis; mainly due to the tunneling works. However tunneling risk may further increase the project costs. Additionally, the failure to complete the project on time could negatively affect the project profitability reducing energy and power sales in the first operational year as expected.

*Spot Market Risk:*

Any generation activity has an element of spot market risk, since prices are a result of market forces. In this case, fuel costs and hydrology are the main price factors. As the SIC has a 60% hydroelectricity base, high price volatility can be present. During a normal or wet hydrological year spot prices are very low, severely impacting project revenues. By other hand, in dry seasons spot price can increase several times, however the project will have lesser generation capacity and a higher exposure risk when required to supply contracted energy to industrials or distributors.

To avoid spot market exposure, the project operator may reduce energy purchase contracts, but this will result on a reduced income for normal and humid year operations, where surplus generation will have to be sold at lower spot prices.

*Market and Regulatory risk:*

Despite being a highly developed, deregulated and transparent system, the Chilean Electricity sector is still subject to changes that provide considerable barriers to the project. The first example of this is the introduction of limitations of force majeure causes to exempt liabilities for under delivery of electricity (the new Article 99bis of the Electrical Law or DFL 1/82 Ley General de Servicios Eléctricos in Spanish), following a severe drought in 1999. Generators were unable to supply under their contracts to distributors and claimed *force majeure*. To try and reduce the likelihood of blackouts in the future, the authorities removed drought as an allowable *force majeure* event, thus making the generators responsible for finding other ways of securing delivery.

The result has been that generators without a diverse portfolio of hydro and thermal generation assets have not been able to sign Power Purchase Agreements (PPAs) with distributors, who fall under Article 99bis jurisdiction. Since distributors are 80% of the market for sales, it severely limits the project to find financially attractive EPC to ensure financing.

The second example is current changes being made by CNE with respect to the period for which Firm Capacity is calculated. In October 2004, the authority changed the 5 hour period to 8 hours in winter time (May and September). As the project has very limited ability for storage (5 hours), the project will loose power selling capacity since Economic Dispatch Center (Centro de Despacho Economico de Carga, CDEC) would downgrade the assigned saleable capacity of the power Plant.

**Sub-step 3b.** Show that the identified barriers would not prevent the implementation of at least one of the alternatives

Natural gas combined or open cycle plants are considered the least cost investment by CNE, the governmental Electricity Authority. On this basis CNE uses combined cycle gas plants as the default investment in planning (see table 7). It can easily be shown that these projects do not suffer the barriers identified above.

*Hydrology Risk:*

Natural gas plants are not constrained by hydrological conditions. While there may be some fuel supply risk for these plants they typically can run on either natural gas or diesel, the latter of which is readily available.

*Tunneling Risk:*

Technological risk, in particular tunneling is not relevant to gas fired plants. Construction techniques and technology are well established, resulting in a lower investment cost.

*Spot Market Risk:*

As discussed above natural gas plants are also able to use diesel, thus mitigating supply risks that run of river projects, such as Chacabuquito, face. On this basis this barrier is not as extreme for a natural gas plant as the project activity.

*Market and Regulatory risk:*

As mentioned the project is particularly susceptible to changes in regulation governing the authority's recognition of the plants firm power. Water, environmental and geographical restraints restrict the ability for the project to adapt. A natural gas plant does not face the same restrictions, and generally such flexibility has a lower capital cost for these types of projects.

On the basis of the above analysis it is obvious that the project activity faces unique, identifiable and significant barriers, not faced by its most likely alternative, a gas fired plant.

**Step 4. Common practice analysis.**

Sub-step 4a Analyze other activities similar to the proposed activity:

Since natural gas was introduced as a resource to Chile in 1996, which changed completely the business environment in both main grids, all other technologies with renewable resources became non-competitive, with the exception of big hydro dam power projects. Since 1996, only one other hydro run-of-the-river power project was built in the Chilean interconnected central grid (the Peuchen and Mampil Project).

Sub-step 4b. Discuss similar options that are occurring:

At the moment of the projects investment decision, and even after its commissioning date, there where no similar activities where observed in the SIC. All other similar units that have been developed in the system, after Chacabuquito, are subject to CDM finance.

**Step 5. Impact of CDM Registration**

The revenues from the sales of Emissions Reductions have two main impacts for the project: First, the revenues come from one of the most creditworthy organization in the world, reducing the overall risk of the project and the exchange risk of the cash flows. Second, the additional revenues, in US dollar, increases the IRR by about 1.5 percentage points of the internal rate of return of the project, making the project attractive to the investors from 8.7% to 10.2% (CNE expects a 10% rate of return over natural gas combined cycle technology investments, which represents the least cost expansion option stated on the CNE's indicative Expansion Plan)

Since all above steps are satisfied, the additionality of the proposed CDM project activity is demonstrated according to the Tool for the Demonstration and Assessment of Additionality.

