



**PROJECT DESIGN DOCUMENT FORM  
FOR CDM PROJECT ACTIVITIES (F-CDM-PDD)  
Version 04.1**

**PROJECT DESIGN DOCUMENT (PDD)**

<b>Title of the project activity</b>	Los Andes Photovoltaic Farm
<b>Version number of the PDD</b>	02
<b>Completion date of the PDD</b>	11/10/2013
<b>Project participant(s)</b>	AES Gener S.A
<b>Host Party(ies)</b>	Chile
<b>Sectoral scope and selected methodology(ies)</b>	<p>The project activity is categorized in Scope Number 1; Sectoral Scope- Energy industries (renewable/non-renewable sources)</p> <p>The selected methodology corresponds to Version 14.0 of ACM0002: “Grid-connected electricity generation from renewable sources”.</p>
<b>Estimated amount of annual average GHG emission reductions</b>	361,788 tCO <sub>2</sub> e



## SECTION A. Description of project activity

### A.1. Purpose and general description of project activity

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Los Andes Photovoltaic Farm is a Greenfield renewable generation project. Specifically corresponds to the first phase of a solar photovoltaic energy generation project to be developed by AES Gener S.A, which considers a total installed capacity of 141 MW<sup>1</sup>. The implementation of the project will be performed in different stages.

The project will be located in the region of Antofagasta (III Region), in the north of Chile and consists in the implementation of solar photovoltaic panels. The project participant will use safe and sound technology from a certified manufacturer.

The project will be connected to the Grand North Interconnected System (SING) through the “Andes” substation and it expects to deliver approximately 407,420 MWh<sup>2</sup> per year and generate a total amount of 361,788 tCO<sub>2</sub> emission reductions aprox. per year.

The implementation of Los Andes Photovoltaic Farm will displace the dispatch of thermoelectric power plants currently operating in the SING grid and will contribute with the greenhouse gases (GHG) emission reductions, delivering clean energy to the grid that would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources, and specifically by avoiding the emissions of CO<sub>2</sub> produced by the combustion of fossil fuels, considered the main source of GHG.

The project will contribute to the sustainable development of the country by delivering clean energy to the SING grid, diversifying the energy pool through the implementation of non conventional renewable energy sources and also by contributing to substitute the use of fossil fuel and extending the energy sources in the country.

In Chile, at the present time there is only one solar photovoltaic power plant connected to the SING grid in Chile denominated Selray with an installed capacity of 1.4MW<sup>3</sup> which represents less than 0.02% of the total capacity installed in the grid. Considering this scenario, Los Andes photovoltaic farm will contribute to increase the presence of this technology in the SING grid and to the capacity building and know-how transference of photovoltaic technology in the country.

This type of renewable energy projects enables AES Gener S.A. to deliver zero-emission electricity to the grid in addition to contribute with the diversification of the energy pool.

The company considers environmental management in its business strategies and decision making process in order to ensure the protection of the natural resources and minimization of the environmental impact of its activities. The implementation of this project activity is in line with national and regional policy's contributing to reduce the dependence of the Chilean electricity system in imported fossil fuel and assists the assurance of the electricity supply due to the implementation of a clean energy source,

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<sup>1</sup> This project activity corresponds to the first phase of a larger project which considers a total installed capacity of 220MW as it can be reviewed in the Environmental approval RCA N° 151/2012, page 2.

<sup>2</sup> Calculated based in the installed capacity of the project and plant load factor of the project specified in Section A.3 of this document.

