Project design document form
(Version 11.0)

Complete this form in accordance with the instructions attached at the end of this form.

BASIC INFORMATION	
Title of the project activity	Chile: Lircay Run-Of-River Project
Scale of the project activity	☒ Large-scale ☐ Small-scale
Version number of the PDD	Version 6
Completion date of the PDD	18/08/2020
Project participants	Hidromaule S.A. and C-Quest Capital LLC
Host Party	Chile
Applied methodologies and standardized baselines	AM0026 Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid (AM0026 version 3.0).
Sectoral scopes	Sectoral scope 01.
Estimated amount of annual average GHG emission reductions	59,381 tCO_2e/yr

SECTION A. Description of project activity

A.1. Purpose and general description of project activity

The Chile: Lircay Run-Of-River Project, or the Lircay Project, consists in the construction and operation of a run-of-river hydropower plant of 19 MW. The Lircay Project uses waters of the first section of the Maule Norte Bajo canal, in the San Clemente commune, Province of Talca, VII Region del Maule, at about 30 km northeast of Talca city, and 240 km south of Santiago, in the south bank of the Lircay River. The Lircay hydro power plant generates approximately 130 GWh per year and its commercial operation started in late 2008.

The Lircay Project operates with two horizontal axis Compact Francis turbines, each one with a capacity of 10.658 MW. These turbines connect directly to synchronous generators of 9.5 MW each, obtaining an installed total power of 19 MW (see section A.3 for more details). Both generators connect to a power transformer elevating the voltage from 6.6 KV to 66 kV in the Lircay substation. Project's electric generation is injected to the "Sistema Eléctrico Nacional" (from now on, SEN)[1] by a single-circuit 66 kV transmission line, connecting the Project to the existing Maule substation at 26.6 km east from the Lircay powerhouse. Total project construction costs are estimated in US$ 29.5 million.

The project boundary of the Lircay Project activity encompasses the Lircay run-of-river power plant itself and all the power plants connected to the SEN grid, which is the relevant grid to which the Lircay hydro power plant is connected to. The baseline scenario of the Lircay project activity is the continuing operation of the existing and future power plants in the SEN, without the Lircay power plant electricity generation, to meet the actual electricity demand of the system. The Lircay run-of-river power plant is expected to generate 59,381 tCO_2e/yr (on average) and a total of 415,667 tCO_2e during the second 7-year crediting period.

The Lircay Project contributes to the sustainable development in Chile through:

- Use of local renewable energy resources (small hydro) to displace coal, diesel and natural gas thermal power generation in the SEN.
- Increased commercial activity through clean and renewable source of power.
- Employment generation in the VII Region where the project is located, improving economic benefits of the surrounding communities, where there is a high rate of unemployment and poverty.
- Improvement of the ACM irrigation system (nearly 2,200 irrigators), through annual payments for the water rights.
- Demonstration of finance and development of renewable energy projects through a small startup company using CDM as a relevant financial source.

The Lircay Project's local environmental and socio-economic benefits are summarized in table A.1.

[1] Originally, this project was connected to the SIC ("Sistema Interconectado Central" in Spanish), however in 2017 this system was interconnected to the SING ("Sistema Interconectado del Norte Grande"), generating the new "Sistema Eléctrico Nacional" (SEN).

Table A.1: Domestic and local benefits

Area	Description
Local environmental benefits	• The Lircay Project will contribute with clean energy to Chile's SEN grid, contributing to national development.
Socio-economic benefits	• 150 local jobs will be created during the construction phase of the project, with an average of 60 jobs per month during the construction phase, and 10 permanent jobs during the operation phase. This will generate a positive impact to the surrounding communities of San Clemente, Pelarco, Colbun, Linares, Curicó and Talca, which have a high level of rural population, poverty and unemployment compared to the national average. • Increased economic activity during the construction period and during its operational lifetime. • Annual payment to Asociación Canal Maule (ACM) for water rights will benefit nearly 2,200 irrigators through improvements in their irrigation system that extends to nearly 1,000 km in the Maule valley.
Technology transfer	• Introduction and demonstration of environmentally friendly power generation technologies for the VII Region is an explicit objective of the project. • The demonstration that emission reductions obtained from renewable energy sources can earn additional income and the introduction of CDM will increase environmental awareness in the region/country. • Demonstration on how small startup companies can finance and develop a project through the CDM.
Environmental Impact Assessment (EIA)	• Since the Lircay Project is a small hydro power plant that generates low environmental impacts, only required an Environmental Impact Declaration (DIA), in accordance with Chilean environmental law 19,300 and approved by CONAMA in December 2000. • The Lircay Project was submitted to the environmental qualification process on 20/07/2006, and was approved on 03/11/2006. (Resolución Exenta N° 414 COREMA VII Región del Maule). The complete DIA and Project commitments can be downloaded from the national environmental impact assessment system at https://seia.sea.gob.cl/. • Hidromaule S.A. has set up an Environmental Action Plan as part of the required safeguard policies established by the IFC - World Bank, being its principal creditor. Environmental impacts of the Lircay Project are clearly defined and were adequately assessed by the environmental and sectorial authorities.

A.2. Location of project activity

The Lircay Project activity is located in the VII Region of Maule, Chile, at about 30 km northeast from Talca city and 240 km south from Santiago.

The Project's intake is placed in the Maule Norte Bajo canal and the Powerhouse facilities are located in the south bank of the Lircay River.

The project coordinates are:

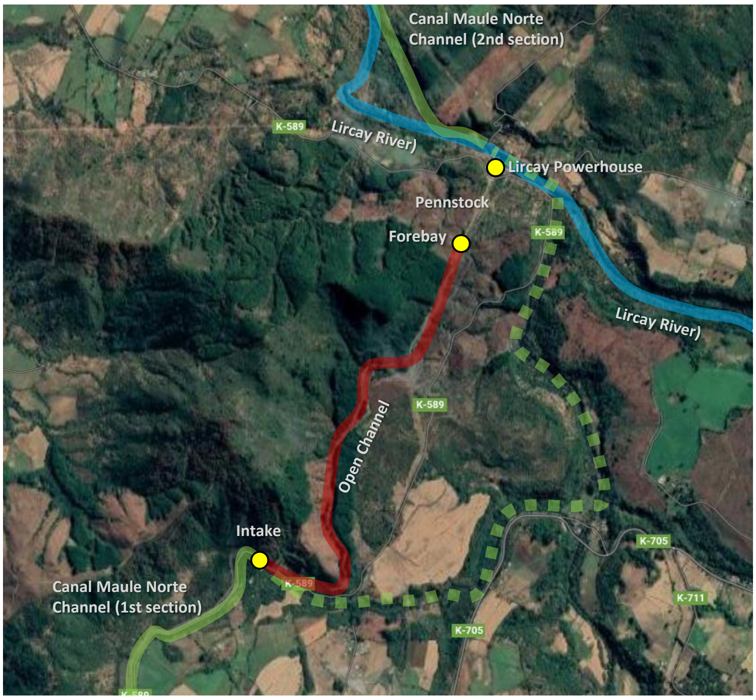
Table A.2: Project Coordinates (UTM PSAT 56)

	East (km)	North (km)
Intake	293,740	6,063,160
Power house	295,188	6,065,434

The location of the Lircay Project activity is shown in Figure A.1 and Figure A.2.

Figure A.1: Geographic location

Figure A.2: Satellite view



A.3. Technologies/measures

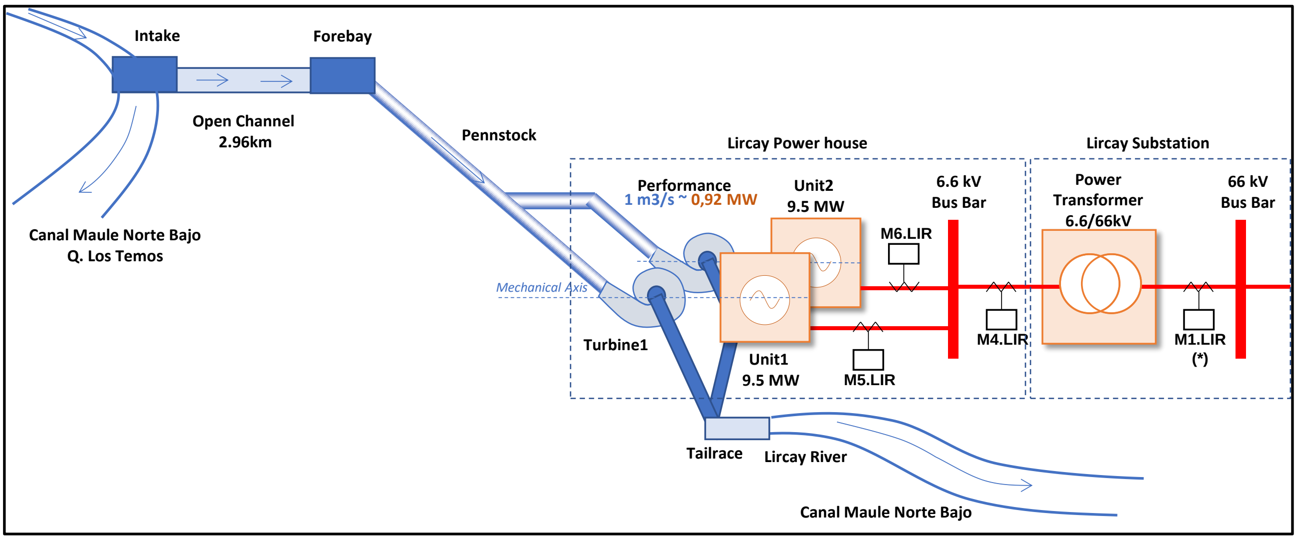
The Lircay Project uses well-proven technologies to accomplish electric power generation. The project contemplates the construction of a water intake in the Maule Norte Bajo canal, an open channel of 2.96 km long and 22 (m^3/s) capacity, a pressure penstock with 104.95-meter head, a powerhouse with two horizontal axis Francis turbines of 10.658 MW, each one of them connected to a power generator of 9.5 MW. This will result on a total installed capacity of 19 MW, a 6.6 to 66 kV and 22 MVA power transformer and 26.6 km of transmission line to connect the project with the SEN grid, through the existing Maule substation.

Table A.3: Project Details

Physical infrastructure	Power plant
• 2 sets of horizontal compact Francis turbines and 2 sets of generators. • 2.96 km of open channel. • Design flow: 22 (m^3/s). • 104.95-meter head. • 26.6 km 66 KV transmission line.	• Capacity: 19 MW. • Average Net Generation: 130 GWh/year. • Located 30 km northeast from Talca city and 240 km south from Santiago. • Construction time: 18 months • Estimated cost: US$ 29.5 million.

The Lircay Project is a new (Greenfield) hydroelectric power generating plant, since before the implementation of the project activity, there was no power plant operating at the project site. The estimated lifetime of the Lircay run-of-river power plant installations is over 40 years and 0 months[2].

Figure A.3: Lircay Run-Of-River Project Diagram



* M1.LIR measures the Project Activity net energy delivered to the grid and is used for sending data to CEN. This device is the relevant measurement equipment for EFy calculations as indicated in section B.6.

[2] The project feasibility study considered a lifetime of 40 years (see Table B.3). However, as stated in section 3.4 of the project's environmental approval (RCA – Exempt Resolution N°414, Comisión Regional del Medio Ambiente, Region del Maule, 03/11/2006), the project should have an even longer lifetime (over 50 years) (see : https://seia.sea.gob.cl/documentos/documento.php?idDocumento=1805021).

A.4. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Chile (host Party)	Hidromaule S.A.	No
Netherlands	C-Quest Capital LLC	No

A.5. Public funding of project activity

No public funding is involved in the project activity. The fund used to financing is not diversion of ODA.

A.6. History of project activity

The Project Participant confirm that Lircay project:

1 (a)	Is neither registered as a CDM project activity nor included as a CPA in a registered CDM PoA.	Lircay project is not included as a CPA in a registered CDM PoA.
1 (b)	Is not a project activity that has been de-registered.	Lircay project is registered in CDM.
2 (a)	Was a CPA that has been excluded from a registered CDM PoA;	Not applicable.
2 (b)	A registered CDM project activity or a CPA under a registered CDM PoA whose crediting period has or has not expired (hereinafter referred to as former project) exists in the same geographical location as the proposed CDM project activity.	Not applicable.
3	If the declaration on 2(a) or 2(b) above is positive, demonstrate that the proposed CDM project activity meets all conditions for registration in accordance with the applicable provisions in the project standard relating to registration of an excluded CPA as a CDM project activity or registration of a project activity that is in the same geographical location as a former project	Not applicable.

The Lircay run-of-river hydro power plant is developed by Hidromaule S.A., a company formed on June 2005 with the aim of developing small hydro projects in Chile. Its first project is the Lircay run-of-river Project, which started with the agreement between Hidromaule S.A. and Asociación Canal Maule (ACM). ACM consists of nearly 2,200 independent local irrigators with consumptive water rights in the Maule basin for about 54.3 (m^3/s), who have agreed to the construction of the project subject to annual payments for the use of the water rights.

Since the Lircay run-of-river Project is only a 19 MW power plant, it is considered under the Chilean legislation as a Non-Conventional Renewable Energy source (ERNC in Spanish), as per article 225, letter aa) of the Chilean General Electric Service Law Directive (DFL4/2006), and its subsequent modifications(available at the Chilean National Congress Library www.bcn.cl).

The Lircay run-of-river project was submitted to the Environmental Impact Assessment process on July 2006, through an Environmental Impact Declaration (DIA in Spanish), not requiring a full Environmental Impact Assessment Study due to its low environmental impact. The Environmental

Authority, CONAMA, formally approved the Project on 03/11/2006. (Resolución Exenta N° 414, COREMA VII Región del Maule).

A.7. Debundling

Not applicable in this case.

SECTION B. Application of methodologies and standardized baselines

B.1. References to methodologies and standardized baselines

Approved baseline methodology AM0026 Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid (Version 3.0). Available at:

https://cdm.unfccc.int/methodologies/DB/OOI7OYUFZOXN07H7EDBA9GVHJ4GK20

In order to estimate the emission factor for the grid, AM0026 (Version 3.0) refers to the TOOL07 "Tool to calculate the emission factor for an electricity system (Version 7.0)". Available at:

https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v7.0.pdf/history_view

Since this PDD is submitted for the renewal of the project activity crediting period, the following tool was also applied: TOOL11 "Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period" (version 3.0.1). Available at:

https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-11-v3.0.1.pdf/history_view

B.2. Applicability of methodologies and standardized baselines

The Lircay project activity is a grid connected run-of-river power plant, connected to Chile's SEN interconnected transmission grid. The methodology AM0026 (version 3.0) has been specifically designed for the Chilean power sector, where the Project meets every condition of applicability.

As stated by AM0026 (version 3.0), the applicability of this methodology requires the following conditions to be met:

Condition N° 1) Projects that are renewable electricity generation projects of the following types:

(a) Run-of-river hydro power plants and hydroelectric power projects with existing reservoirs where the volume of the reservoir is not increased;
(b) New hydroelectric power projects with reservoirs having power densities (installed power generation capacity divided by the surface area at the full reservoir level) greater than 4 W/m^2.
(c) Wind sources;
(d) Solar sources;
(e) Geothermal sources;
(f) Wave and tidal sources.

Applicability: The Lircay Project activity fulfills letter (a) of the previous conditions.

Condition N° 2) Projects that are connected to the interconnected grids of the Republic of Chile and Projects that fulfils all the legal obligations under the Chilean Electricity Regulation;

or Proposed projects implemented in countries other than Chile provided the country has a regulatory framework for electricity generation and dispatch that meets the following conditions:

(a) An identifiable independent identity is responsible for optimal operation of the system based on the principle of lowest marginal costs.
(b) The data for merit order based on marginal costs is publicly made available by the authority responsible for operation of the system.
(c) The data on specific fuel consumption for each generation source in the system is publicly available.
(d) It is possible with the information available, to ensure that power plants dispatched for other considerations (e.g. safety conditions, grid stability, transmission constraints, and other electrical reasons) are not identified as marginal plants.

Applicability: The project activity connects with the SEN Grid of the Republic of Chile, fulfilling all legal obligations under the Chilean electric power regulations.

Condition N° 3) the methodology is not applicable to:

1) The proposed CDM project activities that involve switching from fossil fuels to renewable energy at the site of the project activity, and
2) If the baseline is the continued use of fossil fuels at the site.

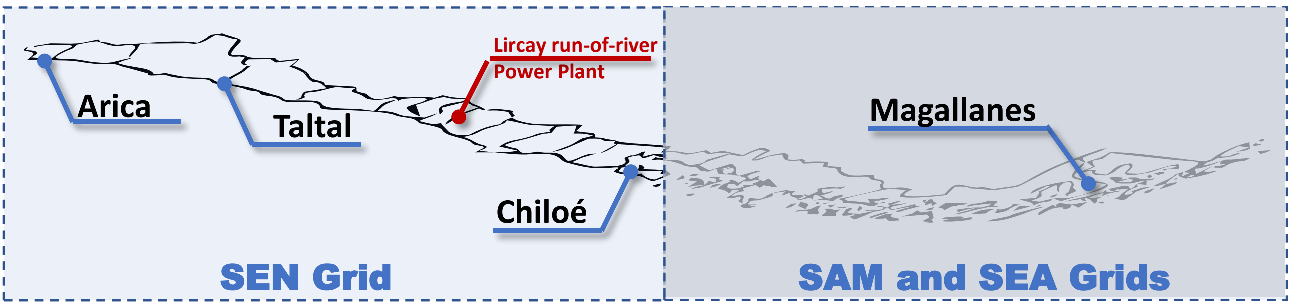
Applicability: The Lircay Project activity does not involve switching from fossil fuels to renewable energy at the site of the project activity and the baseline is not the continued use of fossil fuels at the site.

B.3. Project boundary, sources and greenhouse gases (GHGs)

According to the CDM methodology AM0026 Version 3.0, the spatial extent of the project boundary includes the project site and all power plants connected physically to the electricity system to which the CDM project power plant is connected. As described in section B.4, until November 2017, the relevant electricity system for the Lircay Project activity was the "Sistema Interconectado Central" (SIC[5]) grid. From December 2017 onwards, the SIC was connected with the SING[6] and became the "Sistema Eléctrico Nacional" (SEN). This system is centrally coordinated by a single dispatch center, the "Coordinador Eléctrico Nacional" (CEN). As a result, the SEN is now the relevant grid system for the Chile: Lircay Run-Of-River Project activity.

The methodology only claims emissions reductions from the substitution of power generation due to the implementation of a CDM activity in the SEN transmission grid. Only CO_2 emissions derived from the combustion of fossil fuels in thermal power plants are considered in this case.

<u>Figure B.1 Project boundary diagram</u>



[5] Central Interconnected System (from Taltal to Chiloe).
[6] Great North Interconnected System (from Arica to Taltal).

Table B.1 Project boundary by sources

	Source	GHG	Included?	Justification/Explanation
Baseline	SEN thermal dispatch	CO_2	Yes	Emission due to thermal power plant dispatch.
		CH_4	No	Methodology does not consider other GHGs besides CO_2.
		N_2O	No	Methodology does not consider other GHGs besides CO_2.
Project activity	Project activity electric power plant	CO_2	No	The project is a zero emissions electricity generation activity.
		CH_4	No	The project is a zero emissions electricity generation activity.
		N_2O	No	The project is a zero emissions electricity generation activity.

B.4. Establishment and description of baseline scenario

Identification of the Baseline Scenario

In a centrally planned system, such as the Chilean system, 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 expansion plan, which is used for calculating system energy and power node prices. This calculation is based on the most plausible scenario for least cost capacity additions on the grid. However, sector investments come from private investors who are free to choose the projects they want to develop and base their decisions regarding investments and operation of plants on their own perception of the market, where the CNE node price determination is a key factor.