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

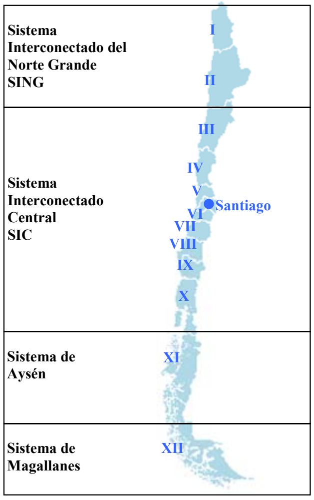
>>

The methodology only claims emissions reductions from generation that is avoided due to the implementation of a CDM activity in one of the grids. Only $CO_2$ derived from the combustion of the thermal plants is claimed.

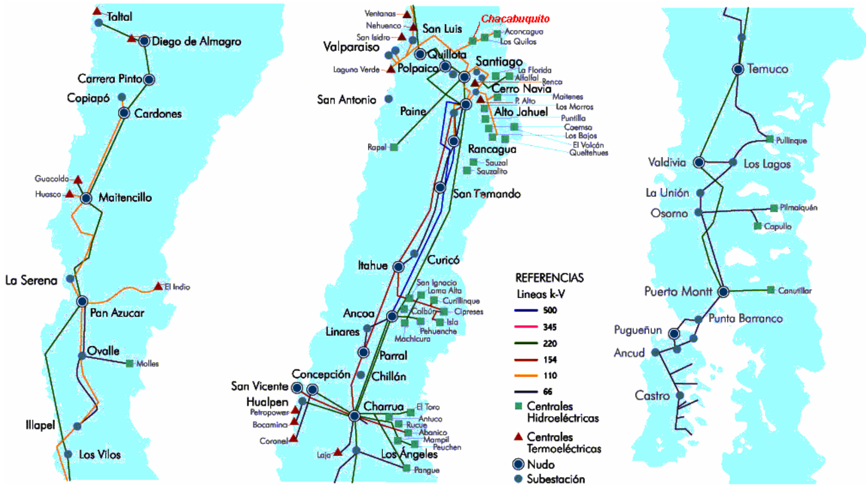
Chile has four different grids and there are no interconnections between them. Therefore, each grid defines the geographical and system boundaries for proposed projects located within it (see map below). The Northern Interconnected Grid (SING) compromises the regions 1 to 3 and accounts 34 percent of the total capacity. The Central Interconnected Grid (SIC) compromises the regions 3 to 10 and accounts 64 percent of the total capacity. The Aysen and Magallanes grids are located in the 11 and 12 regions, respectively, and accounts less than one percent of the total capacity. If there is any expansion of the current grids, then the boundaries must be expanded accordingly.

**Figure 5**

**Chile Electric Grids**




**Sistema Interconectado Central – SIC**




The Chacabuquito project is located in the 5th Region and connected to the SIC and therefore the SIC is the project boundary to the Project.

**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:**

> A first baseline study was completed by March 2001, revised in September 2001 and recently reviewed for the purpose of this project, showing it is still valid.

1. Chandra Shekhar Sinha , Fernando Cubillos, Carbon Finance Unit, c/o The World Bank, 1818 H Street, NW, Washington, D.C. 20433, USA, tel: +1-202-473-9189; csinha@worldbank.org, fcubillos@worldbank.org.

2. Carl Weber, Hidroeléctrica Guardia Vieja S.A., Teatinos 220 Piso 8, Santiago, Chile, tel +56-2-421-6000; cweber@hgv.cl.

3. Jose Manuel Contardo, Consultant, Carbon Finance Unit, The World Bank, jmcontardo@gmail.com.

>

## 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:**

>> The project started its operation on July 1st 2002 and generated emission reductions since then.

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

>> The operational lifetime of run-of-river hydropower plants is estimated as 30 years. Therefore the project seeks a 7 year, twice renewable crediting period (total 21 years).

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

**C.2.1. Renewable crediting period**

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

>> The first crediting period started on: 01/07/2002

**C.2.1.2. Length of the first crediting period:**

>>Seven (7) years

**C.2.2. Fixed crediting period:**

**C.2.2.1. Starting date:**

>>

**C.2.2.2. Length:**

>>

## SECTION D. Application of a monitoring methodology and plan

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

>> ACM002, Version 6: "Consolidated Monitoring Methodology for zero-emissions grid-connected electricity from renewable sources".