<sup>3</sup> Information available in the Installed Capacity per grid 2012 document performed by the National Commission of Energy.



with less environmental impacts compared with other energy sources, and that's also sustainable over time

## **A.2. Location of project activity**

### **A.2.1. Host Party(ies)**

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Chile

### **A.2.2. Region/State/Province etc.**

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Province and Region of Antofagasta

### **A.2.3. City/Town/Community etc.**

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City of Antofagasta

### **A.2.4. Physical/Geographical location**

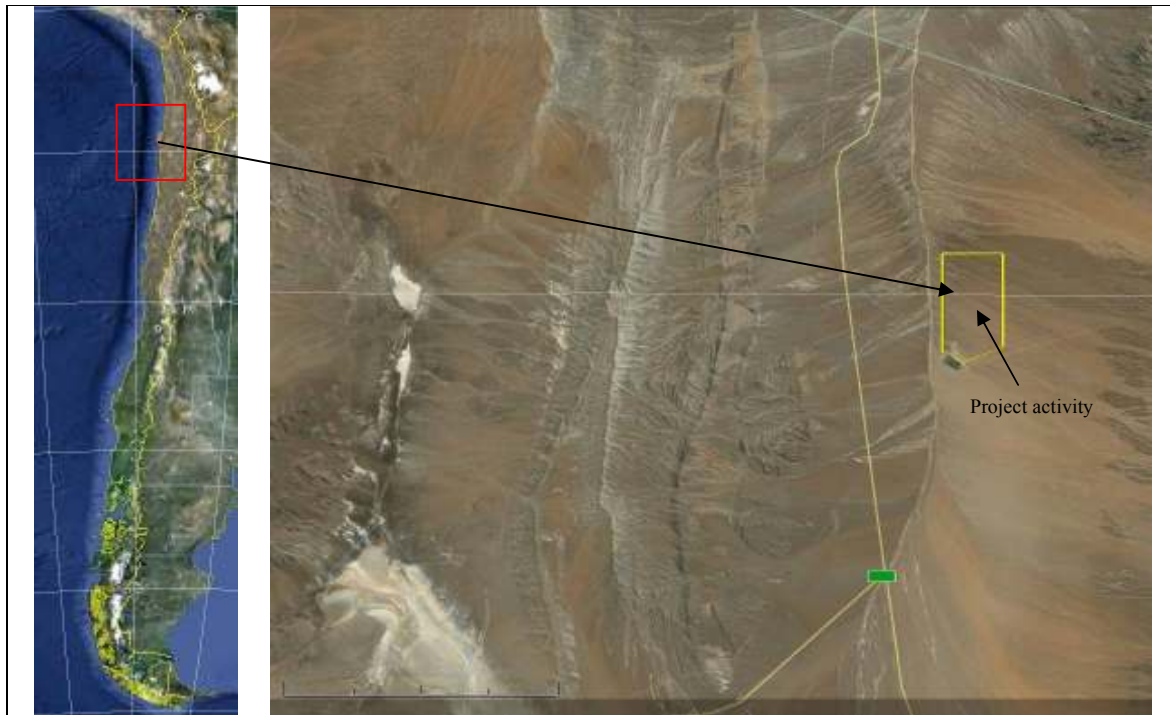
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The approximate geographic coordinates (Full degrees coordinate, Datum WGS 84) that demarcate the project emplacement are:

**Table 1: Project GPS Coordinates**

	<b>Longitude</b>	<b>Latitude</b>
A	-68.586373°	-24.014485°
B	-68.585063°	-24.015113°
C	-68.585337°	-24.015593°
D	-68.582471°	-24.016976°
1	-68.581576°	-24.016974°
2	-68.571196°	-24.012890°
3	-68.571274°	-23.989424°
4	-68.587839°	-23.989388°
5	-68.587759°	-24.014498°

The following figure gives a better understanding of the location of the project:



**Figure 1: Location of Project Activity**

Source: Google Earth, 2013

### A.3. Technologies and/or measures

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Los Andes photovoltaic farm is a Greenfield facility located in the north of Chile. The energy generated will displace the dispatch of thermoelectric power plants currently operating in the SING grid and will contribute with the greenhouse gases (GHG) emission reductions, delivering clean energy to the grid that would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources.

The technology used in this project will be environmentally safe and sound solar photovoltaic panels from a certified and respected supplier. The manufacturer will transfer to the Host Party its know-how by means of training the power plant staff during the construction, commissioning and operation of the project activity.