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, available technology for capacity expansions and expected price of fuels. Thus, the baseline scenario consists of the current power plants in the relevant system grid for the Lircay run-of-river Project boundary, plus the projected capacity expansion and including the generation pattern in the SEN as it occurs in the absence of the generation of this CDM Project.

Description of the identified Baseline Scenario

The baseline scenario of the Lircay Project activity is the continuing operation of the existing and future power plants, without the Lircay run-of-river Project electricity generation, to meet the actual electricity demand. In the project scenario the same electricity demand is met with the Lircay run-of-river Project 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 from the SEN.

Considering the above and according to AM0026 (Version 3.0), in this case, the baseline scenario for project activities that do not modify or retrofit an existing electricity generation facility, like the Lircay Project activity, is the following:

Electricity delivered to the grid by the project that would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, as reflected in the Combined Margin (CM) calculations described in the following sections of this PDD.

Revalidation of the baseline of the project activity

According to the “CDM project standard for project activities” Version 2.0, the validity of the original baseline or its update should be assessed using the TOOL11 “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period” (Version 03.0.1).

The tool provides a stepwise approach to assess the continued validity of the baseline and to update the baseline at the renewal of a crediting period. The tool consists of two steps:

Step 1: Assess the validity of the current baseline for the next crediting period

The validity of the current baseline is assessed using the following Sub-steps:

Step 1.1: Assess compliance of the current baseline with relevant mandatory national and/or sectoral policies

According to the tool “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period (Version 03.0.1)”:

“(…) if the current baseline complies with all relevant mandatory national and/or sectoral policies which have come into effect after the submission of the project activity for validation or the submission of the previous request for renewal of the crediting period and are applicable at the time of requesting renewal of the crediting period, go to Step 1.2”.

There have been no new national and/or sectoral policies that could affect the Lircay Project activity, by the time it was submitted for revalidation under the CDM. According to the registered PDD, the original baseline is:

“(…) the electricity delivered to the grid that would have otherwise been generated by the operation of the currently operating power plants and by the addition of new generation sources”.

The original baseline complies with all the current relevant mandatory national and/or sectoral policies.

Step 1.2: Assess the impact of circumstances

According to TOOL11:

“(…) in the situation where the baseline scenario identified at the validation of the project activity was the continuation of the current practice without any investment, an assessment of the changes in market characteristics is required for the renewal of the crediting period.”

Currently, the main market characteristics of the electricity sector are still the same as the ones described in the original PDD of the Lircay Project activity. In fact, the planning authority, the “Comisión Nacional de Energía” (CNE) is still the same and the private sector is still the responsible actor in electricity generation, distribution and transmission market.

The main sector changes since the registration of the Lircay Project is that the national Independent System Operator has changed its name from CDEC (Centro de Despacho Economico de Carga) to CEN (Coordinador Eléctrico Nacional), which now oversees the national electric grid (SEN in Spanish), comprising the SIC and SING grids that were not previously interconnected. However, none of these changes compromises in any way the validity of the original baseline scenario used in the Lircay Project activity.

The conditions used to determine the baseline emissions in the previous crediting period are still valid, as baseline emissions depend on the grid connected power plants operation.

Step 1.3: Assess whether the continuation of use of current baseline equipment(s) or an investment is the most likely scenario for the crediting period for which renewal is requested.

According to TOOL11:

"(…) this sub-step should only be applied if the baseline scenario identified at the validation of the project activity was the continuation of use of the current equipment(s) without any investment and, the projects proponents or third party (or parties) would undertake an investment later due, for example, to the end of the technical lifetime of the equipment(s) before the end of the crediting period or the availability of a new technology".

The tool also specifies the assessment of the following:

"(…) whether the remaining technical lifetime of the equipment that would have continued to be used in the absence of the project activity, as determined in the PDD, exceeds the crediting period for which renewal is requested".

Since the baseline scenario identified at the validation of the project activity has not changed and it did not imply the continuation of use of current or existing equipment, this sub-step does not apply.

Step 1.4: Assessment of the validity of the data and parameters

According to TOOL11, the following must be assessed:

"(…) whether data and parameters that were only determined at the start of the crediting period and not monitored during the crediting period are still valid or whether they should be updated."

During the first crediting period, the Combined Margin grid emission factor was calculated ex-post, in accordance with the methodology AM0026 Version 3.0. During the second and third crediting periods, the weights for the Operating Margin and Build Margin emission factors are set to 25% and 75%, respectively. These values are explicitly indicated in the "Tool to calculate the emission factor for an electricity system Version 7.0" (as required in the applicable methodology AM0026 Version 3.0).

Since some data and parameters were only determined at the beginning of the crediting period (and therefore not monitored), they need to be updated for the second crediting period.

Step 2: Update the current baseline and the data and parameters

Step 2.1: Update the current baseline

According to TOOL11, the following must be updated:

"(…) the current baseline emissions for the subsequent crediting period, without reassessing the baseline scenario, based on the latest approved version of the methodology applicable to the project activity. The procedure should be applied in the context of the sectoral policies and circumstances that are applicable at the time of request for renewal of the crediting period."

In order to meet these requirements, the calculation of baseline emissions was developed for the second crediting period as described in section B.6.3 of this PDD.

Step 2.2: Update the data and parameters

According to TOOL11 the following must be observed:

"(…) if the application of Step 1.4 showed that the data and/or parameters that were only determined at the start of the crediting period and not monitored during the crediting period are not valid anymore, project participants should update all applicable data and parameters, following the guidance in Step 1.4."

Specifically, as mentioned in Step 1.4, and considering that the baseline emission calculation was carried out for the second crediting period, parameters w_{OM} and w_{BM} are updated and parameter EF_{BM} and all parameters used for its calculation are included as fixed parameters for the second crediting period. These parameters are described in sections B.6.1 and B.6.3 of this PDD.

B.5. Demonstration of additionality

As this PDD is designed for the second crediting period of a registered project activity, a reassessment of additionality is not required. Therefore, the following steps show the demonstration of additionality presented in the original (first) PDD.

How the anthropogenic GHG emissions are to be reduced

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

The Project Activity 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 CDM has been considered at an early stage of the project feasibility analysis. The feasibility report of the project showed that carbon credits sales are a relevant part of the project finance and essential to the project implementation. The following schedule shows some of the relevant milestones of the project development:

- 18/05/2006 Hidromaule S.A. and Asociación Canal Maule signed the agreement for water rights use for the Lircay Project.
- July 2006 Hidromaule submits the project for environmental qualification process. On 03/11/2006 the project got its official approval by COREMA.
- October 2006 Hidromaule starts negotiating with the IFC for the project finance. The project valuation document demonstrated the relevance of carbon finance incomes for the project success. The project achieves its financial closure with IFC on 26/06/2007.
- 31/01/2007 Hidromaule S.A. submits to VATECH the Purchase Order of the electromechanical equipment of Lircay, being this date the relevant date for the project commencement as stated in Section C.1.
- February 2007 Hidromaule starts the process for obtaining the Letter of Approval, officially signed by CONAMA on April 2007.
- October 2007 Hidromaule instructs Det-Norske Veritas to proceed with the project validation.

The following steps are used to demonstrate Lircay run-of-river Project additionality. These steps are based on the latest "Tool for the demonstration and assessment of additionality" (version 5.2).

Step 1) Identification of alternatives to the project activity, based on the Chilean national authority indicative expansion plan; this step shows that Lircay run-of-river Project is not the only alternative

for the expansion of the system and nor the least cost alternative, which are combined cycle natural gas or diesel fired power plants, coal and hydro dams (non-run-of-river).

Step 2) Investment Analysis is included optionally, as per guidance of the “Tool for the demonstration and assessment of additionality” (version 5.2). This analysis is done through a Benchmark Analysis (Option III), showing that the Project is not financially attractive.

Step 3) Barrier Analysis shows that the project faces several particular and identifiable barriers that other generation projects do not.

Step 4) With a common practice analysis, other projects similar to Lircay run-of-river Project were searched for, showing that there are no similar activities observed in the SIC, with the exception of those projects that have been submitted under, or are seeking, carbon finance under the CDM.

Additionality Assessment

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 (node 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 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.

$$Min\left\{\sum Investment + Operation\ \&\ Maintenance\ Costs + Variable\ Costs - Residual\ Value\right\}$$

The effective CNE Node Price Report at the time the project was considered as an investment option is the October 2006, and thus, the one that affected the investment decision. It is then the relevant report to test the additionality of the Lircay run-of-river Project. The following Table B.2 shows the expansion plan from that report (www.cne.cl).

Table B.2: CNE Indicative Expansion Plan for the SIC

Month	Year	Project	Capacity
January	2008	Turbina GNL Quinteros I	125 MW
January	2008	Turbina GNL Polpaico I	125 MW
October	2008	Central Eólica Concepción Modulo I	20 MW
January	2009	Cierre Ciclo Combinado Taltal GNL	360 MW
April	2009	Ciclo Abierto GNL Quinteros I	240 MW
May	2009	Central Desechos Forestales VII Región	17 MW
August	2009	Central Desechos Forestales VIII Región	25 MW
October	2009	Central Carbón Maitencillo I	200 MW
October	2009	Central Eólica Concepción Modulo II	20 MW
October	2009	Cierre Ciclo Combinado GNL I	385 MW
January	2010	Central Hidroeléctrica Confluencia	145 MW
January	2010	Central Carbón I V-Región	250 MW
July	2010	Central Carbón Pan de Azúcar I	250 MW
July	2010	Central Carbón Coronel I	250 MW
April	2011	Central Geotérmica Calabozo Etapa 1	40 MW
April	2011	Central Geotérmica Chillan Etapa 1	25 MW
October	2011	Ciclo Combinado GNL Quinteros II	385 MW

Month	Year	Project	Capacity
April	2012	Central Carbón Pan de Azúcar II	250 MW
October	2012	Central Hidroeléctrica Neltume	403 MW
April	2013	Central Geotérmica Calabozo Etapa 2	40 MW
April	2013	Central Geotérmica Chillan Etapa 2	25 MW
June	2013	Central Carbón Puerto Montt I	250 MW
June	2014	Central Carbón Los Vilos I	250 MW
June	2014	Central Carbón Coronel II	250 MW
April	2015	Central Geotérmica Calabozo Etapa 3	40 MW
April	2015	Central Geotérmica Chillan Etapa 3	25 MW
June	2015	Central Carbón II V-Región	250 MW
October	2015	Ciclo Combinado GNL I VI Región	385 MW
October	2016	Ciclo Combinado GNL Quinteros III	385 MW
April	2017	Central Geotérmica Calabozo Etapa 4	40 MW
April	2017	Central Geotérmica Chillan Etapa 4	25 MW

Source: Node Price Report October 2006 www.cne.cl.

As shown above, the least cost alternative for the expansion of the SIC are combined cycle natural gas (Liquefied Natural Gas Plants or GNL in Spanish), and coal fired power plants, with the exception of Central Neltume 403 MW in April 2012 which is a large reservoir project and faces particular conditions in the system. The rest of the projects are renewable energy CDM projects in development, additional to the baseline, such as Central Eólica Concepción y Central Desechos Forestales VII and VIII región (biomass), Confluencia and some Goethermic power units (Calabozo and Chillan).

Step 2. Investment analysis (Sub-step 2b Option III. Benchmark analysis)

Taking into account that the additionality of the Project is justified by using the Barrier Analysis in the Step 3, supply of the investment information would not be necessary and therefore the analysis could go directly to Step 3. Nevertheless, it is considered interesting to demonstrate that the project activity is economically or financially less attractive than other alternatives without additional revenues from the sale of emission reductions.

Sub-step 2a) Determine de appropriate analysis method

Since the proposed project will earn revenues from CO_2 emission reductions and from electricity sales, the simple cost analysis method is not applicable. Instead, Benchmark analysis (Option III) must be applied.

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

The financial indicator for this analysis is the IRR, which is the most commonly used parameter to determine the investment decision. According to the Chilean electric law (DFL 4/2006), the official rate of return for electric projects is 10%, used to determine node prices, transmission line and distribution investments. Based on this Benchmark, calculation and comparison of financial indicator are carried out in sub-step 2c.

It should be noted that the presented Benchmark is a conservative rate, applicable to the Chilean power sector where most of the projects investments come from large companies that benefit from scale economies, which is not the case of the Lircay project, which would require a higher rate (Company scale barrier is analyzed in the in Step 3 Barrier analysis).

Sub-step 2c) Calculation and comparison of financial indicator.

Calculation and comparison of financial indicator of the Project is implemented according to the *Guidance on Assessment of Investment Analysis*. According to the feasibility study of the project, the parameters needed for calculation of key indicators are the following.

Table B.3: Lircay Project Valuation Parameters

Installed Capacity	19 MW
Firm capacity	7.1 MW
Energy production (1)	130 GWh / year
Contract and Spot sales	70% at Node Price and 30% at Spot
Total Investment	USD 29.5 millions
Operation Life	40 years
Income Tax	17%
Debt rate	8%
Avg. Node Energy Price (2)	33.06 USD/MWh
Avg. Spot Energy Price (2)	38.65 USD/MWh
Capacity Price	72.31 USD/KW-year
CERs Price	12 USD/CER
O&M costs	USD 0.71 millions / year
Water rights costs	USD 0.45 to 0.65 millions / year
Channel maintenance	USD 0.35 / year
Transmission toll	USD 0.10 million / year
Administrative costs	USD 0.75 millions / year

Source: Hidromaule S.A. according to the Lircay Feasibility Study.

(1) Based on 63 years statistical average (1943 to 2006), resulting in 78% plant factor.

(2) Average over 40 years of plant operation. As shown in the feasibility study and confirmed in the CNE Node Price Report, system prices tend to decrease in the following years, because of the construction of new coal, natural gas and hydro power plants, thus reducing the more expensive operation of oil power in the SIC.

In accordance with the Benchmark Analysis, if the financial indicators of the Project, such as the Project IRR, are lower than the Benchmark, the Project is not considered financially attractive.

Table B.4: Financial Indicator Comparison

	IRR over assets	NPV (10% discount rate)
Project with emission reduction (CER) sales.	11.75%	3,260
Project without emission reduction (CER) sales.	8.62%	-2,485

Table B.4 shows the Project IRR of the Project with and without the CER sales. Without CER sales the Project IRR is 8.62%, which is lower than the financial Benchmark. Therefore, the Project is not considered financially attractive.

However, taking into account the de additional revenues from CDM, the Project IRR is 11.75%, which is higher than the financial Benchmark. Therefore, the CDM revenues enable the project to overcome the investment barrier and the additionality of the Project is demonstrated.

Sub-step 2d) Sensitivity analysis

The sensitivity analysis shall show whether the conclusion regarding the financial attractiveness is robust enough to reasonable fluctuations of the critical parameters and assumptions. For the Project, four parameters where selected as sensitive factors to check out the financial attractiveness, plus a fifth parameter to see the impact of emission reduction sales on the Lircay Project:

1) Total investment cost.
2) Hydrological impact during the first two years of operation.
3) Energy node prices during the first six years of operation.
4) O&M costs.

5) Emission reduction sales up to 2012, sales for 21 years.

The results of sensitive analysis are shown in Tables B.5, B.6 and Figure B.2 below.

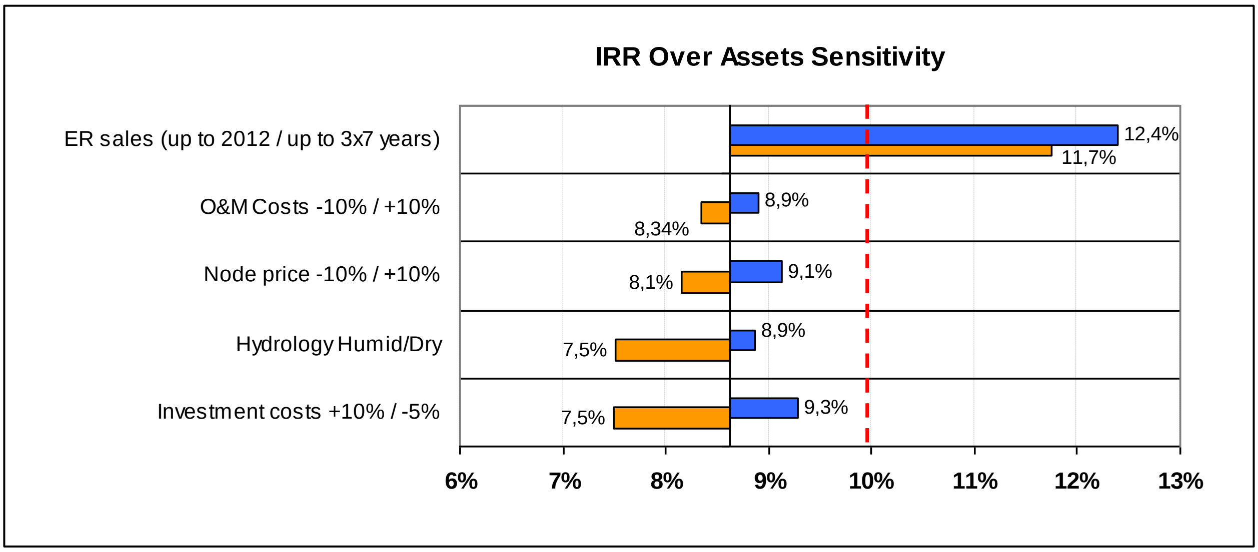
Table B.5: Sensitivity analysis

Parameters	LOW	HIGH	To Benchmark
Investment costs	+10%	–5%	–10%
IRR over assets	**7.49%**	**9.28%**	**10.0%**
Hydrology variations	Humid	Dry	(see comment)
IRR over assets	**7.50%**	**8.87%**	**-**
Energy Node price	–10%	+10%	+27%
IRR over assets	**8.15%**	**9.12%**	**10.0%**
O&M Costs	+10%	–10%	–50%
IRR over assets	**8.34%**	**8.90%**	**10.0%**

Table B.6: Emission reduction sales impact

Scenarios	IRR over assets
Emission reduction sales up to 2012	11.75%
Emission reduction rales up to 3x7 = 21 years	12.39%

Figure B.2: Sensitivity analysis



The Project IRR varies depending on the fluctuation of the selected parameters. The IRR range is (+7.49% to +9.28%).

As can be seen, the Project IRR is below the Benchmark, even when the total investment decreases by 5%. Investment cost is not expected to decrease more than 5%, considering that main equipment, construction materials and labor costs have all increased worldwide in the past years.

Energy node prices sensitivity for the first six years of operation show that an increase by 10% results in a slight increase of the Project IRR by 9.12%. To reach the Benchmark energy node prices would

have to increase by 27%. Such increase is not likely to occur under the current scenario, where node prices have already adjusted in 2005 to reflect natural gas restrictions from Argentina. After the adjustment of 2005, subsequent node price fixations have not shown mayor variations. It must be noted that energy node prices reflect a long-term average of the system operation, considering most plausible capacity additions; available technologies and fuel prices (see Appendix 4).

Hydrology variations do have a relevant impact in the IRR, however the effects are mostly negative and keep the IRR below the Benchmark. Since it is unlikely that a hydropower project would face an extreme hydrological scenario for many years, the sensitivity analysis for hydrology variations only considers the first two years operation facing a Dry or Humid condition. These first two years have the largest impact in the project revenues and IRR and show a realistic scenario over hydrology variations impacts.

For the remaining years of this analysis, the power plant is expected to produce an average generation output (130 GWh/year). The Humid condition produces 136 GWh of energy generation and a Dry condition produces 95 GWh of energy generation (See figure B.4 in the Barrier analysis for monthly detail). It is important to note that hydrological scenarios not only affect the project generation output but it is also inversely correlated with system spot prices, where low spot prices appear in humid conditions (nearly 20 USD/MWh) while high spot prices appear in dry conditions (nearly 150 USD/MWh). As it is shown in the table above, the humid condition presents a more negative result compared to the average case and the dry scenario, and both conditions, dry and humid, remain under the Benchmark of 10% IRR.