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

>> The project activity is a grid-connected run of river hydropower project, where the grid's geography and system boundaries are explicit and characteristics are available through CNE and CDEC-SIC. On this basis the conditions for applying ACM0002 are met

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

In project scenario we define the actual scenario after the Chacabuquito project starts its operation. The baseline emissions are calculated as the emissions that would occur during the project crediting period by observing the actual operation of the project scenario.

The monitoring methodology involves the monitoring of the following:

- Electricity generated and fed into the grid by the proposed project;
- Public data on dispatch of electricity and other relevant information from the dispatch center.;
- Data needed to calculate the Emission Factors for every thermal power plant that operates in the Central Grid.

>>Not applicable

**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 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

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

**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 | 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 |
|---|---|---|---|---|---|---|---|---|
| 1. $Generation_y$ | Generation of the Chacabuquito Project | Metering system | MWh | m | Hourly | 100% | electronic | Electricity supplied to the grid by the Project. |
| 3. $EF_{OM,y}$ | Operating Margin Emission Factor | Dispatch data calculations | $tCO_2$ | c | Monthly or yearly | 100% | electronic | (**f1**) |
| 4. $\lambda y$ | Lambda | | % | c | yearly | 100% | electronic | |
| 5. $EF_{BM,y}$ | Build Margin EF for the set o “m” plants that compromises the latest 20% of capacity added to the grid | CNE Node Price Report, IPCC manual, CDEC-SIC | $tCO_2$/GWh | c | yearly | 100% | electronic | (**f2**) |
| 6. $F_{i,j,y}$ | Fuel consumed by *all thermal plants* | CNE | tonnes | m | Monthly, yearly | 100% | electronic | |
| 7. $COEF_{i,n}$ | $CO_2$ emission factor of each plant by fuel type used | 1996 Revised IPCC Guidelines | $tCO_2$ /TJ | e | yearly | 100% | electronic | |
| 8. $NCV_i$ | Net calorific fuel value per mass or volume unit of a fuel *i* | 1996 Revised IPCC Guidelines | TJ/tonne | e | yearly | 100% | electronic | |
| 9. $OXID_i$ | Oxidation factor of the fuel | 1996 Revised IPCC Guidelines | % | e | yearly | 100% | electronic | |

| ID number | 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. $GEN_{j,y}$* | Generation of electricity delivered to the grid by *all thermal* plants | CDEC-SIC | MWh | m | hourly | 100% | electronic | |
| *11. $EF_y$* | Emission Factor of the project activity | CDEC-SIC Dispatch data calculations and CNE reports | tCO2/MWh | c | yearly | 100% | electronic | **(f4)** |
| 12.$SFC_{BM,i}$ | Specific fuel consumption of the i$^{th}$ electricity generation plant | CNE node price report and CDEC-SIC | ton of fuel /MWh or TJ of fuel /MWh | m | yearly | 100% | electronic | |
| 13. $CEF_{BM,}$ | $CO_2$ content of fuel used in i$^{th}$ electricity generation plant | CNE node price report and 1996 Revised IPCC Guidelines | $tCO_2$/(ton of fuel or TJ of fuel). | e | yearly | 100% | electronic | |
| 14. $Oxid_i$ | Fuel oxidation factor, expressed as fraction | 1996 Revised IPCC Guidelines | % | e | yearly | 100% | electronic | |
| *15.* | Changes in the regulatory framework that could affect the methodology | Official Gazzette | Text | m | As required | 100% | electronic | Changes in the regulatory framework that could affect the assumptions in which this methodology relies. |

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

>>

The proposed methodology determines the baseline emissions by observing the actual power dispatch data from CDEC-SIC and the official expansion plan provided by CNE.

Please refer to section B.2 for formulae reference (f1)

The monitoring methodology involves the monitoring of the following:

- Electricity generated and fed into the grid by the proposed CDM project, and other CDM registered projects (data available at CDEC-SIC).
- Public data on dispatch of electricity and other relevant information from the CDEC-SIC.
- Public data on official CNE node price report.

**Step 1. Calculation of Operating Margin Emission Factors**

The next diagram shows the complete process for calculating and assigning the operating emission factors for the Chacabuquito Project:

Net Hourly Generator output from Chacabuquito CMD project and other units in the system (MWh)

⇩

Analysis of hourly dispatch from all units of the SIC to determine number of hours for which low cost/must-run sources are on the margin $\lambda_y$
(CDEC-SIC hourly data)

⇩

Calculation of emission factor of all operational thermal units of the system
(CNE semestral report and IPCC manual)
(tonnes CO2e/MWh)

⇩

Determination of $EF_{OM}$ of the project as the weighted average emission factor
(tonnes CO2e/MWh)

**Step 2 - Calculation of the Build Margin**

The Build Margin is calculated with the least cost options identified in the official expansion plan.