The main technical specifications of the project activity are presented in the following table:

**Table 2. Technical specifications**

Item	Specifications
Total installed capacity	141 MW
Type of technology	Solar photovoltaic panels
Technical lifetime	20 years
Plant load factor	33%

In section B.3 of the PDD is presented a general flow diagram of the project.

The monitoring equipment will consist in an electricity meter that will measure the net energy from the power plant and will be located at the Andes Substation. The meters specification will comply with the



current national regulations which at the present time correspond to bidirectional meters Class 02 with a 0.2% of accuracy according to Resolution N° 395/2003 “Manual de procedimientos N°13 Instalación, lectura, sincronización y mantenimiento de equipos de medida utilizados en la valorización de transferencias entre integrantes del CDEC-SING”<sup>4</sup>.

#### A.4. Parties and project participants

Party involved (host) indicates a host Party	Private and/or public entity(ies) project participants (as applicable)	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Chile (host party) <i>Chile ratified the Kyoto Protocol on August, 2002.</i>	AES Gener S.A (private entity)	No

#### A.5. Public funding of project activity

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Los Andes Photovoltaic Farm does not consider public funding.

### SECTION B. Application of selected approved baseline and monitoring methodology

#### B.1. Reference of methodology

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For this project activity applies the Approved consolidated baseline and monitoring methodology ACM0002: “Grid-connected electricity generation from renewable sources” version 14.0, Sectoral Scope 01; in effect as of EB 75.

<http://cdm.unfccc.int/methodologies/DB/MPY3HVJIMTKE5P0UNTYE827D6Q7EHB>

This methodology also refers to the followings tools:

- “Tool to calculate the emission factor for an electricity system” Version 04.0 in effect as EB75  
<http://cdm.unfccc.int/methodologies/PAMethodologies/tools/am-tool-07-v4.0.pdf>

- “Tool for the demonstration and assessment of additionality” Version 07 in effect as EB70  
[http://cdm.unfccc.int/methodologies/PAMethodologies/tools/am-tool-01-v7.0.0.pdf/history\\_view](http://cdm.unfccc.int/methodologies/PAMethodologies/tools/am-tool-01-v7.0.0.pdf/history_view)

More information about approved methodologies can be obtained at:

<http://cdm.unfccc.int>

#### B.2. Applicability of methodology

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Project participants choose Approved Consolidated Methodology ACM0002 version 14.0 to develop the project activity design document due to the fact that this methodology is applicable to grid-connected renewable power generation project activities that involve the installation of a new power plant.

The project activity fulfils the applicability conditions of the methodology as follows:

<sup>4</sup>Document available at Web site: [http://cdec2.cdec-sing.cl/pls/portal/cdec.pck\\_web\\_cdec\\_pages.pagina?p\\_id=3009](http://cdec2.cdec-sing.cl/pls/portal/cdec.pck_web_cdec_pages.pagina?p_id=3009)