Since the Benchmark cannot be reached on any of the extreme conditions, a simplified example can show the unlikelihood of reaching the Benchmark: For the dry scenario, it would be required a price increase of 40% of the system spot prices (210 USD/MWh as average for the first two years of operation). In the humid scenario, it would be required an increase of nearly 500% in the average system spot prices to reach the 10% IRR Benchmark (120 USD/MWh as average price for the first two years of operation). In each case, such increase in the system prices are not likely to occur considering the latest CNE Node Price fixations reports (Oct-2005, Apr-2006, Oct-2006), all of which estimate a relatively stable result for the projected spot prices for the next 10 years of the system operation, with an average of approximately 67 USD/MWh.

Compared with the total investment, the annual O&M cost has little impact on the IRR and can be regarded as not very relevant for this analysis. To reach the Benchmark, O&M costs would have to decrease by 50%.

Therefore, even if the uncertain factors changed within the reasonable range, the IRR of the Project could not reach the Benchmark and the additionality of the Project would not be affected.

Table B.6, and Figure B.2 also show the case when additional income is generated by the project through emission reduction sales. The additional revenues change substantially the IRR of the project beyond the Benchmark, thus evidencing the impact of these revenues on the investment decision.

Step 3. Barrier Analysis

The following section outlines the main barriers faced by the Project Participant in undertaking the Lircay 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 one of the main risks that run-of-river projects face, that is not present on thermal technology projects, which are the least-cost expansion alternatives outlined by CNE. As a result,

there is no way the Project can mitigate against drought and low inflow periods. Consequently, Project incomes are highly variable.

Furthermore, from the annual fluctuations due to dry or humid years of a particular hydrological condition, the Project faces monthly energy variations in average conditions, going from 15 GWh in summer to 7 GWh in winter, resulting in idle installed capacity.

Both, seasonal and annual fluctuations of the Lircay Project, affect and limits the capacity to contract energy at stabilized prices, which are necessary to reduce cash flow risks.

As described earlier, the Lircay run-of-river Project uses irrigation water rights of 22 (m^3/s from Canal Maule Norte. However, the water rights legal definition does not assure actual water availability during drought conditions.

Despite the previous statement, water rights and water distribution to local irrigators is not necessarily affected in the same way. Canal Maule Norte is only one of many irrigation channels in the basin, and normally whenever there is difficulty to delivering waters from Canal Maule Norte, it can be compensated to irrigators by delivering waters through other upstream or downstream channels or even through the main Colbún reservoir discharge. In fact, the irrigation channels in the area are a vast and complex structure of channels that cover many hundreds of kilometers. Nevertheless, reductions of water flows in the Canal Maule Norte will inevitably reduce Lircay run-of-river electric power generation.

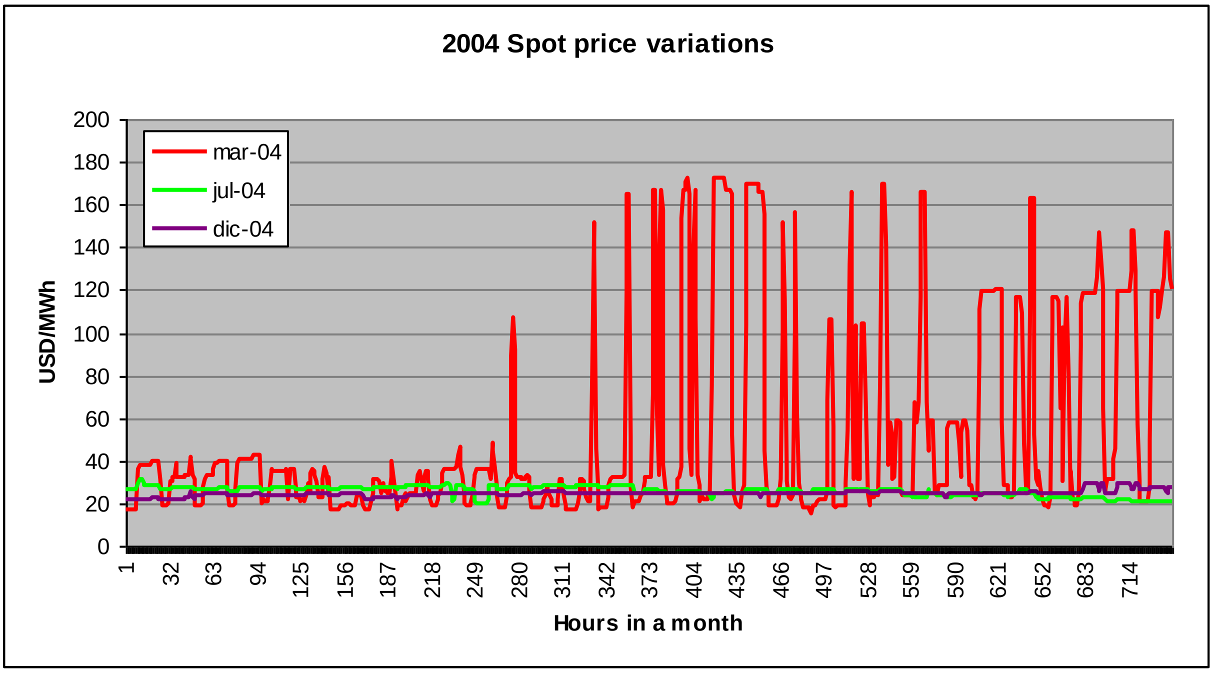
Spot Market Risk:

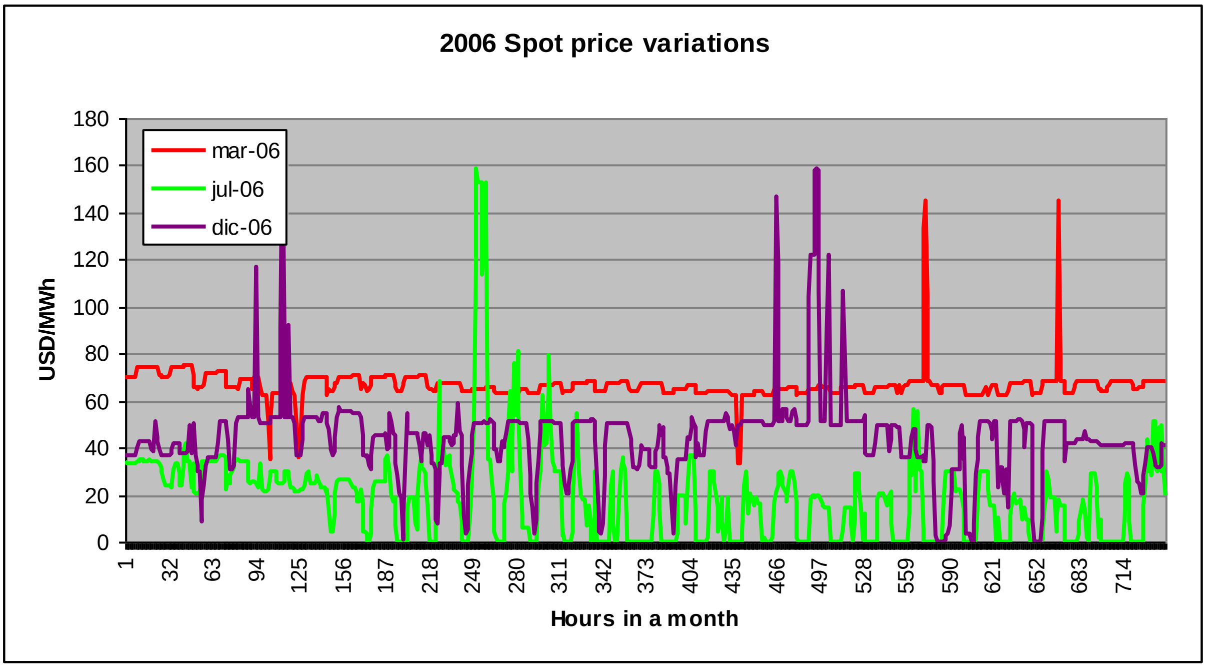
Any generation activity has an element of spot market risk. The SIC has a 60% hydroelectricity base, and system prices are very sensitive to hydrology conditions. Dry conditions will effectively reduce Lircay run-of-river Project generation but will also expose the Project to higher spot prices. On the other hand, during humid conditions where more generation is available, it may result in null spot prices during wintertime, resulting in a decrease of energy sales.

Without taking into account price volatility during different hydrology scenarios, hourly dispatch and hourly energy transactions may negatively affect project incomes if the project is a net buyer or seller at peak price hours. Lircay generation has been estimated based on monthly or weekly average water flows in the basin, but there is no good information on the water flow behavior on an hourly basis.

Figure B.3. shows the system spot prices of year 2004 and 2006, which are presented as samples of the SIC spot prices volatility in hourly basis, where 2004 was a semi dry year and 2006 a semi humid year. Both scenarios clearly show the volatility risk inherent in spot prices transactions.

Figure B.3: Hourly spot price variations in March, July and December of 2004 and 2006





Finance and Company scale risk:

Before entering into the implementation phase, several preliminary steps are required for the identification and scope of the project. These steps include pre-feasibility study, feasibility study, topography and environmental assessment, basic and detailed engineering, etc. These sunk costs are a significant barrier for a small generation project like Lircay, which does not benefit from scale economies that large energy companies have. The same applies to obtain competitive financing rates, due to the higher inherent risk. This is indeed a significant barrier for a small company with a sole generation project.

Hidromaule, the Project Participant, is a small startup company with no previous experience in the Chilean power sector. The high cash expenses required to develop the project will depend on the availability to get the project finance structure with banks willing to support the construction risk, as the reimbursement of the loan will depend on the cash flows generated by a successful project implementation. Banks will require a thorough due diligence and milestone based disbursements during the project execution period. However, small to medium variations in the project budget could jeopardize the project development if the shareholders do not have the flexibility to support the budget variations.

Project financing is not a common business in Chilean banking. Normally a local bank will require hard and equivalent guaranties to support the loan, to be provided by project owners. This limits the action of the developers to international banks. Since the company does not account further assets, all common finance and acquisition procedures required for the development of the Lircay project are very restricted. Additional finance provided by the carbon credits are then a relevant finance tool for the project success.

Market and Regulatory risk:

Despite being a highly developed, deregulated and transparent sector, 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 to regulated consumers. Following a severe drought in 1999, generators were unable to supply energy to their clients and claimed *force majeure*. To try to 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 (former Article 99bis of the Electrical Law or DFL 1/82 Ley General de Servicios Eléctricos in Spanish, now Article 163 of the DFL 4/2006).

Distributors represent near 80% of the SIC demand. The result of Article 163, translated into higher risk for any generator willing to supply energy to distributors, unless having a diversified portfolio of hydro and thermal generation assets. For the case of a small project developer, with a reduced portfolio with no thermal backup, Article 163 limits the possibility of finding financially attractive PPA (Power Purchase Agreement), affecting financing possibilities for the project development.

A second example of regulatory risk is the case of RM 88 decree and Transitory Article 27 of DFL4. Energy sold to distributors is regulated by law and cannot exceed Node Prices (fixed by CNE report). However, the decree is a consequence of Article 163, where the higher risk imposed for attending distributors, resulted in non-renewed energy contracts. RM 88 tried to remedy the energy supply requirement of distributors, imposing the obligation to all generators to supply non-contracted energy proportionally to their firm energy. Legal amendments of RM 88 implementations, stated by Transitory Article 27 of DL4, require a crediting structure to distributors, where any difference in the price between node prices and spot prices, shall be charged to distributors by generators in the following six months period as a surcharge over the Node Prices. Total RM 88 supply volume in the system reaches nearly 600 GWh per month, from where nearly 0.2% must be supplied by Lircay[8].

[8] This is calculated as a ratio between the Project firm energy and the total system firm energy.

This represents nearly 1 GWh per month of energy for the Lircay Project as it can be estimated through the CDEC-SIC RM 88 distribution procedure, representing almost 10% of the project generation. The RM 88 effect is proportionally applied to all generators in the SIC. However, in the case of Lircay run-of-river Project and the company size, the RM 88 effect in the energy sales will require near USD 500.000 every six-month period, to be financed entirely by the project operator. This is a high amount of working capital for the company size. (See financial and company scale risk).

A third example are latest changes made by CNE with respect to the period for which Firm Capacity is calculated. In October 2004, authority changed the 5 hour period to 8 hours in winter time (May to September). And recently CNE proposed new changes extending the period of months that power is to be calculated and the way how the maximum power of the system will be calculated. All this changes might have a medium impact on the Project revenues, since the project may lose some firm power selling capacity. This particular change in the law is intended to favor Thermal instead of Hydro generation, with the aim of enhancing the system's reliability reducing the dependency from hydrological variations.

Water Rights risks

Hydroelectric projects must necessary have water rights in order to operate. This is the most important barrier hydropower project face, since without water rights, no project can be developed.

In Chile, water rights are freely obtained through water national authority (Dirección General de Aguas or DGA). This is usually a long process where the DGA establishes the availability of the resources and the conditions how the water rights will be granted.

Obtaining water rights through the DGA can be a difficult task involving several years. Alternatively, water rights can be purchased from third parties who already own the water rights, but this implies high costs for the project. At present, most or all relevant water rights are already taken, and the only way to develop a new project without having water rights in advance is to acquire them at an expensive price.

In the case of Lircay, water rights are the result of a long negotiation process with the Asociación Canal Maule (ACM) irrigators. Actually, as stated in the agreement between Hidromaule and ACM, all Lircay Project water rights require an annual payment to ACM (nearly USD 450.000 to USD 650.000 per year).

Land right-of-way risks

Hydropower projects usually need the use of key areas for their implementation. This is required for the construction of channels, penstock, material waste sites and transmission lines. The latest is one of the main barriers any hydropower project faces, since if the project is too far away from existing transmission lines, the cost of evacuating the energy could turn down the project for economic reasons (see Project Scale Barrier).

The Project Participant may use two alternative methods for the land acquisition. One is through privately and mutually agreed right-of-way agreements between the Project Participant and land owners. Another alternative method can be applied through the "electrical concession law" established by law (DFL4). The second alternative requires an exhaustive and usually very long process with the authorities to obtain the final decree approval.

In the case of the Lircay run-of-river Project, the 26.6 km transmission line right-of-way considers near 114 lands. Many of these lands are composed by heirs of rural population, totalizing near 250 land owners, turning the negotiation process into a very complex and thorough process. For the power station, the land acquisitions considered only four lands, however one of the lands consisted in an heir of near 115 owners where original land ownership documents dated from 1914.

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

At the moment the project investment decision was made, combined or open cycle natural gas plants (Natural gas acquired offshore as Liquefied Natural Gas or GNL in Spanish) and coal fired plants where considered the least cost investment planning by CNE (See table B.2). This represents the comparison base of the Lircay run-of-river Project. As it is exposed below, the least-cost alternative projects proposed by the CNE are not affected by any of the barriers outlined above.

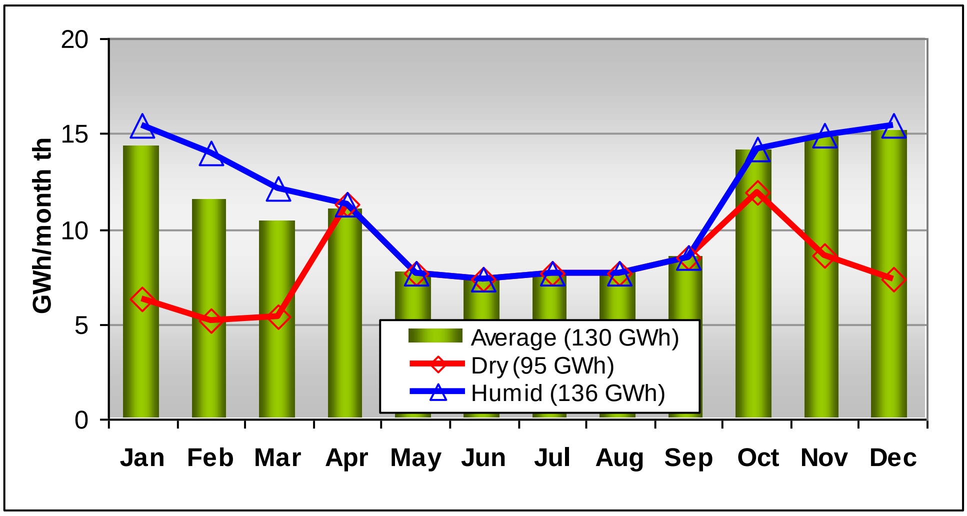
Hydrology Risk:

The least-cost expansion alternatives are not affected by hydrology conditions and are able to use alternative fuels in case of fuel restrictions (such as natural gas power units that can operate with diesel), thus mitigating supply risks that the Lircay run-of-river Project must face.

Figure B.4 shows average monthly generation and hydrological variations of the Lircay run-of-river Project, obtained through historical and estimated data. The figure shows that, between humid and dry seasons, there are near 41 GWh of energy variations, representing 31% of the average energy production.

The main effect of this 41 GWh variation is that it limits the amount of energy that can be contracted at long-term and stabilized prices. This limitation requires then a certain amount of average production to be sold at volatile spot prices, increasing the cash flow risk and affecting finance costs.

Figure B.4: Lircay run-of-river Project monthly projected generation



Source: Hidromaule estimate based on hydrological data for 64 years (1944 to 2006).

Spot Market Risk:

During wet hydrological years, even if surplus energy is produced by the Lircay run-of-river Project, it is sold at low spot prices that may even reach null value from time to time. On the other hand, in dry hydrological years the Project produces lesser energy increasing exposure at higher spot prices.

Spot market risk could be reduced through an energy contract at stabilized prices. However, the delivery of this energy block may require energy backups in extreme dry conditions, where the Project may be exposed at high spot prices for the backup, but still selling the contract energy at fixed price. This may imply important cash-flow risks for the project.

In addition to the seasonal and monthly variations in the Projects energy production, which determines the spot price exposure, there is also an exposure risk in hourly terms. In effect, spot prices also show a high variability on an hourly basis. The Lircay run-of-river Project hourly water inflows are not known in advance and will only be known after the project implementation, adding additional risk to the project incomes if contracted volumes follow a different load curve of the hourly water generation. In these cases, the Project will be required to buy and/or sell hourly blocks at spot prices, where the final weighted sum could result in negative incomes.

The least-cost alternatives selected in CNE indicative expansion plan, being thermal gas, coal and diesel units, have a very limited spot market risk, since energy production is nearly constant and it is unlikely to see energy backup purchases unless the spot market is lower than the operational cost of the unit.

Finance and company scale risk:

Lircay run-of-river Project is the first project being developed by Hidromaule S.A. and it is the first of several small scale projects in the system to be developed by a small independent generator, different from the three main generators in the electric power market: Endesa, Colbún and AES Gener, where Hidromaule competes with companies that have a hydrothermal balance in their assets.

Large to medium operators in the electric sector have considerable assets background allowing them for better financing conditions and rates, aiding in the development of new projects. Hidromaule S.A. is a small private company owned by local and foreign shareholders with no other asset background but the Lircay run-of-river Project and must mitigate its financing risk by itself.

Hidromaule started negotiating with the International Finance Corporation (IFC) in June 2006 to obtain the main source of financing for the project, and since then, additional incomes from emission reduction sales where already considered crucial part of the Project cash flow and financing plan, relevant for going ahead with the investment decision.

The Project loan from the International Finance Corporation IFC is USD 19.7 million and the remainder will be directly provided by Hidromaule shareholders.

Market and Regulatory risk:

As mentioned before, the project is particularly susceptible to changes in regulation governing the authority's recognition of the power plants firm power. Water, environmental and geographical conditions restrict the ability of the project to adapt. Fossil fuel thermal plants do not face the same restrictions, and generally such flexibility implies a lower capital cost for financing structures.

Water rights risks

Generally, run-of-river projects water rights are freely obtained through the National Water Authority (DGA in Spanish). Most of the projects already in study or under development in the SIC, have their water rights long before the projects decision-making.