Please refer to formulae stated in section B.2 (f2 and f3)

The next diagram shows the complete process for calculating and assigning the Build Margin emission factor:

| |
|---|
| SIC Dispatch of all power units of the system<br>(MWh) |
| ⇩ |
| Determination of 20% of energy generated from most recent power units<br>(set of m plants following ACM002 option2)<br>(MWh) |
| ⇩ |
| Calculation of emission factor of thermal units in the plan<br>(CNE semestral report and IPCC manual)<br>(tonnes CO2e/MWh) |
| ⇩ |
| Determination of $EF_{BM}$ (ACM002) as the weighted average emission factor of the dispatched plants and their individual emission factor<br>(tonnes CO2e/MWh) |

**Step 3 – Calculation of the Project Emissions Reductions**

The combined emission factor for the proposed Chacabuquito project, according to ACM002, is calculated with weighted average for both the Operating Margin (OM) and the Build Margin (BM).

Please refer to formulae stated in section B.2 (f**4, f5** and **f6**)

| |
|---|
| Calculation of Combined Margin Emission factor of $EF_{BM}$ and $EF_{OM}$<br>(tonnes CO2e/MWh) |
| ⇩ |
| Energy generation of the Chacabuquito CDM Project<br>(from CDEC-SIC or metering data)<br>(MWh) |
| ⇩ |
| Calculation of Baseline Emissions of the Project<br>(tonnes CO2e) |
| ⇩ |
| Discount any leakage or project activity emissions, if any<br>(No leakage emission was identified for Chacabuquito, and project emissions are null)<br>(tonnes CO2e) |

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

| 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.2.2.2. 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 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

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

>> There is no leakage because the project uses renewable energy sources

**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.)**

>> There is no leakage since energy sources are renewable

| 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. |
| *1. Generation$_y$* | *Low* | *Electronic commercial metering of class 0.2. They are checked once a year according to Chilean regulation. That data is submitted to the Dispatch Center on hourly basis for CDEC-SIC billing and energy balance purposes* |
| *3. $EF_{OM}$* | *Low* | *CDEC-SIC dispatch and official data, like efficiency and fuel consumption, and IPCC default values will be used* |
| *4. $\lambda y$* | *Low* | *CDEC-SIC dispatch data, considered accurate, will be used. Not additional QA/QC required* |
| *5. $EF_{BM}$* | *Low* | *CDEC-SIC dispatch and official data, like efficiency and fuel consumption, and IPCC default values will be used* |

**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**

>> There is no leakage because the project uses renewable energy sources

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

>>Fernando Cubillos, Carbon Finance Business, The World Bank
José Manuel Contardo, Consultant, Carbon Finance Unit, The World Bank

## SECTION E. Estimation of GHG emissions by sources

### E.1. Estimate of GHG emissions by sources:

>>Zero

The project is a run-of-the-river hydropower project and it does not increase the GHG emissions.

### E.2. Estimated leakage:

>>Zero

No leakage was identified for this kind of project.

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

>>Zero

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

>>The project calculates, on the basis of ex-post monitored data, the actual emissions reductions due to its operation. The emissions reductions will depend in three main factors: the project electricity generation, the growth of the electricity demand in the SIC, and the availability of other resources for electricity generation. In dry years the project will generate less energy but at the same time it will displace most costly power plants, which in the case of Chile are the less efficient and more carbon intensive; in wet years the scenario will be totally different generating more electricity but displacing less intensive fossil fuels or displacing other renewable energies with zero emission of GHG.

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

>>Because there is no leakage from the project, the above table represents the emissions reductions of the project activity.

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

>> For an estimation purpose, the following table summarizes the emissions reductions of the first seven years of operation and the expected emissions reductions:

Table 6. Estimation of Emission Reductions for the First Crediting Period

| Year | Estimation of project activity emissions reductions (tonnes of $CO_2e$) | Estimation of baseline emission reductions (tonnes of $CO_2$/MWh) | Estimation of Leakage (tonnes of $CO_2e$) | Estimation of Emission Reductions (tonnes of $CO_2e$) |
|---|---|---|---|---|
| 2002 | | 44,052 | | 44,052 |
| 2003 | | 90,568 | | 90,568 |
| 2004 | | 71,966 | | 71,966 |
| 2005 | | 76,700 | | 76,700 |
| 2006 | | 76,700 | | 76,700 |
| 2007 | | 76,700 | | 76,700 |
| 2008 | | 76,700 | | 76,700 |
| 2009 | | 38,350 | | 38,350 |
| **Total (tonnes of $CO_2e$)** | | **551,736** | | **551,736** |

## SECTION F. Environmental impacts

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

>>

Chilean Law 19.300 of 1994, effective in 1997, established an Environmental Impact Assessment System (SEIA) in the country. This system requires projects to either prepare a full scale Environmental Impact Assessment (EIA) or, for projects with lesser or insignificant impacts, such as Chacabuquito power plant, an Environmental Impact Statement (DIA) would be required. Review and clearance of all EIAs or DIAs is a perquisite for an environmental license issued by the National Commission for the Environment (CONAMA).