Table 3: Applicability Conditions of the Methodology ACM0002 v. 14.0

Applicability condition	Fulfilment of applicability conditions
The project activity is the installation, capacity addition, retrofit or replacement of a power plant/unit of one of the following types: hydro power plant/unit (either with a run-of-river reservoir or an accumulation reservoir), wind power plant/unit, geothermal power plant/unit, solar power plant/unit, wave power plant/unit or tidal power plant/unit;	The project activity considers the installation of the first phase of a Greenfield solar photovoltaic farm. The information can be confirmed in the Environmental Impact Statement (DIA) of the project and its environmental approval (RCA N°151/2012).
In the case of capacity additions, retrofits or replacements (except for wind, solar, wave or tidal power capacity addition projects which use Option 2: on page 16 to calculate the parameter $EG_{p,y}$ ): the existing plant started commercial operation prior to the start of a minimum historical reference period of five years, used for the calculation of baseline emissions and defined in the baseline emission section, and no capacity expansion or retrofit of the plant has been undertaken between the start of this minimum historical reference period and the implementation of the project activity;	This condition does not apply to the project activity since it is not a capacity addition, retrofit or replacement project. The information can be confirmed in the Environmental Impact Statement (DIA) of the project and its environmental approval (RCA N°151/2012).
In case of hydro power plants: One of the following conditions must apply: - The project activity is implemented in an existing single or multiple reservoirs, with no change in the volume of any of reservoirs; or - The project activity is implemented in an existing single or multiple reservoirs, where the volume of any of reservoirs is increased and the power density of each reservoir, as per the definitions given in the Project Emissions section, is greater than 4 W/m <sup>2</sup> ; or - The project activity results in new single or multiple reservoirs and the power density of each reservoir, as per the definitions given in the Project Emissions section, is greater than 4 W/m <sup>2</sup> .	This condition does not apply to the project activity since is not an hydro power plant. The information can be confirmed in the Environmental Impact Statement (DIA) of the project and its environmental approval (RCA N°151/2012).
In case of hydro power plants using multiple reservoirs where the power density of any of the reservoirs is lower than 4 W/m <sup>2</sup> all the following conditions must apply: -The power density calculated for the entire project activity using equation 5 is greater than 4 W/m <sup>2</sup> ; - Multiple reservoirs and hydro power plants located at the same river and where are designed together to function as an integrated project that collectively constitute the generation capacity of the combined power plant;	This condition does not apply to the project activity since is not a hydro power plant. The information can be confirmed in the Environmental Impact Statement (DIA) of the project and its environmental approval (RCA N°151/2012).



Applicability condition	Fulfilment of applicability conditions
<ul style="list-style-type: none"> <li>- Water flow between multiple reservoirs is not used by any other hydropower unit which is not a part of the project activity;</li> <li>- Total installed capacity of the power units, which are driven using water from the reservoirs with power density lower than 4 W/m<sup>2</sup>, is lower than 15MW;</li> <li>- Total installed capacity of the power units, which are driven using water from reservoirs with power density lower than 4 W/m<sup>2</sup>, is less than 10 per cent of the total installed capacity of the project activity from multiple reservoirs.</li> </ul>	
<p>The methodology is not applicable to the following:</p> <ul style="list-style-type: none"> <li>- Project activities that involve switching from fossil fuels to renewable energy sources at the site of the project activity, since in this case the baseline may be the continued use of fossil fuels at the site;</li> <li>- Biomass fired power plants;</li> <li>- Hydro power plant that result in new single reservoir or in the increase in existing single reservoir where the power density of the power plant is less than 4 W/m<sup>2</sup>.</li> </ul>	<p>The proposed project is not an activity that involves switching from fossil fuels to renewable energy at the site of the project activity, uses biomass nor result in a new reservoir. The information can be confirmed in the Environmental Impact Statement (DIA) of the project and its environmental approval (RCA N°151/2012).</p>
<p>In the case of retrofits, replacements, or capacity additions, this methodology is only applicable if the most plausible baseline scenario, as a result of the identification of baseline scenario, is the continuation of the current situation, that is to use the power generation equipment that was already in use prior to the implementation of the project activity and undertaking business as usual maintenance.</p>	<p>This condition does not apply to the project activity since the project activity doesn't consider a retrofit, replacement or capacity addition. The information can be confirmed in the Environmental Impact Statement (DIA) of the project and its environmental approval (RCA N°151/2012).</p>

### B.3. Project boundary

According to version ACM0002 version 14.0, the project boundary is “The spatial extent of the project boundary includes the project power plant and all power plants connected physically to the electricity system that the CDM project power plant is connected to.”

Due to Chile's geography, its electric infrastructure is divided into five separate systems that are not connected between them: Grand North Interconnected System (SING), Central Interconnected System (SIC), Aysén System, Magallanes System and Isla de Pascua System.

Considering that the project activity is located in the Antofagasta region, the renewable electricity generation is going to be delivered to the SING grid.