In the case of Lircay run-of-river Project, the water rights come from nearly 2,200 independent irrigators organized through the Asociación Canal Maule (ACM). The negotiation process was very long and the final agreement between Hidromaule and ACM compromises annual disbursements towards ACM of nearly 10% of the project's income. The additional incomes that ACM will receive through this agreement, will be used to cover ACM's administrative expenses and improve their whole irrigations system that covers near 1,000 km of channels in the Maule basin, all of which have been poorly maintained over the last decades.

Comparing the project to the least-cost expansion alternatives, no water rights risk exist in case of thermal power plant options, since fuel for the operation is accessible to anyone at market prices.

Land right-of-path risks

In the case of the Lircay run-of-river Project, which is considered a small project in the Chilean electrical system, it requires a relatively long transmission line (approximately 26.6 km) and nearly 2.96 km of open channels, affecting in total nearly 114 rural lands and nearly 250 landowners.

Since it is a long process, and in order to avoid project delays, the project participant started negotiations with each affected landowner, long before the project started its construction. All of these costs have been directly supported by the shareholders at their own risk.

In the case of the least-cost expansion alternative considered by CNE, the transmission line risks are limited, since thermal power facilities do not require extensive areas and the project location can be optimized in order to connect near existing transmission facilities.

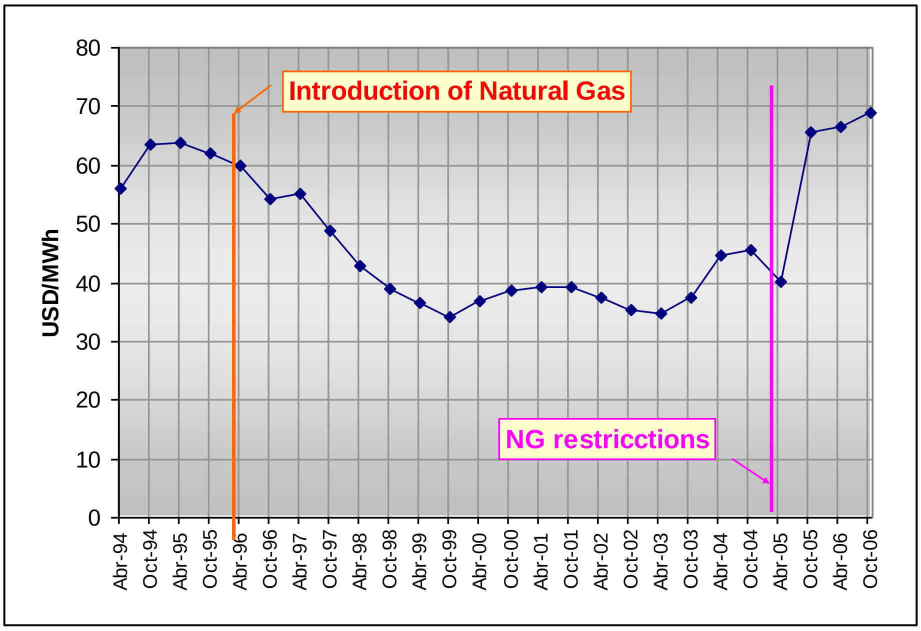
On the basis of the above analysis it is concluded that the Project Activity faces unique, identifiable and significant barriers, not faced by its most likely alternative, a gas or coal fired plant.

Step 4. Common practice analysis.

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

The following figure shows SIC's historic energy price variations. It can be clearly identified an energy price reduction in the system after natural gas introduction in Chile. The actual price levels are explained by the effect of natural gas restrictions from Argentina, where natural gas units are being dispatch with diesel fuel to supply the always-increasing system demand.

Figure B.5: CNE Node Price Fixations (in real USD as of Oct-2006)



Source: CNE price reports (www.cne.cl) and US CPI index (www.bls.gov).

Even with the actual node price scenario, where the monomic price levels are over 60 USD/MWh, thermal generation alternatives are still the least cost option for capacity additions, as indicated by CNE in its Node Price Report and indicative expansion plan published in October 2006 (see table B.2). This is explained by the increasing development cost that hydroelectric projects face worldwide, followed by the increase of international costs for copper, aluminum, cement costs, and all other base construction materials, which are more intensive in hydraulic projects. Furthermore, electromechanical equipment involved in similar projects, face higher costs and longer delivery dates,

explained by the reduced availability of manufacturers of hydropower equipment worldwide. As stated before, transmission lines investment is one of the main barriers projects like Lircay face. These costs are not necessarily faced by the least-cost expansion alternatives proposed by the CNE, which can be located near high demand areas, reducing the need for long transmission line construction.

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

There are no similar activities observed in the SIC system being carried at the Project start date, with the exception of those projects that have been submitted under, or are seeking, carbon finance under the CDM.

The following table, obtained from October 2006 CNE Node Price Report, shows all the capacity additions being in construction, which are different from diesel, coal and gas technologies (least-cost expansion) are the following.

Project name	Capacity	Type	CDM status
Quilleco	70 MW	Run-Of-River HPP	Registered
Chiburgo	19.4 MW	Run-Of-River HPP	Under validation
Canela	9.9 MW	Eolic HPP	Registered
Hornitos	55 MW	Run-Of-River HPP	Registered
Palmucho	32 MW	Run-Of-River HPP	-
La Higuera	155 MW	Run-Of-River HPP	Registered

Source: UNFCCC CDM web page (https://cdm.unfccc.int/).

The previous table shows that all the above projects are not common practice alternatives, since they are all additional to the baseline being CDM projects or undergoing CDM registration. Palmucho project faces particular characteristics since it has been conceived to utilize the ecological water flow discharge from the existing Ralco 570 MW reservoir power plant, requiring limited additional civil works and benefiting from the existing Ralco's substation and power line for grid interconnection. In addition, Palmucho is being developed by the largest electric player in the Chilean electric power market – ENDESA - who owns and operates nearly 4,300 MW of hydrothermal installed capacity in the Central Interconnected System. Therefore, Palmucho does not face the same barriers as the Lircay Project, and due to its particular conditions, cannot not be considered as common practice in the electric power sector in Chile.

The Lircay run-of-river project feasibility study presented to obtain the project finance, accounted in the analysis the additional incomes from emission reduction sales, and were a relevant part of the financial structure.

Since all above steps are satisfied, the additionality of the proposed CDM Project Activity is therefore fulfilled, according to the "Tool for the demonstration and assessment of additionality" (version 5.2).

B.6. Estimation of emission reductions

B.6.1. Explanation of methodological choices

According to the selected methodology AM0026 "Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid" Version 3.0, the emission reduction calculation is determined by the following equations.

Equation 1. Emission reduction calculation (AM0026 (Version 3.0), formula 2)

$$ER_y = BE_y - PE_y - L_y$$

Where:

ER_y = Emission reductions of the project activity during year y (tCO_2).
BE_y = Baseline emissions due to displacement of electricity during year y (tCO_2).
PE_y = Project emissions during year y (tCO_2).
L_y = Leakage emissions during year y (tCO_2).

Baseline emissions

According to the methodology, the baseline emissions result from electricity generation due to the operation of existing and likely future grid-connected power plants. These emissions are calculated as follows:

Equation 2. Baseline emissions calculation (AM0026 (Version 3.0) formula 6)

$$BE_y = EF_y \times Generation_y$$

Where:

BE_y = Baseline emissions due to displacement of electricity during year *y* (tCO_2).
EF_y = Baseline emission factor for year *y* (tCO_2/MWh).
$Generation_y$ = Electricity generated by the proposed CDM project during year *y* (MWh).

The baseline emission factor (EF_y) corresponds to the Combined Margin (CM) grid emission factor, consisting of the combination of Operating Margin (OM) and Build Margin (BM) emission factors. The Combined Margin is calculated according to the following equation:

Equation 3. Emission factor calculation (AM0026 (Version 3.0) formula 7)

$$EF_y = w_{OM} \times EF_{OM} + w_{BM} \times EF_{BM}$$

Where:

EF_y = Baseline emission factor for year y (tCO_2/MWh).
w_{OM} = Weight for the Operating Margin emission factor (%).
EF_{OM} = Operating Margin emission factor (tCO_2/MWh).
w_{BM} = Weight for the Build Margin emission factor (%).
EF_{BM} = Build Margin emission factor (tCO_2/MWh).

The values for w_{OM} and w_{BM} must be determined according to the latest version of the methodological tool “Tool to calculate the emission factor for an electricity system (Version 7.0)”. For the second and third crediting period, w_{OM} and w_{BM} shall be set at 25% and 75% respectively.

Operating Margin (OM) emission factor

The OM emission factor used for the emission reduction of the Lircay project activity will depend on the actual generation data from the SEN. The dispatch data, to be provided ex-post by the CEN Dispatch Center, will conclusively indicate the type of generation displaced by the addition of the

Lircay power plant in the generation mix of the SEN. The monitoring and verification plan for the project uses data provided by the CEN, CNE and the IPCC.

The next diagram shows the complete process for calculating and assigning the operating emission factors for the Lircay power plant.

Net hourly generator output from other CDM Projects and Lircay power plant.
(CEN[9] and Project Participant hourly energy generation data.)
(MWh)

Analysis of hourly dispatch of all units of the SEN to determine the marginal plant(s) that would have been dispatched if the system were operated without all the CDM projects in the system.
(CEN)[10]

Calculation of emission factor of all operational thermal units of the system.
(CEN, CNE report[11] and 2006 IPCC manual).
(tCO_2e/MWh)

Determination of the marginal plants and energy being displaced due to the operation of the Lircay power plant CDM project.
(MWh and tCO_2e/MWh)

Determination of EF_{OM} of each CDM project as the weighted average emission factor of the marginal plant(s) not dispatched (or displaced) by the project activity.
(tCO_2e/MWh)

The Operating Margin emission factor is calculated using the emissions factor estimation methodological tool shown above, in accordance with the following equations:

Equation 4. Operating Margin emission factor calculation

$$EF_{OM,y} = \frac{\sum_{h=1}^{8,760} EF_{j,h} \times \ Generation_{j,h}}{\sum_{h=1}^{8,760} Generation_{j,h}}$$

[9] https://www.coordinadorelectrico.cl/
[10] Energy generation data and merit order.
[11] www.cne.cl

Where:

$EF_{OM,y}$	=	Operating Margin emission factor for year *y* (tCO_2/MWh).
$EF_{j,h}$	=	Operating Margin emission factor for the proposed CDM project activity "*j*" for hour "*h*" (tCO_2/MWh).
$Generation_{j,h}$	=	Generation of the proposed CDM project "*j*" during hour "*h*" (MWh).

The emission factor for the CDM project "*j*", in a system with *n* CDM projects, for an hour "*h*" is based on identification of the marginal plant(s) that would be operated to meet the electricity supplied by the proposed CDM project "*j*". The identification of marginal plant(s) displaced by proposed CDM project "*j*" is based on the "first-built first served" principle. "Date of built" is defined as the date when the plant begins the dispatch of energy to the grid. The Lircay power plant started delivering power to the grid on 13/10/2008 and was registered as a CDM project activity on 04/08/2009.

The emission factor for any hour "*h*" for a CDM project "*j*" in system is estimated as a weighted average of emission factor of the identified marginal plant(s) that would have supplied electricity to the grid in absence of the "j^{th}" CDM plant. The emission factor is estimated as follows:

Equation 5. CDM Project "*j*" emission factor calculation (AM0026 (Version 3.0) formula 9)

$$EF_{j,h} = \frac{\sum_{i=1}^{M} D_{(j,i)} \times d_i}{\sum D_{(j,i)}}$$

Where:

$EF_{j,h}$	=	Project "*j*" emission factor.
$D_{(j,i)}$	=	Energy displacement of the marginal plant "*i*" due to the proposed CDM project "*j*" (MWh).
d_i	=	Emission factor of the marginal plant "*i*" (tCO_2/MWh).
M	=	M is the total number of marginal plants that would be dispatched if the system is operated without the N CDM projects.

M is such that:

Equation 6. Number of marginal plants determination (AM0026 (Version 3.0) formula 10)

$$\sum_{j=1}^{N} C_j \leq \sum_{i=1}^{M} (A_i - B_i)$$

Where:

C_j	=	Energy generation of the CDM project "*j*" (MWh/h).
N	=	Total number of CDM projects in the system.
A_i	=	Maximum energy generation of the marginal plant "*i*" (MWh/h, equivalent to plant capacity in MW).
B_i	=	Actual energy generation of the CDM marginal plant "*i*" (MWh/h). The difference $(A_i - B_i)$ represents the maximum possible additional electric energy that can be supplied by the "i^{th}" marginal plant.

Energy displacement of the marginal plant "*i*" due to the proposed CDM project "*j*", is calculated as follows:

Equation 7. Energy displacement calculation (AM0026 (Version 3.0) formula 11)

$$D_{(j,i)} = MIN\left\{C_j - \sum_{l=1}^{i-1} D_{(j,l)}; (A_i - B_i) - \sum_{k=j+1}^{N} D_{(k,i)}\right\}$$

Where:

$D(j, 0)$	=	0
$D(N + 1, i)$	=	0
$D(j, i)$	=	0 for all $i < m$, s.t. $\sum_{i=1}^{m}(A_i - B_i) > \sum_{k=j+1}^{N} C_k$
$D(j, i)$	=	0 for all $i > m^*$, s.t. $\sum_{i=1}^{m^*}(A_i - B_i) > \sum_{k=j+1}^{N} C_k + C_j$

The emission factor for displaced marginal plant d_i is calculated as follows:

Equation 8. Emission factor calculation (AM0026 (Version 3.0) formula 12)

$$d_i = SFC_i \times CEF_{OM,i} \times Oxid_i$$

Where:

d_i	=	Displaced marginal plant emission factor (tCO_2e/MWh).
SFC_i	=	Specific fuel consumption of "i^{th}" marginal power plant (TJ/MWh).
$CEF_{OM,i}$	=	CO_2 emission factor of fuel used in "i^{th}" marginal power plant (tCO_2e/(ton of fuel or TJ)).
$Oxid_i$	=	Fraction of carbon in fuel used in "i^{th}" marginal plant, oxidized during combustion.

The marginal plant(s) are those power plant listed in the top of the grid system dispatch order during hour "*h*" needed to meet the electricity demand at the hour "*h*" without the generation of CDM project(s). If no thermal power plants are needed to meet the demand without the CDM projects, then the emission factor of the marginal plant is zero.

The generation of the Lircay power plant is obtained from the metering system which follows a national standard of 0.2% error allowed[12] on a kWh base. Hourly energy data obtained from the metering system is periodically submitted to the CEN as for all other generating units of the system.

The CEN and CNE reports and the 2006 IPCC Good Practice Guidance[13] provide all the information to calculate the emission factors for all the power plants within the Chilean grids.

Calculation of the Build Margin

The Build Margin emission factor will be calculated with Option (i) of the baseline methodology AM0026 Version 3.0, i.e. as described in the "Tool to calculate the emission factor for an electricity system Version 7.0". According to this tool, for the second crediting period, the Build Margin must be updated using the most recent information on units already built at the time of submission of the

[12] Chilean Regulation NCH 2542.
[13] http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

request for renewal of the crediting period to the DOE. This calculated factor remains fixed both for the second and third crediting period of the project activity.

The sample group of power units to be included in the Build Margin calculation considers the set of capacity additions in the electricity system that comprise 20% of the system generation and that have been built most recently. This represents Paragraph 75 (b) of Step 5: Identify the group of power units to be included in the Build Margin of the "Tool to calculate the emission factor for an electricity system Version 7.0".

As shown in Appendix 4 of this PDD, the selection of plants that comprises 20% of annual generation from plants that have been most recently built, has clearly more than five power plants, making option (a) inapplicable in this case.

Power plants registered as CDM project activities are excluded from the sample group. The following diagram shows the complete process for calculating and assigning the Build Margin emission factor:

SEN Dispatch of all power units of the system
(CEN Dispatch Center)
(MWh)

Determination of 20% of energy generated from most recent power units and the generation from the five most recently built plants. The set of power plants that comprises the larger annual electric power generation, which is the set of power units *m* that comprises the 20% of the system generation, is chosen.
(Set of *m* plants following the "Tool to calculate the emission factor for an electricity system (Version 7.0)).
(MWh)

Calculation of emission factor for set of *m* plants
(CNE reports and IPCC manual)
(tCO_2e/MWh)

Determination of EF_{BM} ("Tool to calculate the emission factor for an electricity system (Version 7.0)", step 4, (a)) as the weighted average emission factor of the dispatched plants and their individual emission factor (tCO_2e/MWh)

The Build Margin emission factor is calculated using the emissions factor estimation mathematical tool as explained above, in accordance with the following equations:

Equation 9. Build Margin Emission factor calculation (TOOL07 (Version 7.0), paragraph 77, equation 15)

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{grid,BM,y}$	=	Build Margin CO_2 emission factor in year y (tCO_2/MWh).
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh).
$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh).
m	=	Power units included in the Build Margin (number).
y	=	Most recent historical year for which power generation data is available at the time of submission of the Project Design Document to the DOE for the renewal of the crediting period.

The CO_2 emission factor of each power unit m ($EF_{EL,m,y}$) should be determined as per the guidance of Step 4 section 6.4.1 of TOOL 7 (Version 7.0) for the simple OM, using Options A1, A2 or A3, using for y the most recent historical year for which electricity generation data is available, and using for *m* the power units included in the Build Margin.

If the power units *m* included in the Build Margin correspond to the sample group $SET_{sample\text{-}CDM\text{->}10yrs}$, then, as a conservative approach, only Option A2 from guidance in Step 4 section 6.4.1 can be used. In such case, the default values provided in Table 2, Appendix of TOOL 09:"Determining the baseline efficiency of thermal or electric energy generation systems Version 3.0" shall be used to determine the parameter $\eta_{m,y}$ for the power units that started to supply electricity to the grid more than 10 years ago.

Option A1. If for a power unit *m* data on fuel consumption and electricity generation is available, the emission factor ($EF_{EL,m,y}$) is determined as follows:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \times NCV_{m,i,y} \times EF_{CO2,m,i,y}}{EG_{m,y}}$$

Where:

$EF_{EL,m,y}$	=	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh).
$FC_{i,m,y}$	=	Amount of fossil fuel type *i* consumed by power unit *m* in year *y* (Mass or volume unit)[14].
$NCV_{m,i,y}$	=	Net calorific value (energy content) of fossil fuel type *i* used in the power unit *m* in year *y* (TJ / mass or volume unit).
$EF_{CO2,m,i,y}$	=	Emission factor of fossil fuel type *i* used in power unit *m* in year *y* (tCO_2/GJ).
$EG_{m,y}$	=	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh).
m	=	Power units included in the Build Margin.
i	=	All fossil fuel types combusted in power unit *m* in year *y*.
y	=	Most recent historical year for which power generation data is available at the time of submission of the Project Design Document to the DOE for the renewal of the crediting period.

Option A2. If for a power unit *m* only data on electricity generation and the fuel types used is available, the emission factor should be determined based on the CO_2 emission factor of the fuel type used and the efficiency of the power unit, using equation 5 of TOOL7 Version 7, as follows:

[14] This parameter is calculated using the power plant's specific fuel consumption and the annual net power generation.

$$EF_{EL,m,y} = \frac{EF_{CO2,m,i,y} \times 3.6}{\eta_{m,y}}$$

Where:

$EF_{EL,m,y\ CO2}$	=	Emission factor of power unit *m* in year *y* (tCO_2/MWh).
$EF_{CO2,m,i,y}$	=	Average CO_2 emission factor of fuel type *i* used in power unit *m* in year *y* (tCO_2/GJ).
$\eta_{m,y}$	=	Average net energy conversion efficiency of power unit *m* in year *y* (ratio).
y	=	Most recent historical year for which power generation data is available at the time of submission of the Project Design Document to the DOE for the renewal of the crediting period.