In October 2000, the project completed an Environmental Impact Statement. The report recommends a number of measures to mitigate environmental impacts during the construction and implementation phases:

- <u>Minimum Ecological Flow:</u> The project commissioned a specific study to analyze and propose minimum ecological flows in that stretch of the Aconcagua River. The DGA established a minimum ecological flow of 3 $m^3$/s. This minimum flow is considered adequate and any potentially negative impacts on aquatic biodiversity are further minimized by the presence of a major affluent to the Aconcagua downstream from the intake.
- <u>Land Acquisition and Compensation:</u> This processes considered the acquisition of 17, 5 hectares along the canal and power house. A private compensation was made for each land owner affected by the project.
- <u>Reforestation Plan :</u> In addition, any tree removed due to construction activity needs to be compensated for by adhering to the *Corporacion Nacional Forestal (CONAF)* requirement of

planting three trees for every tree cut. However, the density of trees in the area was quite low. A Management Plan for Clearing of Vegetation and Reforestation for the Chacabuquito Project (*Plan de Manejo de Corta de Reforestacion en Obras Civiles, Proyecto Chacabuquito, January 2001*) was approved by CONAF in February, 2001 (the Plan and the Official resolution are in project files). The Plan requires the reforestation of 18 has. in an area proposed by the project sponsor, but approved by CONAF within the Los Andes municipality. The Plan established the protection of riverine vegetation along two streams that cannot be cleared during construction activities.

- Environmental Management during Construction: Environmental and social mitigation measures implemented during the construction phase where included in technical specifications in bidding documents and Supervision of the Construction as part of the civil works supervision contract. These specifications considered all construction activities.

**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:**

>>

Chacabuquito plant does not entail any physical construction such as dams and dikes, or cause reservoir-like impoundments on the Aconcagua River or any of its branches. Low height diversion weirs are placed on the river bed to ensure adequate diversion of water and hydraulic heads during the low-flow winter months.

The main negative impact of the Chacabuquito project relates to the deforestation area due to civil works such as canals and power house. The total area considered for mitigation was 18 hectares. Mitigation measures are considered in the *Plan de Manejo de Corta de Reforestacion en Obras Civiles, Proyecto Chacabuquito,* which was approved by the National Forestry Corporation (CONAF) in February 2001 (the Plan and the Official resolution are in project files).

## SECTION G. Stakeholders' comments

>>

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

>> Since Chacabuquito is a small project with a minor impact, and did not require a full Environmental Impact Assessment, there was no obligation to carry out a public consultation. Nevertheless, the project sponsors carried out direct consultations with all directly affected people or institutions. Also, the project sponsor actively participated, and still participates, in local community assemblies such as Asociación del Rio Aconcagua, Asociación de Regantes and Corporación de Empresas Pro Aconcagua. Pro Aconcagua is an environmentally focused institution that develops several community projects in the Aconcagua Valley. Many of the comments received by the project sponsors came from these institutions.

**G.2. Summary of the comments received:**

>>

Extensive consultation and negotiations have taken place with downstream water users (Asociacion de Usuarios del Rio Aconcagua, and Asociacion de Regantes) concerning the need for a unified water outlet for irrigation control purposes. An agreement was reached to build a new reservoir downstream the Chacabuquito power plant called Vizcachas. Hidroeléctrica Guardia Vieja S.A. covered the cost of construction and maintenance of this reservoir.

Also, individual agreements were reached with each property owner affected by the project. All in all, consultations have been extensive with the owners of the Los Quilos Canal, the downstream farmers, and the affected landowners. The latter consultations resulted in several reroutes for the canals (for example, at entrance to the "Tunnel Chacabuquito").

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

>> Apart from the above comments and negotiations, no major issues were raised that could be related to the environmental or CDM aspect of the project. All comments and questions were duly taken into account by the project developer for the construction and operation of the project. The main concern of the community was related to the construction and location of bridges and the Vizcachas downstream reservoir. At present, two new public access bridges across the Aconcagua river where constructed by HGV, allowing local villagers to have vehicle access to the main international road, and the Vizcachas downstream reservoir is operated in coordination with water users.

Annex 1

## CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

| | |
|---|---|
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| | |
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Annex 2

## INFORMATION REGARDING PUBLIC FUNDING

There is no public funding in the projects.