The SING transmission system covers the north of Chile as it is shown in Figure 2 below.



Figure 2: Distribution of the SING grid

The GHG emissions within the project activity boundaries are associated to the baseline, produced from electricity generation in fossil fuel-fired power plants connected to the SING electric grid. The project activity will supply zero-emissions electricity to the grid, thus avoiding GHG emission by displacing the dispatch of thermoelectric power plants. As it is shown in **Figure 3** there are no GHG emissions associated to the project activity.



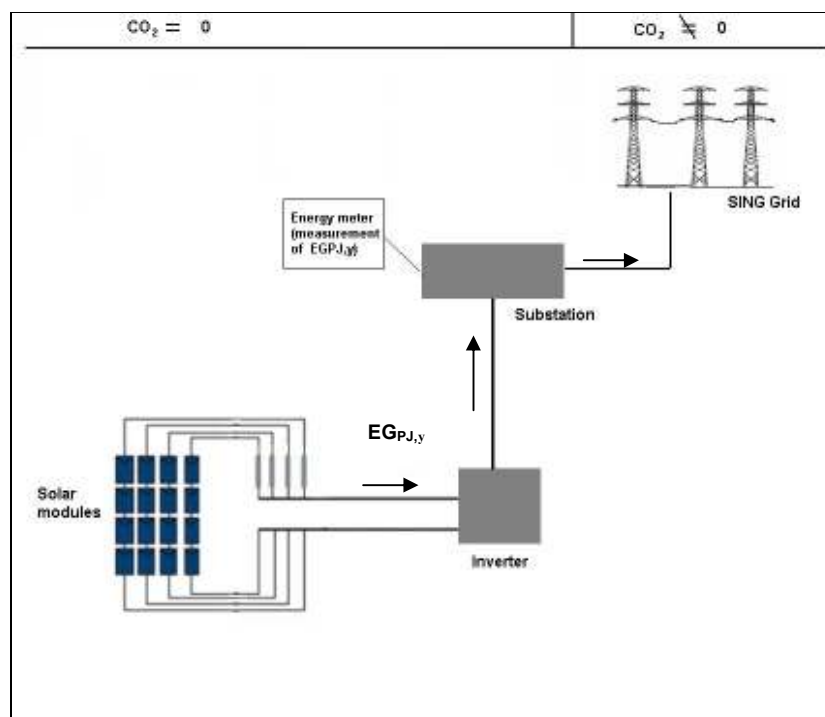


Figure 3: General flow diagram of the project

The GHGs and emission sources included or excluded from the project boundary are shown in **Table 4** below.

**Table 4: Emissions sources included in or excluded from the project boundary**

	Source	GHGs	Included?	Justification/Explanation
Baseline scenario	CO <sub>2</sub> emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity.	CO <sub>2</sub>	Yes	Main emission source.
		CH <sub>4</sub>	No	Minor emission source.
		N <sub>2</sub> O	No	Minor emission source.
Project scenario	For geothermal power plants, fugitive emissions of CH <sub>4</sub> and CO <sub>2</sub> from non condensable gases contained in geothermal steam.	CO <sub>2</sub>	No	Not applicable. The project activity is a solar photovoltaic project
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	No	
	CO <sub>2</sub> emissions from combustion of fossil fuels for electricity generation in solar thermal power plants and geothermal power plants	CO <sub>2</sub>	No	Not applicable. The project activity is a solar photovoltaic project
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	No	
	For hydro power plants, emissions of CH <sub>4</sub> from the reservoir	CO <sub>2</sub>	No	Not applicable. The project activity is a solar photovoltaic project
		CH <sub>4</sub>	No	
		N <sub>2</sub> O	No	



#### **B.4. Establishment and description of baseline scenario**

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According to ACM0002 version 14.0, the baseline scenario of the proposed project activity is defined as the electricity delivered to the grid (SING) by the project activity that would have otherwise been generated by the operation of grid-connected power plants and by the addition of new generation sources. The emission factor for the electricity grid was calculated using the “Tool to calculate the emission factor for an electricity system” Version 04.