Where several fuel types are used in the power unit, use the fuel type with the lowest CO_2 emission factor for $EF_{CO2,m,i,y}$.

Option A3. If for a power unit *m* only data on electricity generation is available, an emission factor of 0 tCO_2/MWh can be assumed as a simple and conservative approach.

Project emission reductions

According to the AM0026 Version 3.0, the emission reductions in a year y requires the calculation of the Combined Margin grid emission factor and the total electricity generation of the CDM project power plant in the corresponding year. The following diagram illustrates the steps involved:

Calculation of Combined Margin Emission factor of EF_{BM} and EF_{OM}
(tCO_2e/MWh)

↓

Energy generation of the Lircay CDM project activity
(Project Participant)
(MWh)

↓

Calculation of Baseline Emissions of the Project
(tCO_2e)

↓

Discount any leakage or project activity emissions, if any
(No leakage emission was identified for the Lircay project, and project emissions are null)
(tCO_2e)

The baseline emissions for the project activity are calculated by using the Combined Margin and the electricity exported to the grid by the project plant, as per Equations 2 and 3 previously outlined in this section of the PDD.

Since the Lircay Project activity is a hydro power plant, there are no Project Emissions (PE_y) to account for. Likewise, according to the AM0026 Version 3.0, there is no leakage (L_y) identified for this project activity. The total net emission reductions of the Lircay Project activity are determined using Equation 1, previously outlined in this section of the PDD, and in this case are equal to the baseline emissions. The baseline emissions for the project activity are calculated by using the Combined Margin and the electricity exported to the grid by the project plant, as per Equations 2 and 3 previously outlined in this section of the PDD.

B.6.2. Data and parameters fixed ex-ante

This section includes all the data and parameters that not monitored through the crediting period, mainly related to the Build Margin emission factor, which is calculated ex-ante according to the "Tool to calculate the emission factor for an electricity system Version 7.0". The source for each parameter is presented in Appendix 4 of this PDD.

Data/Parameter	$EG_{m,y}$
Data unit	MWh
Description	Net electricity generated and delivered to the grid by power plant/unit *m* included in the Build Margin calculation in year *y*.
Source of data	Official statistical information from the CEN (year 2019). Available at: https://www.coordinador.cl/reportes-y-estadisticas/
Value(s) applied	See note on Appendix 4 of this PDD.
Choice of data or measurement methods and procedures	This parameter is required for the BM calculation and the data used for its calculation is sourced from the CEN. The CEN provides the most recent and official data available at the time of sending this PDD to the DOE for revalidation.
Purpose of data	Baseline emission calculation.
Additional comment	No additional comments.

Data/Parameter	$EF_{CO2,m,y}$
Data unit	tCO_2/GJ
Description	Average CO_2 emission factor of fuel type *i* used in power unit *m* included in the Build Margin calculation in year *y*.
Source of data	Official statistical information from the "Informe de Precio Nudo (2019)", the "Coordinador Electrico Nacional" (CEN), the National Energy Balance (2018) from the "Comisión Nacional de Energía" (CNE) and the 2006 IPCC Guidelines. The data used corresponds to the most recent information available at the date of sending this PDD to the DOE for revalidation.
Value(s) applied	See note on Appendix 4 of this PDD.
Choice of data or measurement methods and procedures	This parameter is required for the BM calculation. The data used to calculate this parameter is sourced from official and reliable sources: CNE.
Purpose of data	Baseline emission calculation.
Additional comment	No additional comments.

Data/Parameter	$FC_{i,m,y}$
Data unit	For Diesel, Coal: (kg/year), for Natural Gas: (m^3/year). Please see additional comment below.
Description	Amount of fossil fuel type *i* consumed by power plant / unit m included in the Build Margin calculation in year *y.*
Source of data	Official statistical information from the “Informe the Precio Nudo (2019)” from the CNE or by the technical information provided by CEN.
Value(s) applied	See note on Appendix 4 of this PDD.
Choice of data or measurement methods and procedures	Official statistical information from the “Informe de Precio Nudo (2019)”, from the “Comisión Nacional de Energía (CNE)”. The data used corresponds to the most recent information available at the date of sending this PDD to the DOE for revalidation.
Purpose of data	Baseline emission calculation.
Additional comment	This parameter is calculated using the power plant’s specific fuel consumption (SFC) and the annual net power generation.

Data/Parameter	$NCV_{i,m,y}$
Data unit	GJ/mass or volume unit (see comment below).
Description	Net calorific value of fossil fuel type *i* consumed by power plant / unit *m* included in the Build Margin calculation in year *y*.
Source of data	Official statistical information from the National Energy Balance (CNE), year 2018.
Value(s) applied	See note on Appendix 4 of this PDD.
Choice of data or measurement methods and procedures	Official statistical information from the “Comisión Nacional de Energía” (CNE) or from “Coordinador Electrico Nacional “(CEN). The data used corresponds to the most recent information available at the date of sending this PDD to the DOE for revalidation.
Purpose of data	Baseline emission calculation.
Additional comment	Official sources may report this parameter in other units, therefore data conversion may be required in some cases. The CNE Energy Balance Report includes Gross Calorific Values for the different fuels. These values are corrected to Net Calorific Values based on the IPCC 2006 assumption where, Net Calorific Value is 5% lower than its Gross Calorific Value for coal and diesel fuels, and 10% lower for Natural Gas. The official link for the National Energy Balance is: http://energiaabierta.cl/catalogo/balance-energetico/

Data/Parameter	$EF_{BM,y}$
Data unit	tCO_2e/MWh
Description	Build Margin emission factor of the grid to which the project plant is connected.
Source of data	Official statistical information from the CEN. Available at: https://www.coordinador.cl/reportes-y-estadisticas/
Value(s) applied	0.36899 tCO_2e/MWh.
Choice of data or measurement methods and procedures	According to the “Tool to calculate the emission factor for an electricity system Version 7.0”, the Build Margin emission factor for the second crediting period must be updated using the most recent information available at the date of submission of this PDD to the DOE. The data sources are the CNE and the IPCC 2006 Guidelines.
Purpose of data	Baseline emission calculation.
Additional comment	No additional comments.

Data/Parameter	w_{OM}
Data unit	%
Description	Weight for Operating Margin (OM) emission factor.
Source of data	TOOL07: Tool to calculate the emission factor for an electricity system Version 7.0.
Value(s) applied	25%
Choice of data or measurement methods and procedures	According to the TOOL07: Tool to calculate the emission factor for an electricity system Version 7.0, for the second and third crediting periods: w_{OM} = 25% and w_{BM} = 75%.
Purpose of data	Baseline emission calculation.
Additional comment	No additional comments.

Data/Parameter	w_{BM}
Data unit	%
Description	Weight for the Build Margin (BM) emission factor.
Source of data	TOOL07: Tool to calculate the emission factor for an electricity system, Version 7.0.
Value(s) applied	75%
Choice of data or measurement methods and procedures	According to the TOOL07: Tool to calculate the emission factor for an electricity system, Version 7.0, for the second and third crediting periods: w_{OM} = 25% and w_{BM} = 75%.
Purpose of data	Baseline emission calculation.
Additional comment	No additional comments.

B.6.3. Ex-ante calculation of emission reductions

Operating Margin emission factor

AM0026 Version 3.0 calculates ex-post the emission factor for the Operating Margin by observing actual dispatch data, the generation from the power plants and the merit order. The emission factor for the Operating Margin is determined by the generation that would be dispatched in the absence of this CDM Project based on the latest available data at time of submission of the PDD to the DOE, which is year 2019.

An example of the Operating Margin emission factor calculation for the 2,616th hour of the year 2019 is provided below.

In this case the Lircay power plant displaces electricity (11.3 MWh, C_j) from TOCOPILLA-TG3 power plant remaining capacity (A_i – B_i). This displacement ($D_{j,i}$) is multiplied by the TOCOPILLA-TG3 power plant emission factor (d_i) to calculate the amount of displaced CO_2 in this hour.

Lircay run of the river	**TOCOPILLA-TG3 power plant displaced**
C_j (MWh)	A_i - B_i (MWh)
11.3	36,1
D(j,i) (MWh)	d_i (tCO_2e/MWh)
11.3	0.9316
*D(j,i)**d_i (tCO_2e)	
10.528	

As can be seen from the table above and according to Equation 5, the emission factor is calculated as follows:

$$EF_{j,h=2,616} = \frac{11.3\ \times 10.528}{11.3} = 10.528(\frac{tCO_2e}{MWh})$$

Based on Equation 4, by replying the previous calculation for every hour of the year the result for the Operating Margin emission factor calculation is:

$EF_{OM,y}$ (tCO_2/MWh)
0.72016

For a complete and step by step calculation of the $EF_{OM,y}$ value, please refer to the emission factor calculation spreadsheet, provided to the DOE for the revalidation of the Lircay CDM project activity.

Build Margin Emission Factor Calculation

As explained in section B.6.1, the Build Margin must be calculated be calculated with Option (i) of the approved baseline methodology AM0026 Version 3.0, i.e. as described in the “Tool to calculate the emission factor for an electricity system Version 7.0”. According to this tool, for the second crediting period the Build Margin must be updated using the most recent information on units already built at the time of submission of the request for renewal of the crediting period to the DOE. In this case, the most recent information available for the BM calculation corresponds to 2019 data.

The sample group m of power units to be included in the Build Margin considers the set of capacity additions in the electricity system that comprises 20% of the system generation built most recently. This corresponds to Option (b) of Step 5: “Identify the group of power units to be included in the Build Margin” from the “Tool to calculate the emission factor for an electricity system Version 7.0”. This option is chosen because it comprises a larger annual generation compared to the power generation of the five plants build most recently.

The set of power plants m most recently incorporated in the system that account for 20% of the total power generation in 2019 corresponds to 303 power plants. These power plants were commissioned between the years 2014 and 2019, so there are no power plants older than 10 years. Besides, all information related to power generation and fuel consumption was available for the m power plants considered in the BM calculation, so option A1 of Step 4 of the “Tool to calculate the emission factor for an electricity system Version 7.0” was used.

Considering the large number of power plants that comprise the set of m power plants involved in the 2019 Build Margin calculation, all the information related to these plants is shown separately in the BM calculation Excel spreadsheet. The 2019 Build Margin used for the entire second crediting period is shown below:

$EF_{BM,y}$ (tCO_2/MWh)
0.36899

Combined Margin Emission Factor Calculation

According to Equation 3, the Combined Margin emission factor is calculated as follows:

$$EF_{CM,} = 0.25 * 0.72016 + 0.75 * 0.36899 = 0.45678\ (tCO_2/MWh)$$

As a result,

$EF_{CM,y}$ (tCO_2/MWh)
0.45678

As mentioned before, w_{OM} and w_{BM} values were determined in accordance with the “Tool to calculate the emission factor for an electricity system (Version 7.0)” for the second crediting period.

B.6.4. Summary of ex-ante estimates of emission reductions

Year	Baseline emissions (t CO_2e)	Project emissions (t CO_2e)	Leakage (t CO_2e)	Emission reductions (t CO_2e)
04/08/2016 – 31/12/2016	24,263	0	0	24,263
01/01/2017 – 31/12/2017	59,381	0	0	59,381
01/01/2018 – 31/12/2018	59,381	0	0	59,381
01/01/2019 – 31/12/2019	59,381	0	0	59,381
01/01/2020 – 31/12/2020	59,381	0	0	59,381
01/01/2021 – 31/12/2021	59,381	0	0	59,381
01/01/2022 – 31/12/2022	59,381	0	0	59,381
01/01/2023 – 03/08/2023	35,118	0	0	35,118
Total	415,667	0	0	415,667
Total number of crediting years	7			
Annual average over the crediting period	59,381	0	0	59,381

B.7. Monitoring plan

B.7.1. Data and parameters to be monitored

Data/Parameter	$Generation_y$ (or $Generation_{j,h}$)
Data unit	MWh
Description	Energy Generation of the Project for each hour *h.*
Source of data	On-site metering system (same data submitted to the CEN).
Value(s) applied	14.84 (MWh/h) or 130,000 (MWh/yr), which is the same value used to estimate the emission reductions of the project activity.
Measurement methods and procedures	Electronic measurement system each 15 minutes and integrated hourly for recording and submitting to the CEN. Verification procedures shall be applied based on redundant energy meters.
Monitoring frequency	Hourly.

QA/QC procedures	The meter shall have a maximum error of 0.2% according to NCh 2542 official standard, and will be calibrated every two years through independent certified entities (see Appendix 4). As per the Technical Annex "System Measurement for Economical Transfers", included in the Security and Quality of Service Technical Norms published by the National Energy Commission, CEN has direct access to all measuring equipment in the system, including the Lircay Power Plant meters, Metering data and performs regular and independent interrogation through the PMRTE platform. The metering information of the PMRTE platform is the official data used by CEN to perform energy transactions among power generators in the system. As stated in Article 20 of the Technical Annex, a periodic verification of metering equipment is required every 3 years for equipment older than 10 years. The verification must be executed by an independent and accredited third party. The Technical Annex is available at: https://www.cne.cl/normativas/electrica/normas-tecnicas/ under section: "Norma Técnica de Seguridad y Calidad de Servicio" / "Anexo Técnico: Sistema de Medidas para Transferencias Económicas".
Purpose of data	Calculation of baseline emissions.
Additional comment	The total energy of the period $Generation_y$, equivalent to the sum of all $Generation_{j,h}$ shall be crosschecked with CEN official data from PMRTE platform (https://medidas.coordinador.cl/registro/).

Data/Parameter	$EF_{j,h}$
Data unit	tCO_2e/MWh
Description	Operating Margin emission factor for proposed CDM project *j* for hour *h.*
Source of data	Calculated according to AM0026 Version 3.0, using CEN data, CNE data and the latest IPCC guidelines.
Value(s) applied	Values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Calculated annually for each hour, according to AM0026 Version 3.0 procedures.
Monitoring frequency	Annually for each hour.
QA/QC procedures	Automatic calculation procedure through a revised worksheet. Calculation should be done after CEN energy balance in order to ensure data accuracy.
Purpose of data	Calculation of baseline emissions.
Additional comment	No comments.

Data/Parameter	$D_{(j,i)}$
Data unit	MWh
Description	Energy displacement of the marginal plant "*i*" due to proposed CDM project "*j*".
Source of data	Official data from the CEN.
Value(s) applied	Calculation according to AM0026 Version 3.0 guidelines. Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Calculated hourly from the CEN dispatch data and AM0026 Version 3.0 procedures.
Monitoring frequency	Hourly.
QA/QC procedures	Automatic calculation procedure through a revised worksheet. Calculation should be done after CEN energy balance in order to ensure data accuracy.
Purpose of data	Calculations of baseline emissions.
Additional comment	No comments.

Data/Parameter	d_i

Data unit	tCO_2e/MWh
Description	Emission factor of the marginal plant *i*.
Source of data	CEN, CNE and the latest IPCC Guidelines.
Value(s) applied	Calculation according to AM0026 Version 3.0 guidelines. Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Hourly calculation based on procedures described in the AM0026 Version 3.0 methodology using official data from CNE's, CEN and the latest IPCC Guidelines.
Monitoring frequency	Hourly.
QA/QC procedures	Calculation based on official data. Verification procedure shall be applied based on historical data of power plants per fuel type.
Purpose of data	Calculations of baseline emissions.
Additional comment	No comments.

Data/Parameter	***SFC_i***
Data unit	TJ/MWh (see comment below).
Description	Specific fuel consumption per unit of electric energy produced in the "*i*" marginal power plant.
Source of data	CEN technical information repository and CNE Node Price Report.
Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Calculation based on official data.
Monitoring frequency	Annually.
QA/QC procedures	Verification procedure shall be applied based on historical data per fuel type. Estimation shall be calculated annually or twice a year.
Purpose of data	Calculations of baseline emissions.
Additional comment	It must be noted that in some cases values from official sources may be reported in other units. For example: dam^3/MWh, ton/MWh, or others. As the data unit needed for the calculation is TJ/MWh, the net calorific value of fossil fuel type *'i'* in year *'y'* ($NCV_{i,y}$) will be used if necessary. This parameter is also included in this section.

Data/Parameter	***M***
Data unit	Number.
Description	Number of power plants on the margin that would supply power to the grid in the absence of the CDM projects operating in the system.
Source of data	Data from the CEN.
Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Calculation according to AM0026 Version 3.0 guidelines, using data from the CEN.
Monitoring frequency	Hourly.
QA/QC procedures	An electronic worksheet will be developed in order to deliver automatic calculations of this parameter.
Purpose of data	Calculations of baseline emissions.
Additional comment	No comments.

Data/Parameter	***N***
Data unit	Number.
Description	Total number of CDM projects that operate in the grid, where N is the first built CDM power plant and 1 is the last CDM power plant built in the system.
Source of data	CEN and UNFCCC CDM list of registered CDM projects consisting of grid-connected power plants that operate in Chile.

Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Data obtained directly from the CEN and UNFCCC.
Monitoring frequency	Hourly.
QA/QC procedures	Data will be obtained from official reports.
Purpose of data	Calculations of baseline emissions.
Additional comment	No comments.

Data/Parameter	C_j
Data unit	MWh
Description	Electricity generated by the "*j*" CDM power plant during hour *h*.
Source of data	Data from the CEN.
Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Calculated hourly from the CEN dispatch data and AM0026 Version 3.0 procedures.
Monitoring frequency	Hourly.
QA/QC procedures	The data will be obtained from the CEN official databases.
Purpose of data	Calculations of baseline emissions.
Additional comment	No comments.

Data/Parameter	A_i
Data unit	MWh
Description	Generation capacity of the "*i*" power plant on the margin during hour *h.*
Source of data	Data from the CEN.
Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Calculation according to the AM0026 Version.3.0 guidelines, with CEN data.
Monitoring frequency	Hourly.
QA/QC procedures	An Excel worksheet will be developed to deliver automatic calculations based on the CEN databases.
Purpose of data	Calculations of baseline emissions.
Additional comment	No comments.

Data/Parameter	B_i
Data unit	(MWh)
Description	Electricity generated by the "*i*" power plant on the margin during hour *h*.
Source of data	Data from the CEN.
Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Determined according to AM0026 Version 3.0 procedures using data from the CEN.
Monitoring frequency	Hourly.
QA/QC procedures	Data is obtained directly from the CEN.
Purpose of data	Calculations of baseline emissions.
Additional comment	No comments.

Data/Parameter	***Plant name***
Data unit	Text

Description	Identification of power sources.
Source of data	Data from the CEN.
Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Determined from the CEN databases, as new power plants are available in the system.
Monitoring frequency	Annually.
QA/QC procedures	Based on the CEN identification names. A revised worksheet is used to properly identify each plant name on the system.
Purpose of data	Calculations of baseline emissions.
Additional comment	No comments.

Data/Parameter	$CEF_{OM,i}$
Data unit	tCO_2 per ton of fuel or TJ.
Description	CO_2 emission factor of fuel used in the i^{th} marginal power plant of the Operating Margin cohort.
Source of data	IPCC 2006 Guidelines.
Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Determined from IPCC guidelines according to AM0026 Version 3.0 procedures.
Monitoring frequency	Annually reviewed.
QA/QC procedures	Direct official IPCC data is used.
Purpose of data	Calculations of baseline emissions.
Additional comment	Note that since the BM emission factor is calculated ex-ante, this parameter is monitored annually only for the Operating Margin calculation.

Data/Parameter	$Oxid_i$
Data unit	%
Description	Fraction of fuel oxidized on combustion.
Source of data	IPCC Guidelines 2006.
Value(s) applied	100% for all fossil fuels.
Measurement methods and procedures	Determined from IPCC guidelines following AM0026 Version 3.0 procedures.
Monitoring frequency	Annually reviewed.
QA/QC procedures	Official data from the IPCC.
Purpose of data	Calculation of baseline emissions.
Additional comment	No additional comments.