Annex 3

## BASELINE INFORMATION

For calculating the emission factor of thermal power plants in the Central Grid of Chile the methodology uses the following sources:

- Fuel Specific Consumption for every power plant: Semi-annual CNE Node Price Report
- Calorific Content of every Fuel: Semi-annual CNE Node Price Report
- Fuel Carbon Content: Greenhouse Assessment Handbook, World Bank, September 1998, based on UNEP/OECD/IEA/IPCC/ 1995
- Combustion Efficiency: Greenhouse Assessment Handbook, World Bank, September 1998, based on UNEP/OECD/IEA/IPCC/ 1995

The following table shows the emissions factors for the first period of operation (July 2002 – October 2002):

| 1 Unit = | Kcal | Joule | BTU | KWh |
|---|---|---|---|---|
| Kcal | 1 | 4.187E+03 | 3.968E+00 | 1.163E-03 |
| Joule | 2.388E-04 | 1 | 9.478E-04 | 2.778E-07 |
| BTU | 2.520E-01 | 1.055E+03 | 1 | 2.931E-04 |
| KWh | 8.598E+02 | 3.600E+06 | 3.412E+03 | 1 |

**1. Coal, Petcoke and Petroleum**

| | Units | BOCAMINATV | VENTANAS1 | VENTANAS2 | GUACOLDA 1 | GUACOLDA 2 | HUASCOTV | LAGVERDE | PETROPOWER |
|---|---|---|---|---|---|---|---|---|---|
| Especific consumption (2) | kg/KWh | 0.368 | 0.415 | 0.397 | 0.336 | 0.336 | 0.740 | 0.850 | 0.313 |
| Calorific Content (2) | kcal/kg | 6,458 | 6,650 | 6,650 | 6,544 | 6,544 | 6,333 | 6,650 | 6,790 |
| Factor Conversión (3) | kcal/KWh | 2,377 | 2,760 | 2,640 | 2,199 | 2,199 | 4,686 | 5,653 | 2,125 |
| | TJ/GWh | 9.95 | 11.55 | 11.05 | 9.21 | 9.21 | 19.62 | 23.67 | 8.90 |
| Fuel Carbon Emision Factor (1) | tC/TJ | 25.80 | 25.80 | 25.80 | 26.09 | 26.09 | 25.80 | 25.80 | 27.50 |
| Carbon Emissions | tC/GWh | 256.71 | 298.11 | 285.18 | 240.15 | 240.15 | 506.22 | 610.58 | 244.71 |
| Combustion Efficiency (4) | % | 98.0% | 98.0% | 98.0% | 98.0% | 98.0% | 98.0% | 98.0% | 98.0% |
| CO2 conversion | tCO2/tC | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 |
| **Emisiones de Dioxido de Cart** | **tCO2/GWh** | **922.46** | **1,071.20** | **1,024.74** | **862.93** | **862.93** | **1,819.03** | **2,194.02** | **879.33** |

(1) Exhibit 3-6, page. 28 GHG Assesment Handbook
(2) From CNE semestral report
(1,3) Guacolda uses a mixture of petcoke (16,88%) and coal (83,12%)
(4) Exhibit 3-7, page. 29 GHG Assesment Handbook

**2. Natural Gas**

| | Units | NUEVA RENCA | CENTRAL SAN ISIDRO | NEHUENCO | NEHUE.9B | TALTAL 1 | TALTAL 2 | CC CNE | NEHUENCO 2 |
|---|---|---|---|---|---|---|---|---|---|
| Conversion Factor (2) | KJ/KWh | 6,982 | 6,655 | 6,513 | 14,037 | 10,705 | 10,705 | 6,520 | 0 |
| | TJ/GWh | 6.98 | 6.66 | 6.51 | 14.04 | 10.71 | 10.71 | 6.52 | 0.00 |
| Fuel Carbon Emission Factor (1 | tC/TJ | 15.30 | 15.30 | 15.30 | 15.30 | 15.30 | 15.30 | 15.30 | 15.30 |
| Carbon Emissions | tC/GWh | 106.82 | 101.82 | 99.65 | 214.77 | 163.79 | 163.79 | 99.76 | 0.00 |
| Combustion Efficiency (3) | % | 99.5% | 99.5% | 99.5% | 99.5% | 99.5% | 99.5% | 99.5% | 99.5% |
| CO2 conversion | tCO2/tC | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 |
| **Emisiones de Dioxido de Cart** | **tCO2/GWh** | **389.73** | **371.48** | **363.55** | **783.54** | **597.55** | **597.55** | **363.94** | **0.00** |

(1) Exhibit 3-6, page. 28 GHG Assesment Handbook
(2) From CNE semestral report
(3) Exhibit 3-7, page. 29 GHG Assesment Handbook

**3. Diesel and Oil**

| | Units | Turbina Gas 1 | Turbina Gas 2 | INDIO | RENCA | ANTILHUE50 | DIEGO DE ALMAGRO | HUASCOTG | CONSTITUCION Gener | SAN FRANCISCO M. |
|---|---|---|---|---|---|---|---|---|---|---|
| Fule Type | | Fuel | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel |
| Calorific Content (3) | TJ/ton | 43.33 | 43.33 | 43.33 | 43.33 | 43.33 | 43.33 | 43.33 | 43.33 | 43.33 |
| Especific Consumption (2) | kg/KWh | 0.362 | 0.337 | 0.264 | 0.362 | 0.229 | 0.337 | 0.362 | 0.309 | 0.309 |
| | TJ/GWh | 15.69 | 14.60 | 11.44 | 15.69 | 9.92 | 14.60 | 15.69 | 13.39 | 13.39 |
| Fuel Carbon Emission Factor (1 | tC/TJ | 20.20 | 20.20 | 20.20 | 20.20 | 20.20 | 20.20 | 20.20 | 20.20 | 20.20 |
| Carbon Emissions | tC/GWh | 316.85 | 294.96 | 231.07 | 316.85 | 200.44 | 294.96 | 316.85 | 270.46 | 270.46 |
| Combustion Efficiency (4) | % | 99.0% | 99.0% | 99.0% | 99.0% | 99.0% | 99.0% | 99.0% | 99.0% | 99.0% |
| CO2 conversion | tCO2/tC | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 | 3.67 |
| **Emisiones de Dioxido de Cart** | **tCO2/GWh** | **1,150.15** | **1,070.72** | **838.78** | **1,150.15** | **727.58** | **1,070.72** | **1,150.15** | **981.76** | **981.76** |

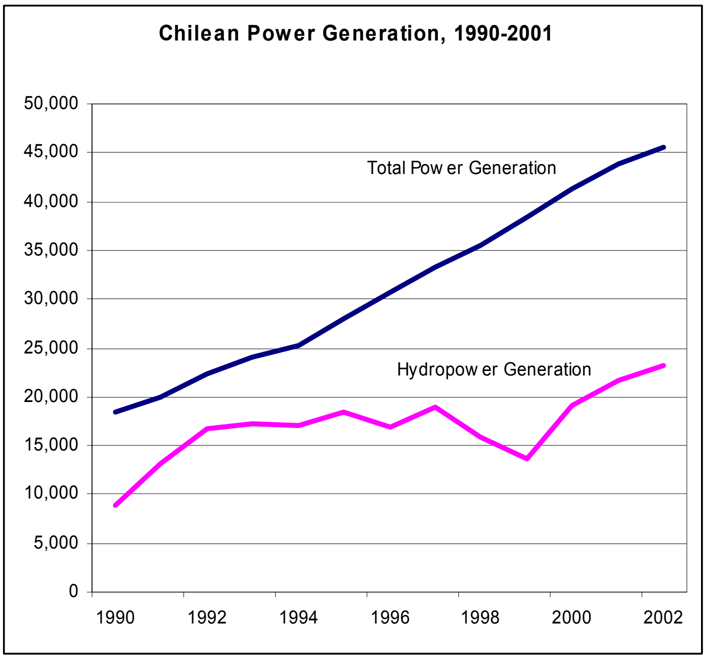
(1) Exhibit 3-6, page. 28 GHG Assesment Handbook
(2) From CNE semestral report
(3) Exhibit 3-3 page 26 From GHG Assesment Handbook.
(4) Exhibit 3-7, page. 29 GHG Assesment Handbook

The above table is updated every six months when the CNE publishes its Node Price Report, and when new power units are incorporated in the System.

>> **National and sector background**

To meet its growing energy demand (approximately 7 percent annually since 1986), in the 1980s Chile began to separate its government-owned power generation, transmission and distribution assets. Over the past decade, Chile completely privatized its electricity industry and unbundled the national generation, transmission, and distribution systems. Private companies now provide 100 percent of Chile's electricity.
Chile's electricity sector has served as a model for subsequent privatizations throughout the world, and despite recent shortages due to drought, is improving its efficiency and reliability. The opening of Chile's gas sector in 1996 has increased choices among energy sources, lowered the energy prices, and helped to satisfy growing demand in the industrial and power-generating sectors. Over the long term, Chile hopes to benefit from opening its energy markets to the private sector by receiving steady and reliable supplies of energy at competitive prices to meet growing demand from all economic sectors. A significant portion of this growth has come from increased power demand by the copper mining sector, the country's single biggest industry, and by growing populations in large urban areas, such as Santiago. Energy policy decisions in Chile are the shared responsibility of the Ministry of the Economy and the specialized agencies the National Energy Commission, the Superintendence of Electricity and Fuels, and the Chilean Commission of Nuclear Energy.