Data/Parameter	$NCV_{i,y}$
Data unit	GJ/mass or volume unit (see comment below).
Description	Net calorific value of fossil fuel type "*i*" in year *y*.
Source of data	Annual Energy Balance Report from CNE and IPCC 2006.
Value(s) applied	Used values available in the OM calculation Excel spreadsheet. See note on Appendix 4.
Measurement methods and procedures	Determined directly from the CNE official data for national energy inventory and the IPCC.
Monitoring frequency	Annually.
QA/QC procedures	Official data from CNE and IPCC.
Purpose of data	Calculation of baseline emissions.

Additional comment	Official sources may report this parameter in other units, therefore data conversion may be required in some cases. The CNE Energy Balance Report includes Gross Calorific Values for the different fuels. These values are corrected to Net Calorific Values based on the IPCC 2006 assumption where, Net Calorific Value is 5% lower than its Gross Calorific Value for diesel and coal fuels and 10% lower for Natural Gas. The official link for the National Energy Balance is: http://energiaabierta.cl/catalogo/balance-energetico/

Data/Parameter	$EF_{OM,y}$
Data unit	tCO_2e/MWh
Description	Operating Margin emission factor for year *y*.
Source of data	Calculated according to AM0026 Version 3.0, using CEN data.
Value(s) applied	0.72016 tCO_2/MWh
Measurement methods and procedures	Annual calculation according to AM0026 Version 3.0 procedures.
Monitoring frequency	Annually.
QA/QC procedures	Automatically calculated from CEN databases and AM0026 Version 3.0 procedures. Calculation should be done after the CEN makes the data official for validation purposes.
Purpose of data	Calculation of baseline emissions.
Additional comment	No additional comments.

Data/Parameter	EF_y
Data unit	tCO_2e/MWh
Description	CO_2e emission factor of the displaced energy from the grid.
Source of data	Calculated according to AM0026 Version 3.0.
Value(s) applied	0.45678 tCO_2e/MWh
Measurement methods and procedures	Calculated according to AM0026 Version 3.0 procedures.
Monitoring frequency	Annually.
QA/QC procedures	Automatic calculation through a revised worksheet.
Purpose of data	Calculation of baseline emissions.
Additional comment	No additional comments.

B.7.2. Sampling plan

Not applicable in this case.

B.7.3. Other elements of monitoring plan

The monitoring methodology determines the baseline emissions by observing the actual power dispatch data from CEN Dispatch Center and the official expansion plan provided by CNE. Refer to section B.6.1 for formulae reference.

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 CEN Dispatch Center).
- Public data on dispatch of electricity and other relevant information from the CEN Dispatch Center. This data is used to calculate the emission factor for the Operating Margin based on a dispatch increment analysis.
- Emission Factors for every thermal power plant that operates in the SEN system.

- Fuel Specific Consumption for every power plant: Semi-annual CNE Node Price Report and/or other official sources.
- Calorific Content of every Fuel: CNE National Energy Balance.
- Fuel Carbon Content: IPCC Guidelines.
- Combustion Efficiency: IPCC Guidelines.

All data monitored and required for verification and issuance are to be kept for two years after the end of the crediting period or the last issuance of CERs for this project activity, whichever occurs later.

The marginal plant(s) are identified using the merit order and the official marginal price for that hour.

1. Data Processing for Emission Reduction calculation

Step 1. Calculation of Operating Margin Emission Factors

The next diagram shows the complete process for calculating the Operating Margin emission factor for the Lircay hydroelectric power plant:

Net hourly generation output from the CDM project activity and all other units in the system. (MWh)

↓

Analysis of hourly dispatch data from all units of the SEN to determine the marginal power plant(s) not dispatched (or displaced) due to dispatch of all existing CDM projects. (CEN hourly data).

↓

Calculation of emission factor of all operational units of the system. (CNE report and latest IPCC Guidelines following AM0026 Version 3.0 procedures). (tCO_2e/MWh).

↓

Determination of the marginal plants and energy being displaced due to the operation of the CDM Project Activity following the "first-built first-served" principle[15] stated on AM0026 Version 3.0. (MWh and tCO_2e/MWh).

↓

Determination of $EF_{OM,y}$ of each CDM project as the weighted average emission factor of the Marginal Plant(s) not dispatched (or displaced) by each CDM Project Activity. (tCO_2e/MWh).

Step 2 – Calculation of the Baseline Emissions Reductions

According to AM0026 Version 3.0 baseline methodology, the Combined Margin grid emission factor (CM) is calculated as the weighted average of the Operating Margin (OM) and the Build Margin (BM). As stated before, the Build Margin is calculated in this PDD using the latest information available at the date of submitting the PDD to the DOE and remains fixed for the second crediting period.

Please refer to section B.6.1 of this PDD for the formulas used to calculate the baseline emission reductions in this PDD.

[15] The "first-built first-served" principle means that the "last" plant existing in the grid, that would have been dispatched to meet the electricity requirement fulfilled by all the CDM projects in the grid is considered to be displaced due to introduction of the first CDM project built in the system. Similarly the first marginal plant is considered to be displaced by the CDM plant built last. Note that all CDM projects (even projects adopting other methodologies) must be considered.

Calculation of the Combined Margin emission factor using $EF_{grid,BM,y}$ and $EF_{OM,y}$ (tCO_2e/MWh)

↓

Energy generation of the Lircay CDM project activity
(from CEN or metering data)
(MWh)

↓

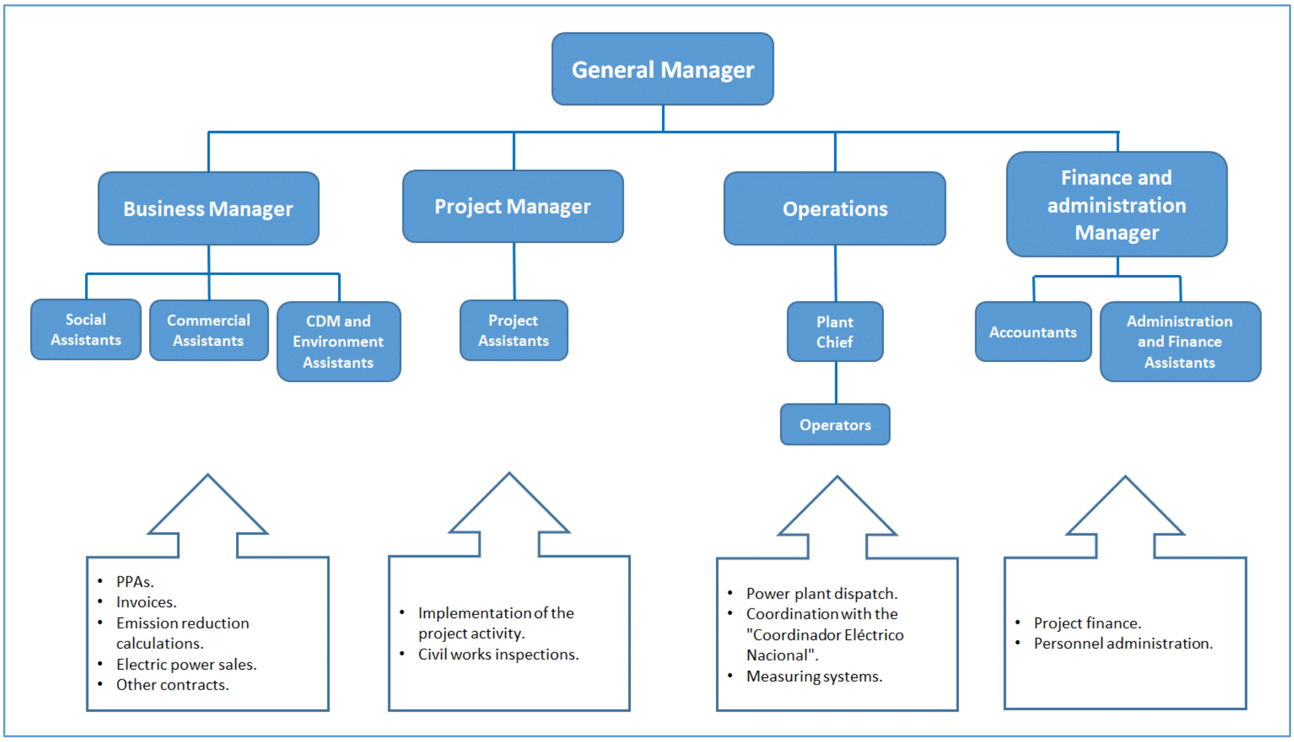
Calculation of Baseline Emissions
(tCO_2e)

↓

Discount any leakage or project activity emissions, if any
(No leakage and project emissions were identified for the Lircay CDM project activity)
(tCO_2e)

2. Operational and Management structure

In order to secure a correct emission reduction calculation for the Lircay project activity, the project owner will implement and maintain the following management structure:



Hidromaule S.A. will designate a competent manager who will be in charge of supervising all aspects related to the calculation of the GHG emission reductions of the project activity. This includes monitoring, record keeping, computation of emission reductions, audits and verification. An operations manager will be in charge of all plant production and maintenance activities. A business manager will be in charge of Power Procurement Agreements (PPA), Emission Reduction Purchase

Agreements (ERPA) and other related commercial activities related to this kind of project and fulfill all social and environmental obligations associated to the power plant. A project manager will be in charge of developing the project in accordance with the detail engineering and all environmental obligations relative to the project activity.

It must be noted that the management structure may vary on time, as it normally happens with any management structure, however, it will maintain all relevant tasks required to ensure proper operation and monitoring procedures related to the calculation of GHG emission reductions described on this PDD.

SECTION C. Start date, crediting period type and duration

C.1. Start date of project activity

The project start date is 31/01/2007.

C.2. Expected operational lifetime of project activity

The operational lifetime of run-of-river hydropower plants is estimated over than 40 years and 0 months[16]. Therefore the project seeks a 7 year, twice renewable crediting period (total 21 years).

C.3. Crediting period of project activity

C.3.1. Type of crediting period

Renewable, second crediting period.

C.3.2. Start date of crediting period

The start date of the second crediting period is 04/08/2016.

C.3.3. Duration of crediting period

The duration of the second crediting period is 7 years and 0 months.

SECTION D. Environmental impacts

D.1. Analysis of environmental impacts

The Lircay project activity does not cause relevant impacts to the environment. All project objections were duly assessed and officially cleared up by COREMA in a meticulous way. Specific measures were considered for soil, natural watercourses, transport, risk and emergency control, specially fire and spills.

[16] The project feasibility study considered a lifetime of 40 years (see Table B.3). However, as stated in section 3.4 of the project's environmental approval (RCA – Exempt Resolution N°414, Comisión Regional del Medio Ambiente, Region del Maule, 03/11/2006), the project should have an even longer lifetime (over 50 years) (see :

https://seia.sea.gob.cl/documentos/documento.php?idDocumento=1805021)

Lircay run-of-river Project does not entail any physical construction such as dams and dikes, or cause reservoir-like impoundments on the Lircay River or any of its branches.

D.2. Environmental impact assessment

Following article 10, letter c) of the Environmental Law Nº19.300 (Ley sobre Bases Generales del Medio Ambiente), and article 3, letter c) of its Regulation (Supreme Decree N°95 of 2001, Reglamento del Sistema de Evaluación de Impacto Ambiental - RSEIA), all energy generation projects having more than 3 MW of installed capacity, must meet the terms of Environmental Impact Evaluation System (SEIA). Further, section II, article 8 of the Environmental Law 19.300 indicates that this kind of projects will not be able to be executed or modified if they do not have the subsequent approval of the Environmental Qualification Resolution (R.C.A. in Spanish).

According the previous paragraph, Lircay run-of-river Project was submitted to the SEIA through an Environmental Impact Declaration (DIA in Spanish), not requiring an Environmental Impact Assessment (EIA in Spanish). The project has little impacts and does not present any of the effects, characteristics or circumstances stated the Article 11 of the Environmental Law 19.300, thus it was not required to enter the project through a full Environmental Impact Assessment (EIA).

The Lircay run-of-river Project RCA was approved on 03/11/2006 (Resolución Exenta Nº 414 COREMA VII Región del Maule), fulfilling all environmental requirements.

Lircay run-of-river Project DIA discusses a wide range of environmental impacts during the construction, operation and end of the project operation, such as: land use, air quality, noise emissions, solid emissions, liquid emissions, etc. It identifies the risk or contingency zones and the type of risk associated to them. It also discusses a number of corrective measures and establishes an environmental management plan to deal with the identified impacts. This plan addresses the significant and medium impacts providing measures for their mitigation, restoration or compensation. In general terms, the project states that:

- The project will not entail any health risks to the surrounding population, related to the quantity and quality of liquid and solid emissions during the construction and operation stages (article 5 RSEIA).
- The project will not entail adverse effects over the quantity and quality of the natural renewable resources, including land, water and air (Article 6 SEIA).
- The project will not entail emissions that may cause health risks or adverse effects over natural sources (Article 7 RSEIA).
- The project will not entail human resettlement nor any significant alteration of actual human living conditions or cultural groups (Article 8 RSEIA).
- The project will not be placed near any population, protected sources or areas that may be affected. And will not affect the environmental value of the place where the project will be built (Article 9 RSEIA).
- The project will not entail any significant change in terms of magnitude and duration of the touristy and land sight in the surrounding zones (Article 10 RSEIA).
- The project will not entail any changes of monuments, sites with anthropological, archaeological or historic value or, in general, those belonging to cultural heritage (Article 11 RSEIA).
- The Lircay run-of-river Project uses the same civil works and water handling of Asociación Canal Maule (ACM), following the national water authority (D.G.A.) resolution N°105 of 19/04/1983, without affecting in any way the water rights of ACM irrigators downstream. All water uses are governed by a private contract between ACM and Hidromaule S.A.

There is no minimum ecological flow considered for this project activity since waters come from consumptive water rights for irrigation purposes, conducted through existing artificial civil works with no river bed intervention.

SECTION E. Local stakeholder consultation

E.1. Modalities for local stakeholder consultation

The Lircay run-of-river Project SEIA project file can be publicly accessed through CONAMA website at www.e-seia.cl containing all project details and the official environmental qualification.

http://www.e-seia.cl/expediente/expediente.php?id_expediente=1578767

E.2. Summary of comments received

Local Authorities:

In compliance with the Chilean Environmental Law 19.300 and the SEIA procedures, the project's DIA collected opinions and information from all relevant authorities selected by COREMA, in consideration to their legal relation to identified impacts of the project. The following authorities were invited and selected by the COREMA:

- CONAMA VII, Región del Maule.
- Dirección General de Aguas Región del Maule.
- Servicio Nacional de Geología y Minería Zona Sur.
- Superintendencia de Electricidad y Combustible, Región del Maule.
- Dirección de Obras Hidráulicas DOH, Región del Maule.
- SEREMI MOP, Región del Maule.
- Servicio Nacional de Turismo, SERNATUR, Región del Maule.
- Dirección Regional de Vialidad, Región del Maule.
- SEREMI de Vivienda y Urbanismo.
- Corporación Nacional Forestal CONAF, Región del Maule.
- Consejo de Monumentos Nacionales.
- Servicio Agrícola Ganadero SAG, Región del Maule.

Local Community:

Chilean Environmental Law 19.300 does not include officially community participation for D.I.A. procedures (differing form the E.I.A. procedures). However, any person has the right to present petitions and clarifications to the authority of any public or private interest matter. Consequently, anyone could send their opinion or questions to the projects DIA, regardless the merit that the legal authority must apply on them for the RCA approval.

In the case of Lircay run-of-river Project, the community mostly affected by the Project is essentially the same community of Asociación Canal Maule (ACM), conformed by nearly 2,200 irrigators. On May 2005, 2006 and 2007 board committees where organized exposing the Project to all participants, where the project was presented and approved, and its water rights have been ratified by the irrigators.

E.3. Consideration of comments received

Comments received relate mainly to the following aspects: land use and treatments, hydrological resources, debris management, irrigation management during construction stage, level improvement, rubble movement, etc.

Details of each of the comments received can be obtained directly from the SEIA process at CONAMA's web site.

http://www.e-seia.cl/expediente/expediente.php?id_expediente=1578767

SECTION F. Approval and authorization

Hidromaule S.A. is a Project Participant in the Chile: Lircay Run-Of-River Project activity and has been duly authorized by the Host Party (Chile) involved in the project activity. Both, the letter of approval and authorization can be found in the Providencia CDM web page, available in the following link: https://cdm.unfccc.int/Projects/DB/DNV-CUK1235737024.56/view

Appendix 1. Contact information of project participants

Organization name	Hidromaule S.A.
Country	Chile
Address	Av. Presidente Kennedy 5454, Of. 1601, Vitacura.
Telephone	56-2-9635200
Fax	56-2-9635200
E-mail	jmcontardo@hidromaule.cl
Website	http://www.hidromaule.cl/en
Contact person	Mr. José Manuel Contardo

Organization name	C-Quest Capital LLC
Country	Netherlands
Address	1211 Connecticut Ave., NW - Suite 800 20036 Washington, DC United States of America
Telephone	+1 (202) 416-2400
Fax	
E-mail	
Website	https://cquestcapital.com/
Contact person	Kenneth Newcombe

Appendix 2. Affirmation regarding public funding

There is no public funding in the projects. The fund used to financing is not diversion of ODA.

Appendix 3. Applicability of methodologies and standardized baselines

There is no further information on applicability of methodologies or standardized baselines.

Appendix 4. Further background information on ex-ante calculation of emission reductions

For calculating the emission factor of thermal power plants in the Sistema Eléctrico Nacional (SEN), the following information sources are used:

- Specific fuel consumption for every power plant: Semi-annual CNE Node Price Report and/or other official sources such as CEN data.
- Calorific content of every fossil fuel type: CNE National Energy Balance and/or CEN data.
- Fuel Carbon content: IPCC Guidelines.
- Combustion efficiency: IPCC Guidelines.

Note: During the last years the number of power plants operating in the SIC, SING (and now the SEN) interconnected system has increased significantly, to the point that now there are more than 500 power plants operating in the SEN system. This makes it impractical to show the data used for the calculation of the OM and BM grid emission factors in this section of the PDD, therefore the Project Participant will include two Excel spreadsheets containing all the information and formulas used to calculate these emission factors.

- **OM calculation Excel spreadsheet:** Contains the data, formulas and algorithms used for the calculation of the OM grid emission factor, in accordance with the AM0026, Version 3.0 baseline methodology.

- **BM calculation Excel spreadsheet:** Contains the data and formulas used for the calculation of the Build Margin grid emission factor, in accordance with the AM0026, Version 3.0 baseline methodology.