Chile consumed about 43.9 billion kilowatt hours (bKWh) of electricity in 2001, 21.7 bKWh of which was hydropower. About 38 percent of Chile's installed power generation capacity is hydroelectric. Hydropower from westward flowing rivers from the Andes Mountains is Chile's single largest electricity source. The severe drought that gripped Chile from late 1997 until well into 1999 hobbled the country's electricity sector. Chile's capital city, Santiago, experienced rolling blackouts from November 1998 until May 1999. As a result, Chile now is working to become less reliant on hydropower. In 1996 Chile and Argentina signed an Agreement to allow the exportation of natural gas from Argentinean fields to Chile. Since then, 1.000 MW in Combined Cycle Power Plants have been added to the Chilean grid decreasing the energy prices dramatically (by about 45 percent to 21 US$/MWh in 1997).
While only an estimated 13 percent of hydroelectric potential is now utilized, large viable sites are far from Santiago (40 percent of demand), requiring large transmission line investments. Together with other fossil fuels, natural gas has become an increasingly important electricity source in the coming years.




No concession is required to become a generator and there is no entry restriction to the market for generators, who freely and competitively can sell firm capacity and energy via negotiated power contract sales and/or make power available to the system's spot market. Generators have no obligation to supply beyond the terms of their contracts. All generation is undertaken by the private sector, under the concept of merchant plants. In each interconnected system, a load dispatch center (CDEC) is responsible for coordinating and dispatching load from generating units utilizing the system. The Law establishes the obligation to optimize generation and thus, dispatch is based on a pre-programmed economic merit order based on least marginal cost of generation for the corresponding system.

Most Chilean power generation companies are organized around four grid systems, the *Sistema Interconectado Norte Grande (SING)*, the *Sistema Interconectado Centra*l (**SIC**), the Aysen Grid and the Magallanes Grid. These four grids are not interconnected to each other. Private sector power transmission companies transmit electricity sold by the generation companies to power distribution companies, regulated and unregulated customers and other power generation company. The central grid (SIC) serves over 90 percent of Chile's population and more than 40 percent of the land area. The northern grid (SING) is mainly thermal and serves mostly mineral-processing centers in the region and the Aysen and the Magallanes systems in the south of the country serve remote areas with a combined capacity of about 1 percent of the total. Coordination within each system is carried out by the Economic Dispatching Center (CDEC), an autonomous entity composed of members from all utilities within each system to ensure efficiency and security of the electric system. Aside from these four grids, "self producers" account for about 12 percent of national generation.

***(ii) Sector institutions:***

**CDEC**: The economic load dispatch center in each system is controlled by a private, independent entity CDEC (*Centro de Despacho Económico de Carga*), composed of representatives of generation and transmission companies, but its operation is fully regulated by law and supervised by the *Comisión Nacional de Energía* (CNE) and the *Superintendencia de Electricidad y Combustibles* (SEC), both described below. CDEC is in charge of planning the optimum operation of the system, based on lowest marginal costs, and of determining values of economic transactions that were carried out among the generators. The SING (Northern Grid) and the SIC (Central Grid) have each their own independent dispatch centers.

CDEC–SIC (Economic Dispatch Center in the Central Interconnected System) will play an important role in the quantification of the actual emission reductions achieved each year. CDEC's operation and information system enables a relatively easy quantification of the actual emission reductions achieved on an hourly basis, calculated as the emissions avoided from the marginal unit that was displaced by the Chacabuquito project.

CDEC-SIC is a private entity composed of representatives of generation and transmission companies, independent of the Government. Although HGV is not a CDEC member (as membership is obligatory only for generators of capacity above 2 percent of the total installed capacity in the whole SIC), all generating plants supplying electricity to the system, including Chacabuquito, are under CDEC-SIC operating supervision.

**CNE:** The sector is regulated by an autonomous agency: *Comisión Nacional de Energía* (CNE). Its main responsibilities for the power sector include (i) proposing sector norms and regulations; (ii) coordinating planning, policies and norms for efficient functioning of the market; and (iii) calculating and enforcing regulated prices.

**Ministry of Economy**: In the area of the power sector, the Ministry of Economy is responsible for (i) setting distribution tariffs and node prices (based on CNE's calculations), (ii) resolving possible conflicts among the members of CDEC, and (iii) awarding concessions.

**SEC:** *Superintendencia de Electricidad y Combustibles* is responsible for supervising compliance with existing laws, regulations and technical norms related to the generation, production, storage, transport and distribution of liquid fuels, gas and electricity.

## Annex 4

## MONITORING PLAN

Please refer to section D.

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