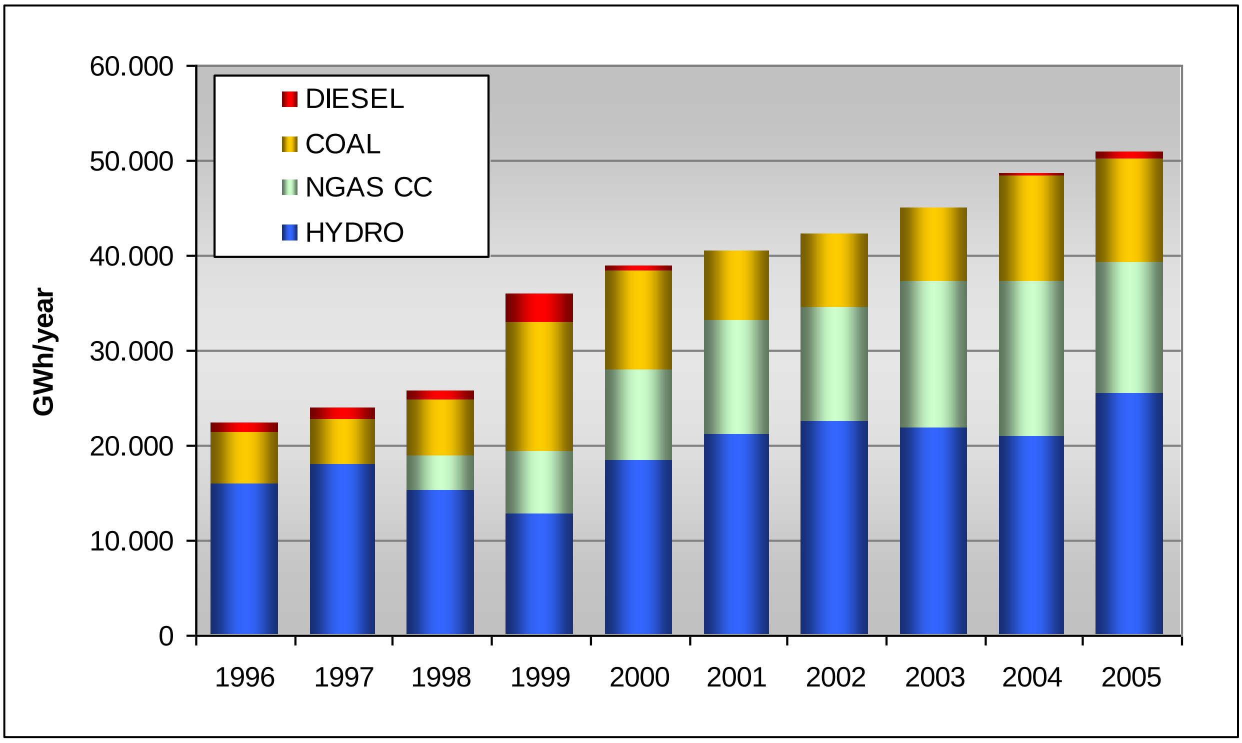
The following information provides additional data and sources, which are relevant for the project activity baseline emission reduction calculation. It must be noted though, that this information refers to the time in which the first PDD of the Lircay project activity was written, so it does not correspond to current information.

National and Electric power Sector background

To meet its growing energy demand (approximately 7% 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% 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. In 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 Energy and the specialized agencies the National Energy Commission and the Superintendence of Electricity and Fuels.

Chile Annual Energy Demand Through 1996 to 2005

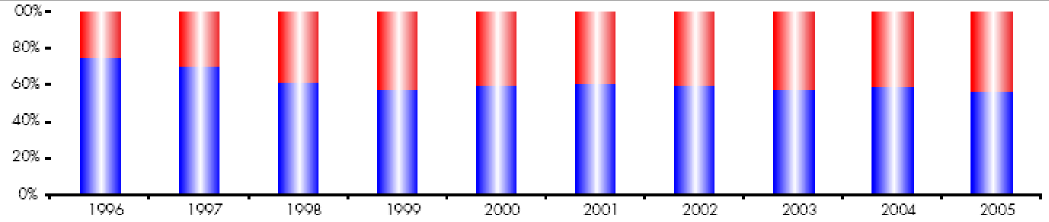


Source: CNE.

Chile consumed nearly 50,000 GWh of electricity in 2004, from this figure, almost 21,000 GWh was hydropower energy. About 38% of Chile's installed power generation capacity is hydroelectric, which is mainly concentrated in the central grid (SIC) representing nearly 60% of SIC’s capacity. 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 export 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% to 21 US$/MWh in 1997).

Chile SIC Power Capacity Evolution Through 1996 to 2005

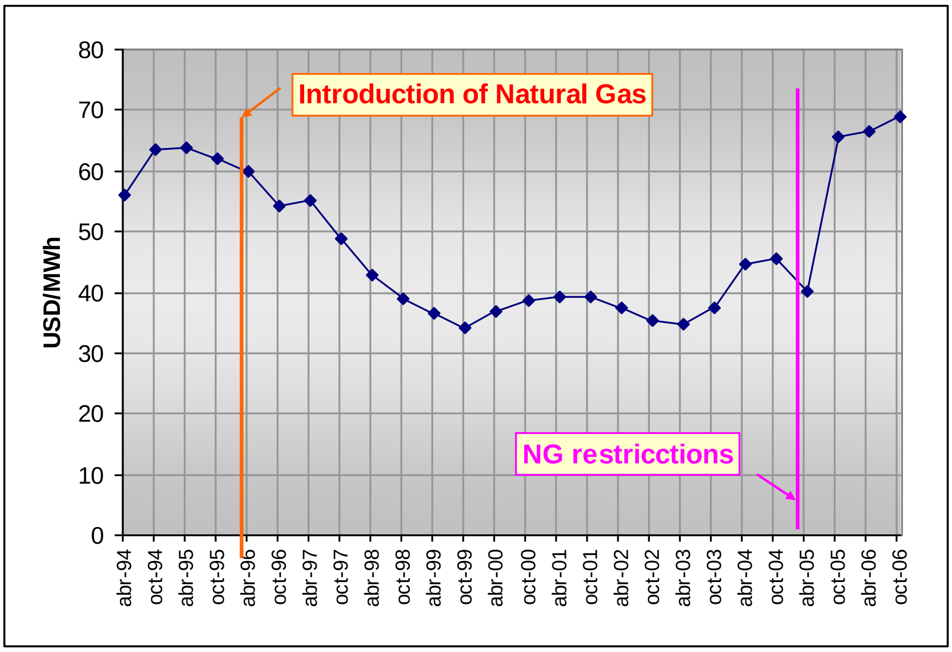


	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
TOTAL[MW]	**4.858,5**	**5.266,8**	**6.242,4**	**6.695,1**	**6.652,8**	**6.579,2**	**6.737,2**	**6.996,2**	**7.867,4**	**8.259,8**
TÉRMICO	1.191,9	1.562,2	2.350,8	2.788,8	2.622,5	2.548,9	2.681,9	2.940,9	3.172,1	3.565,0
	24,5%	29,7%	37,7%	41,7%	39,4%	38,7%	39,8%	42,0%	40,3%	43,2%
HIDRÁULICO	3.666,6	3.704,6	3.891,6	3.906,3	4.030,3	4.030,3	4.055,3	4.055,3	4.695,3	4.694,8
	75,5%	70,3%	62,3%	58,3%	60,6%	61,3%	60,2%	58,0%	59,7%	56,8%

While only an estimated 13% of hydroelectric potential is by now being used, large viable sites are far from Santiago (which represents 40% 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.

In mid-2004 Chile was affected by a natural gas shortage due to Argentina unilateral restrictions on gas supply. The restriction commenced with slight restrictions, however this became more critical on late 2005 once it was evident that the shortage had no easy solution in the short and midterm. Since most of the expansion of the system was based on NG after 1996, the Chilean grids had to react increasing the energy prices in order to avoid midterm energy shortages.

CNE Monomic Node Prices 1996 to 2006



Source: CNE node price reports and bls.gov CPI adjustment.

In October 2005 Node Price fixation returned monomic prices to levels similar to those before the natural gas introduction, adjusting the system to the new fuel availability conditions. Subsequent fixations by CNE in 2006 kept node energy prices around 50 USD/MWh.

Electric Power Sector barriers

No concession is required to become a generator and there is no formal 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 Aysén Grid and the Magallanes Grid. These four grids are not interconnected to each other[17]. Private sector power transmission companies transmit electricity sold by the generation companies to power distribution companies, regulated and unregulated customers and other power generation companies. According to the last official demographic study 2002 (www.ine.cl), the central grid (SIC) serves over 92% of Chile's population and more than 40% of the land area. The northern grid (SING) is mainly thermal and serves mostly mineral-processing centers in the region and the Aysén and the Magallanes systems in the south of the country serve remote areas with a combined capacity of about 1% of the total. Coordination within each system is carried out by the Economic Dispatch Center (CDEC), an autonomous entity composed of members from all companies within each system to ensure efficiency and security of the electric system. Aside from these four grids, "self-producers" account for about 12% of national power generation.

[17] As previously mentioned, this changed in 2017, with the interconnection of the SIC and SING grid, generating the SEN transmission grid.

Electric power sector institutions:

- **CDEC**: The economic load dispatch center in each grid is controlled by a private, independent entity CDEC (*Centro de Despacho Económico de Carga*), composed mainly of representatives of generation and transmission companies, but its operation is fully regulated by law and supervised by the CNE and the *Superintendencia de Electricidad y Combustibles* (SEC), both described below. The CDEC is in charge of planning the optimum operation of the system, based on lowest marginal costs and its security, 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 SIC Grid) 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. The CDEC-SIC is a private entity composed of representatives of generation, transmission and distribution companies, independent from the Government. All generating plants supplying electricity to the system, including Lircay Hydroelectric Plant, are under CDEC-SIC operating supervision and are obliged to perform its dispatch instructions.[18]

- **CNE:** *Comisión Nacional de Energía.* The sector is regulated by an autonomous agency, 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 Energy**: In the area of the power sector, the Ministry of Energy 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.

[18] After the interconnection of the SIC and SING transmission grids in 2017, the two respective dispatch centers (CDEC-SIC and CDEC-SING) were merged into the "Coordinador Eléctrico Nacional Dispatch Center" which is in charge of the operation of the former systems. This new dispatch centers is called "CEN Dispatch Center".

Appendix 5. Further background information on monitoring plan

THE MONITORING AND VERIFICATION PROTOCOL (MVP)

1.0. Purpose of the MVP

In the context of the Clean Development Mechanism (CDM) of the Kyoto Protocol, monitoring describes the systematic surveillance of a project's performance by measuring and recording performance-related indicators relevant to the project or activity. Verification is the periodic auditing of monitoring results, the assessment of achieved emission reductions (ER) and of the project's continued conformance with all relevant project criteria.

This Monitoring and Verification Protocol (MVP) defines a standard against which the project performance in terms of its greenhouse gas (GHG) reductions and conformance with all relevant Clean Development Mechanism (sustainable development) criteria will be monitored and verified. As such, the MVP, after its validation, will be an integral part of the contractual agreement between the Project Sponsor, the Project Operator and the ERs Buyer(s). The MVP builds on the baseline scenario identified in the Baseline Study and is fully consistent with the Baseline Study.

The MVP is a working document that identifies the key project performance indicators and sets out the procedures for tracking, monitoring, calculating and verifying the impacts of the project, in particular with respect to the project’s ERs. The MVP must be used throughout the life of the project.

Specifically, the MVP provides the requirements and instructions for:

- Establishing and maintaining the appropriate monitoring system including spreadsheets for the calculation of emission reductions.
- Checking whether the project meets key sustainable development indicators.
- Implementing the necessary measurement and management operations.
- Preparing for the requirements of independent, third party verification and audits.

The MVP can be updated and adjusted to meet operational requirements, provided such modifications are approved by the verifier during the process of initial or periodic verification. In particular, any shifts in the applicable baseline that are identified by following this MVP may lead to such amendments, which may be mandated by the verifier.

2.0. Concepts and Principle Assumptions

2.1. The Lircay run-of-river Project Activity

The Lircay power plant (the Project Activity), consists of a run-of-river power plant of 19 MW capacity that utilizes the waters of the Maule Norte Bajo canal. The project developer and operator (the Project Operator) is Hidromaule S.A.

Being a CDM activity, Lircay run-of-river Project must meet the requirements of the Kyoto Protocol Art. 12 for CDM projects. The methodology for carrying this out and the monitoring and verification protocol for establishing the emission reduction are provided in this document.

2.2. Emission reductions from the Project Activity

As indicated in the Baseline Study, the actual emission reduction generated by the project activity will depend on the actual dispatch data from the CEN dispatch center.

2.3. Geographic and System Boundaries for the MVP

The Baseline Study defines the project boundary to correspond to the SEN grid for identifying potential emissions and leakage during the Projects lifetime.

The Baseline Study has not found leakage to be a problem for the project as the project is a closed system. Therefore, the MVP does not correct the calculated emission reductions to account for leakage.

2.4. Time Boundary and Baseline Review Protocol

The Baseline Study has opted for a 7-year renewable baseline (for a total crediting period of 21 years) for which the project is likely to generate emission reductions in compliance with the CDM.

2.5. Calculating Emission Reductions

The emission reduction calculation results from the displacement of electricity produced mainly by coal, diesel and other pollutant sources in the SEN, due to the clean energy dispatch of the project activity in the system.

The outline of the method to calculate the emission reduction is as follows:

<u>Key Steps for Estimating Operating Margin Emission Factor</u>

Net hourly Generation output from Lircay Hydroelectric Project and all other units in the system. (MWh)
Analysis of hourly dispatch from all units of the SEN to determine the Marginal Plant(s) not dispatched (or displaced) due to dispatch of all existing CDM projects. (CEN hourly data)
Calculation of emission factor of all operational units of the system. (CNE report and latest IPCC Guidelines following AM0026 Version 3.0 procedures) (tCO_2e/MWh)
Determination of the marginal plants and energy being displaced due to the operation of the CDM Project Activity following the "first-built first-served" principle[19] stated on AM0026 Version 3.0. (MWh and tCO_2e/MWh)
Determination of $EF_{OM,y}$ of each CDM project as the weighted average emission factor of the Marginal Plant(s) not dispatched (or displaced) by each CDM Project Activity. (tCO_2e/MWh)

[19] The "first-built first-served" principle implies that the "last" plant existing in the grid, that would have been dispatched to meet the electricity requirement fulfilled by all the CDM projects in the grid is considered to be displaced due to introduction of the First CDM project built in the system. Similarly, the first marginal plant is considered to be displaced by the CDM plant built last. Note that all CDM projects (even projects adopting other methodologies) must be considered.

Key Steps for Estimating Build Margin Emission Factor

CEN dispatch of all power units of the system.
(MWh)

⇩

Determination of set of *m* plants considered in the Build Margin following the "Tool to calculate the emission factor for an electricity system Version 7.0".
(MWh)

⇩

Calculation of emission factor of the set of *m* plants considered in the Build Margin.
(CNE reports, latest IPCC guidelines and the CEN databases).
(tCO_2e/MWh)

⇩

Determination of $EF_{grid,BM,y}$ as the weighted average emission factor of the dispatched plants and their individual emission factor.
(tCO_2e/MWh)

Key Steps for Calculating Baseline Emissions

Calculation of Combined Margin Emission factor of $EF_{grid,BM,y}$ and $EF_{OM,y}$.
(tCO_2e/MWh)

⇩

Energy generation of the project activity.
(from CEN or metering data).
(MWh)

⇩

Calculation of Baseline Emissions of the Project
(tCO_2e).

⇩

Discount any leakage or project activity emissions, if any
(No leakage emissions were identified for Lircay Hydroelectric Plant, and project emissions are null).
(tCO_2e)

3.0. Operational and Monitoring Obligations

3.1. Operational Obligations

The operational obligations of the project activity operator are to ensure that all reasonable steps are taken to maximize the generation of the project facility and, thereby, maximize the CO_2 emissions reductions. This is in the interest of the operator anyway.

3.2. Data Requirements and Project Database

The data required for the MVP is in line with the kind of information collected by an electricity utility. The data used in this MVP will be collected by the project operator and comes from the following sources:

- The hourly generation of the project is obtained from the metering system of the plant, which is submitted every two hours to the CEN.
- The actual dispatch of all units in the system and dispatch priority list of the power units is collected from the CEN website (https://www.coordinador.cl/).
- Data of Emission factors of the thermal units in the system is collected from CNE reports, latest IPCC guidelines and the CEN databases.

4.0. Project Workbook

4.1. Main Data

The project MVP consists of the following three workbooks:

- MVP workbook for the Operating Margin calculation.
- MVP workbook for the Build Margin calculation. Note that the Build Margin is calculated once at the first revalidation of the project and remains fixed for second crediting period.
- MVP workbook for the ERs calculation of the CDM project.

In the MVP workbooks for the Operating Margin and Build Margin calculations, the following data is used:

- **Generation and other data collected from CEN:** Data from electricity generation of all units of the system from Load Economic Dispatch Center (CEN Dispatch Center).
- **Tons of CO_2e (tCO_2) Emission Factors:** Emission Factor of thermal units of the system, calculated every six months form the CNE official node price reports.
- **Emission Displacement:** Calculation of the Operating Margin and the Build Margin. Determination of emission displacement due to the operation of the project.

The calculations resulted from these workbooks are used in the MVP workbook for the emission reductions calculation to calculate the GHG emission reductions of the CDM project.

The following sections describe how the emission reductions are calculated:

4.2. Energy Generation of The CDM Project

The hourly net generation of the Project Activity is obtained from the metering system of the power plant. This information is submitted to the CEN Dispatch Center every two hours, as all other plants of the SEN. With this data, the CEN provides an hourly report of the system dispatch.

		Hour				
Day		1	2	3	..	24
1	Energy Generation (MWh)					
2	Energy Generation (MWh)					
3	Energy Generation (MWh)					
	Energy Generation (MWh)					
31	Energy Generation (MWh)					

The electronic metering system of the Project Activity must have precision class of 0.2%, according the NCh 2542 / 2001, which is the general standard in the electric system in Chile for all power generating units. This meter will be placed at the high voltage bus. The metering register the instantaneous sum of the power of the generators, which is integrated in 15 minutes intervals. The data from the meter will be collected by the Project Operator, and is then transmitted every two hours to the CEN electronically.

Every meter in the system, including the Project Activity meters, are equipment that fulfill highly reliability and quality standards. Actually, there is no official indication or regulations that require a periodic calibration verification of metering equipment is required by CNE Technical Annex every 3 years for equipment older than 10 years by independent and accredited third parties that will certify the meters fulfill the precision requirements. The calibration procedure consists in comparing the measuring system with a higher precision reference meter. A calibration report is then issued for each meter.

4.3. Energy Generation Data of All Generating Units of the System

Actual Dispatch in the CEN

For every hour of the monitoring period, the actual dispatch of the SEN is obtained from the CEN. This information can be retrieved through a web access or a dedicated connection that works as a file server. A sample data is shown below.

DATE	DD-MM-YYYY								
Type	**V.COST**	**PLANT**	**POWER**	**Hr01**	**Hr02**	**Hr…**	**Hr23**	**Hr24**	**TOT**
Reservoir		ANTUCO	300	171	235	…	181	171	5,113
		MACHICURA	90	19	19	…	60	60	881
		RANGUE	467	463	463	…	461	461	11,117
		SANIGNACIO	37	…	…	…	20	20	168
		RALCO	570	570	570	…	570	570	14
		…	…	…	…	…		…	…
Total of Reservoir				1.512	1.534	…	2.602	2.224	48,005
Run-of-River		ABANICO	136	45	45	…	44	43	1
		ACONCAGUA	72.9	28	28	…	28	28	692
		ALFALFAL	160	56	53	…	57	57	1
		CAPULLO	10.7	12	12	…	11	12	280
		CDM CHACABUCO	26	19	18	…	17	17	421
		CDM QUILLECO	70	40	40	…	40	40	960
		CDM OTHER	…	…	…	…	…	…	…
		CDM PROVIDENCIA	12.75	12.75	12.75	…	12.75	12.75	306
Total of Run-of-River				803	787	…	833		18.850
Thermal	0	ACONSTITUCION	20	16	15	…	15	15	354
	0	CONSTITUCION	8,7	7	7	…	7	6	146
	0	HORCONES TG	12,1	18	17	…	16	16	405
	0	LAJA	8,7	3	4	…	8	6	124
	0	LICANTEN	13	2	2	…	…	…	17
	0	P.VALDIVIA	70	…	…	…	…	…	…
	0	PETRPOWER	48,6	68	68	…	68	68	1.634
	2,4	ARAUCO	101,3	31	32	…	31	31	761
	9,9	CHOLGUAN	15	12	12	…	10	11	276
	12,5	NUEVA RENCA	379	186	67	…	367	332	6.463
	16,6	NEHUENCO 2	380	379	379	…	…	…	4.603
	16,7	NEHUENCO 2	352	351	336	…	354	356	8.262
	17,3	CENTRAL SAN	370	305	167	…	352	353	7.269
	20,4	GUACOLDA 1	152	…	…	…	…	…	…
	20,4	GUACOLDA 2	152	150	150	…	15,1	152	3.610
	21,3	TALTAL 1	120	97	80	…	116	117	2.435
	21,3	TALTAL 2	120	…	…	…	…	…	…
	27,4	VENTANAS2	212	…	…	…	…	…	…
	29,4	BOCAMINATV	125	…	…	…	…	…	…
	…	…	…	…	…	…	…	…	…
Total Thermal				1.626	1.336	…	1.511	1.465	36.432
Total				3.940	3.657	…	4.946	4.496	103.287

Dispatch Priority List

For every week the CEN states the dispatch priority list of the power units in the SEN according to their marginal operation cost. That information is also available from CEN and a sample is reproduced below.

Priority	Variable Cost USD/MWh	Unit
1	0	ACONSTITUCION Arauco
2	0	CONSTITUCION Gener
3	0	HORCONES TG
4	0	LAJA
5	0	LICANTEN
6	0	P.VALDIVIA
7	0	PETROPOWER
8	2,4	ARAUCO
9	9,9	CHOLGUAN
10	12,5	NUEVA RENCA
11	16,6	NEHUENCO 2
12	16,7	NEHUENCO
13	17,3	CENTRAL SAN ISIDRO
14	20,4	GUACOLDA 1
15	20,4	GUACOLDA 2
16	21,3	TALTAL 1
17	21,3	TALTAL 2
18	27,4	VENTANAS2
19	29,4	BOCAMINATV
…	…	…

The "Marginal Power Unit in the SEN

From the data issued by the CEN on the hourly marginal power unit, it is possible to determine the marginal power plant and the next marginal plants in the priority dispatch order list that would be dispatch in the system if no CDM project activities were present in the system.

Every thermal plant has its own (tCO_2/GWh) conversion factor according to its specific consumption and type of fuel. The emission factors can be calculated using CNE node price report, CEN databases and IPCC manual.

plants		date of commissioning	plant capacity (net)	fuel type	plant CO2 emission factor (1) x (2) x (3) x (4) x (5)
unit	unit_id	comm	MW	ft.name	[tCO2e/GWh]
Arauco	2	01-01-1996	30,10	biomass	0,00
Cholguán	3	01-01-2003	13,00	biomass	0,00
Constitución Arauco	4	01-01-1996	8,00	biomass	0,00
Horcones TG gas	5	01-01-2004	24,30	natural gas	920,38
Licantén	6	01-01-2004	4,00	biomass	0,00
Pedro de Valdivia	7	01-01-2004	61,00	biomass	0,00
Antilhue TG	9	10-11-2005	100,60	diesel	778,32
Canutillar	10	01-01-1990	171,60	reservoir	0,00
Candelaria 1 gas	11	16-05-2005	135,32	natural gas	688,92
Candelaria 2 gas	12	01-05-2005	135,32	natural gas	688,92
Colbún	13	01-01-1985	476,80	reservoir	0,00
Machicura	14	01-01-1985	95,76	reservoir	0,00
Nehuenco 9b gas	15	01-01-2002	101,95	natural gas	689,84
Nehuenco 9B diesel	16	01-01-2002	101,95	diesel	928,87
Nehuenco 1 gas	17	01-01-1998	373,56	natural gas	432,22
Nuehuenco 2 gas	18	01-01-2003	382,49	natural gas	397,12
Nehuenco 1 diesel	19	01-01-2004	373,56	diesel	539,71
Rucue	20	01-01-1998	177,70	run-of-river	0,00
San Ignacio	21	01-01-1996	36,90	run-of-river	0,00
Constitución Gener	22	01-01-1995	10,06	biomass	0,00
Laja	23	01-01-1995	11,70	biomass	0,00
Nueva Renca gas	24	01-01-1997	370,88	natural gas	424,20
Nueva Renca diesel	25	01-01-2004	370,88	diesel	578,26
Abanico	26	01-01-1948	128,60	run-of-river	0,00
Antuco	29	01-01-1981	323,20	run-of-river	0,00
Bocamina TV	31	01-01-1970	119,38	coal	1.053,55
Campanario 1 gas	35	21-03-2007	54,44	natural gas	644,45
Campanario 1 diesel	36	21-03-2007	54,44	diesel	831,88
Candelaria 1 diesel	37	16-05-2005	135,32	diesel	914,67
Candelaria 2 diesel	38	01-05-2005	135,32	diesel	914,67
Cipreses	43	01-01-1955	99,70	reservoir	0,00

The “Theoretical Dispatch without CDM Projects” and the Emission Displacement

Without the Project Activity and other CDM projects, the marginal dispatched plant should increment its generation to supply the system demand in each hour. Since the generation from the marginal plant has limited capacity, and it´s increment may not be sufficient to meet the system demand, a next power unit must be dispatched in the economic merit order priority to supply the required energy. And if there is still not sufficient energy with the next marginal plant, then other unit(s) must be dispatched following the same order. In order to determine the Project Activity’s energy and emission displacement, it must be taken into account all other CDM units of the system. The following table presents an example how the dispatch should change and the energy displacement that CDM projects will produce in the system.

				Hr1	Hr2	Hr…	Hr23	Hr24
CDM N°1 (CHACABUQUITO)	Energy in MWh		C1	19	18	…	17	17
	Capacity in MW			26	26	…	26	26
CDM N°2 (QUILLECO)	Energy in MWh		C2	40	40	…	40	40
	Capacity in MW			70	70	…	70	70
CDM N°N-1 (--)	Energy in MWh		C3	25	30	…	30	30
	Capacity in MW			55	55	…	55	55
CDM N°N (PROVIDENCIA)	Energy in MWh		C4	12.75	12.75	…	12	12.75
	Capacity in MW			12.75	12.75	…	12.75	12.75
Marginal Plant 1	Energy	MWh	B1	97	80	…	116	117
	plant Name			TALTAL1	TALTAL1	…	TALTAL1	TALTAL1
	Capacit	MW	A1	120	120	…	120	120
	E. Factc	TCO2/GWh	d1	641	641	…	641	641
Marginal Plant 2	Energy	MWh	B2	-	-	…	-	-
	plant Name			TALTAL2	TALTAL2	…	TALTAL2	TALTAL2
	Capacit	MW	A2	120	120	…	120	120
	E. Factc	TCO2/GWh	d2	641	641	…	641	641
Marginal Plant 3	Energy	MWh	B3	-	-	…	-	-
	plant Name			VENT2	VENT2	…	VENT2	VENT2
	Capacit	MW	A3	212	212	…	120	120
	E. Factc	TCO2/GWh	d3	1,025	1,025	…	1,025	1,025

If other CDM projects are implemented in the system then, for each hour, the emission displacement should meet the formulae stated on AM0026 (Version 3.0).

Emission Displacement for the Operating Margin

The emission factor form the Operating Margin can be estimated following formulas indicated in the AM0026 (version 3.0). The following table presents an illustrated example to calculate the emission displacement of the Operating Margin.

		Hr1	Hr2	Hr…	Hr23	Hr24
MDL N°1 (CHACABUQUITO)						
MWh Displacement						
Marginal Plant 1	min(C1; (A1-B1) - D21-D31-D41) = D11	0	0	…	0	0
Marginal Plant 2	min(C1-D11; (A2-B2) - D22-D32-D42) = D12	19	18	…	17	17
Marginal Plant 3	min(C1-D11-D12; (A3-B3) - D23-D33-D43) = D13	0	0	…	0	0
TCO2 Displacement						
	d1*D11+d2*D12+d3*D13 = ER1	12.2	11.5	…	10.9	10.9
MDL N°2 (QUILLECO)						
MWh Displacement						
Marginal Plant 1	min(C2, (A1-B1) - D31-D41) = D21	0	0	…	0	0
Marginal Plant 2	min(C2-D21; (A2-B2) - D32-D42) = D22	40	40	…	40	40
Marginal Plant 3	min(C2-D21-D22; (A3-B3) - D33-D43) = D23	0	0	…	0	0
TCO2 Displacement						
	d1*D21+d2*D22+d3*D23 = ER2	25.6	25.6	…	25.6	25.6
MDL N°N-1 (---)						
MWh Displacement						
Marginal Plant 1	min(C3, (A1-B1) - D41) = D31	10.25	27.25	…	0	0
Marginal Plant 2	min(C3-D31; (A2-B2) - D42) = D32	14.75	0	…	30	30
Marginal Plant 3	min(C3-D31-D32; (A3-B3) - D43) = D33	0	0	…	0	0
TCO2 Displacement						
	d1*D31+d2*D32+d3*D33 = ER3	16	17.5	…	19.2	19.2
MDL N°1 (PROVIDENCIA)						
MWh Displacement						
Marginal Plant 1	min(C4, (A1-B1) - 0) = D41	12.75	12.75	…	4	3
Marginal Plant 2	min(C4-D41; (A2-B2) - 0) = D42	0	0	…	8	9.75
Marginal Plant 3	min(C4-D41-D42; (A3-B3) - 0) = D43	0	0	…	0	0
TCO2 Displacement						
	d1*D41+d2*D42+d3*D43 = ER4	8.2	8.2	…	7.7	8.2

The Build Margin Calculation Worksheet

For the second crediting period, the Build Margin must be calculated using the most recent information available at the time of submitting this PDD to the DOE for revalidation. The BM remains fixed for the entire second crediting period. The calculation requires to account for energy and emission from the power plants capacity additions in the electricity system that comprise 20% of the system generation (in MWh), or the set of five power units that have been built most recently. This will depend on which method comprises the largest electric power generation of the corresponding year.

The following table presents an illustrated example of how the Build Margin is calculated for a given year. Note that this is just an illustrative example, since the real calculation for the 2019 Build Margin grid emission factor is provided in the BM calculation Excel spreadsheet):

COMM DATE	Plant Name	Type	EF	Energy
	OTHERS			3.853.386
1970	BOCAMINATV	Thermal	925	300.051
1973	EL TORO	Reservoir	0	1.693.974
1977	HUASCOTG	Thermal	1002,9	29.064
1977	VENTANAS1	Thermal	1071	413.467
1977	VENTANAS2	Thermal	1024,96	1.050.510
1981	ANTUCO	RoR	0	1.662.081
1981	ARAUCO	Thermal	0	156.044
1985	COLBUN	Reservoir	0	2.021.022
1985	CONSTITUCION Gener	Thermal	982	50.265
1985	CURILLINQUE	RoR	0	627.902
1985	DIEGO DE ALMAGRO	Thermal	1071	6.236
1985	MACHICURA	RoR	0	453.530
1990	CANUTILLAR	Reservoir	0	1.094.674
1991	PEHUENCHE	Reservoir	0	2.567.234
1993	ACONCAGUA	RoR	0	371.391
1993	\CONSTITUCION Arauc	Thermal	0	132.388
1993	ALFALFAL	RoR	0	840.860
1995	CAPULLO	RoR	0	74.237
1995	GUACOLDA 2	Thermal	893,697	2.468.970
1995	LAJA	Thermal	0	39.483
1996	PANGUE	Reservoir	0	1.675.343
1996	SAN IGNACIO	RoR	0	182.344
1997	LOMA ALTA	RoR	0	276.888
1997	NUEVA RENCA	Thermal	396	2.275.586
1997	PUNTILLA	RoR	0	118.339
1998	QUELTEHUES	RoR	0	357.697
1998	RUCUE	RoR	0	1.091.127
1998	CENTRAL SAN ISIDRO	Thermal	424,012	2.705.618
1998	NEHUENCO	Thermal	396,115	1.847.504
1998	PETROPOWER	Thermal	879	526.035
2000	MAMPIL	RoR	0	173.898
2000	PEUCHEN	RoR	0	261.831
2000	TALTAL 1	Thermal	641	624.403
2000	TALTAL 2	Thermal	641	364.208
2002	NEHUE.9B	Thermal	604	106.395
2003	CHOLGUAN	Thermal	0	93.347
2003	NEHUENCO 2	Thermal	411,691	1.996.332
2003	SAN FRANCISCO M.	Thermal	982	9.380
2004	ANTILHUE TG (*)	Thermal	0	160
2004	ANTILHUE TG	Thermal	820	710
2004	HORCONES TG (*)	Thermal	0	12.023
2004	HORCONES TG	Thermal	944	56
2004	ITATA	Thermal	0	319
2004	LICANTEN	Thermal	0	21.412
2004	P.VALDIVIA	Thermal	0	153.204
2004	RALCO	Reservoir	0	1.332.259
Total SIC Energy Generation of 2004			MWh	36.113.187
Latest 20% of Capacity additions Generation			MWh	7.523.475
Total Emiission of latest 20%			TCO2e	2.723.889
EF_BM			**TCO2/GW**	**362**

(*) Commisioning tests

5.0. Project Activity Sustainable Development MVP

5.1. Monitoring Sustainable Development

The MVP compares the project's actual environmental and development performance as measured by the indicators below, with the set target values and determine whether the targets have been reached. The following local environmental benefits have been identified from the Lircay Hydroelectric Plant (see Lircay Hydroelectric Plant DIA from SEA's official website www.sea.gob.cl for more details).

- The project will contribute with clean renewable energy for Chile's SEN transmission grid, displacing thermal generation.

The direct social and development impact of the project are as follows (see Lircay Hydroelectric Plant DIA from SEA official website www.sea.gov.cl for more details).

- Job creation during the construction period and also during the operation.
- Economic activity during the construction period and during all of its lifetime.

5.2. Monitoring, Recording and Reporting

For project operator shall monitor and record the environmental, social and developmental impacts identified for the Project.

6.0. Management and Operational Systems MVP

6.1. Allocation of Project Management Responsibilities

The management and operation of the project, related to CDM activities, is part of the Project Operator's responsibilities. Ensuring the environmental credibility of the project through accurate and systematic monitoring of the project's implementation and operation for the purpose of achieving trustworthy CO_2 emission reductions is the key responsibility and accountability of the sponsor as far as this MVP is concerned.

6.2. Management and Operational Systems

Data handling

The establishment of a transparent system for the collection, computation and storage of data, including adequate record keeping and data monitoring systems. The Project Operator shall develop and implement a protocol that provides for these critical functions and processes, which must be fit for independent auditing.

Quality assurance

The Project Operator must designate a competent manager who will be in charge of and accountable for the generation of emission reductions including monitoring, record keeping, computation of emission reductions, audits and verification. He or she will officially sign-off on all GHG Emission worksheets. The Project Operator will keep proper management processes and systems records, as the auditors will request copies of such records to judge compliance with the required management systems.

Reporting

The Project Operator will report regularly to the emission reductions buyer(s) as well as to Chilean authorities as required by them.

Training:

It is the responsibility of the Project Operator to ensure that the required capacity and internal training is made available to its operational staff to enable them to undertake the tasks required by this MVP. Initial staff training must be provided before the project starts operating and generating emission reductions.

7.0. Auditing and Verification Procedures

7.1. Audit and Verification Regime

The Project Activity must be submitted to third party validation and verification, which is conducted by independent firms, specialized in environmental auditing services (auditors, validators, verifiers, certifiers). The verification system for the project activity consists of these four activities:

Validation of project design

The Project Activity must undergo a CDM validation of the project's design, baseline and MVP against CDM requirements and modalities. Validated MVP for a project must be followed by the Project Operator.

Verification of the Project

The Project Activity will a periodic verification process for the acceptance of emission reductions delivered by it. To prevent conflicts of interest, verification must not be conducted by the same firm and individuals that have provided validation services for the project.

The purpose of the periodic verification process is threefold:

- Ensure that the project has been implemented as planned, that the monitoring system is in place and that the project is ready to generate and record GHG emission reductions.
- Approve adjustments and amendments to the MVP that may have become necessary during the detailed design and construction of the project.
- Assist complying obligations and clear the way for project commissioning and generation of high quality ERs.

Periodic verification of emission reductions

The project activity must undergo periodic audits and verification of emission reductions. This is a CDM requirement and the basis for issuance of Certified Emission Reductions (CERs). Verification must be arranged and conducted annually or longer intervals as appropriate for the project participant. Verification concludes with a formal verification report. The report may include a statement that may allow the renewal of the project's crediting period in line with applicable CDM rules and modalities.

The purpose of periodic audits and verification is to confirm that:

- The project has achieved the emission reductions for the verification period in compliance with the methodology laid down in this PDD.
- The claimed emission reductions are real and additional to any that would have occurred in the baseline scenario as interpreted and developed in the Baseline Study and this MVP.
- The operation of the project continues to be in compliance with all Kyoto Protocol, host country requirements and modalities for CDM projects, and the emission reductions buyer(s).

- The project maintains a high quality monitoring systems consistent with the MVP.

Certification of emission reductions

After a successfully completed verification process and the related verification report provide the basis for the issuance by the UNFCCC. The issuance certificate is a legally binding statement, which confirms the (successful) verification report's conclusion that Project has achieved the stated quantity of ERs in compliance with all relevant criteria and requirements.

Auditing Criteria and Needs

Verification includes an audit of the project's output information and data and management systems on the basis of the following established criteria: Completeness; accuracy; coverage and risk management controls.

The auditor will produce an audit report and verification report, which summarizes the audit findings. The draft verification report will state the number of emission reductions achieved by the project and will point to areas of possible non-compliance if warranted. The report will also include conclusions on data quality, the projects monitoring and management and operational system, and other areas where corrective action may be required to come into compliance, improve performance or mitigate risks.

Appendix 6. Summary report of comments received from local stakeholders

All data regarding stakeholder’s comments is presented in section E3 of this PDD.

Appendix 7. Summary of post-registration changes

During the first crediting period, the Lircay PDD had a post-registration change related to the following aspects:

1. Providing more information about the physical description of the Lircay power plant.
2. Making editorial changes and providing more information/better description about the equations used to calculate the project activity's emission reductions.
3. Providing more accurate description of the monitored variables, correct some data sources used monitor some parameters and add some missing parameters to the monitoring plan.
4. General editorial changes and improvements to the PDD.

These changes and the revised PDD were approved on July 20th, 2011. It must be noted that all the post registration changes have been incorporated in this PDD.

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Document information

Version	*Date*	*Description*
11.0	31 May 2019	Revision to: • Ensure consistency with version 02.0 of the “CDM project standard for project activities” (CDM-EB93-A04-STAN); • Make editorial improvements.
10.1	28 June 2017	Revision to make editorial improvement.
10.0	7 June 2017	Revision to: • Improve consistency with the “CDM project standard for project activities” and with the PoA-DD and CPA-DD forms; • Make editorial improvement.
09.0	24 May 2017	Revision to: • Ensure consistency with the “CDM project standard for project activities” (CDM-EB93-A04-STAN) (version 01.0); • Incorporate the “Project design document form for small-scale CDM project activities” (CDM-SSC-PDD-FORM); • Make editorial improvement.
08.0	22 July 2016	EB 90, Annex 1 Revision to include provisions related to automatically additional project activities.
07.0	15 April 2016	Revision to ensure consistency with the “Standard: Applicability of sectoral scopes” (CDM-EB88-A04-STAN) (version 01.0).
06.0	9 March 2015	Revision to: • Include provisions related to statement on erroneous inclusion of a CPA; • Include provisions related to delayed submission of a monitoring plan; • Provisions related to local stakeholder consultation; • Provisions related to the Host Party; • Make editorial improvement.
05.0	25 June 2014	Revision to: • Include the Attachment: Instructions for filling out the project design document form for CDM project activities (these instructions supersede the "Guidelines for completing the project design document form" (Version 01.0)); • Include provisions related to standardized baselines; • Add contact information on a responsible person(s)/ entity(ies) for the application of the methodology (ies) to the project activity in B.7.4 and Appendix 1; • Change the reference number from F-CDM-PDD to CDM-PDD-FORM; • Make editorial improvement.
04.1	11 April 2012	Editorial revision to change version 02 line in history box from Annex 06 to Annex 06b.
04.0	13 March 2012	Revision required to ensure consistency with the “Guidelines for completing the project design document form for CDM project activities” (EB 66, Annex 8).

Version	*Date*	*Description*
03.0	26 July 2006	EB 25, Annex 15
02.0	14 June 2004	EB 14, Annex 06b
01.0	03 August 2002	EB 05, Paragraph 12 Initial adoption.

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