The project activity will replace the energy generated by fossil fuel power plants operating in the SING grid. The list of power plants that are operating in the SING grid along with the energy source that they use can be seen in the “Installed Capacity” per grid document<sup>5</sup> performed by the National Commission of Energy (CNE, 2011)

#### **B.5. Demonstration of additionality**

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##### **Prior Consideration of the CDM**

CDM project cycle procedure (version 04) indicates that for project activities with a start date on or after 2 August 2008, the project participant shall inform the designated national authority (DNA) of the host party of the project activity and the secretariat in writing of the commencement of the project activity and its intention to seek CDM status within 180 days of the start date of the project activity.

Since the project activity has not started yet, it is proved the prior consideration of the CDM.

##### **Additionality**

According the methodology ACM0002 version 14.0 the additionality of the project activity shall be demonstrated and assessed using the latest version of the “Tool for the demonstration and assessment of additionality”, which corresponds to the version 07 from EB70.

This tool considers the following steps to demonstrate and assess additionality:

Step 1: Identification of alternatives to the project activity;

Step 2: Investment analysis to determine that the proposed project activity is either: 1) not the most economically or financially attractive, or 2) not economically or financially feasible;

Step 3: Barriers analysis; and

Step 4: Common practice analysis.

##### **Step 1 - Identification of alternatives to the project activity**

Under this analysis there are defined realistic and credible alternatives to the project activity.

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

The alternative scenarios to the proposed project activity are the following:

- (a) The proposed project activity undertaken without being registered as a CDM project activity;
- (b) The continuation of the current situation (no project activity or other alternatives undertaken).

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<sup>5</sup> Document available at web page: <http://www.cne.cl/estadisticas/energia/electricidad>

**Sub-step 1b: Consistency with mandatory laws and regulations:**

The electricity generation through any of the previously identified alternatives represents a realistic and credible alternative scenario to the project activity, and are in compliance with Chilean mandatory legislation and regulations taking into account the enforcement in the country and EB decisions on national and/or sector policies and regulations

**Step 2. Investment analysis**

This analysis aims to demonstrate that the proposed project activity can't be considered to be economically attractive, without the revenue from the sale of CER.

To conduct the investment analysis the “Guidelines on the Assessment of Investment Analysis” version 05 will be taken into account and the following sub-steps will be completed:

***Sub-step 2a. Determine appropriate analysis method:***

The CDM project activity will generate financial or economic benefits other than the CDM related income, so simple cost analysis cannot be used (option I). Under this situation, investment comparison analysis (option II) or benchmark analysis (option III) applies.

And according the “Guidelines on the Assessment of Investment Analysis” version 05 (paragraph 19) the benchmark analysis is appropriate if the alternative to the project activity is the supply of electricity from a grid. Then, the benchmark approach (option III) is selected for the investment analysis as it is suited to circumstances where the baseline does not require investment or is outside the direct control of the project developer, i.e. cases where the choice of the developer is to invest or not to invest.

***Sub-step 2b: Option III. Apply benchmark analysis:***

For the investment analysis the financial indicator is post-tax IRR (100% equity) and it was compared against a benchmark.

According the “Guidelines on the Assessment of Investment Analysis” v.5 paragraph 19, if the alternative to the project activity is the supply of electricity from a grid, a benchmark approach is considered appropriate.

**Benchmark determination:**

According to the Appendix of the “Guidelines on the Assessment of Investment Analysis” v.5, the selected benchmark as per Group I: Energy Industry, in Chile is therefore, equal to 10.3% post-tax. Since the financial evaluation is performed in nominal terms, the inflation considered is 2.5% and therefore the benchmark is 12.8%.

This value is expressed in percentages in nominal terms and compared with the IRR which was also calculated in nominal terms.

***Sub-step 2c: Calculation and comparison of financial indicators***

The project activity's financial evaluation considers the following parameters:

**Table 5. Financial evaluation parameters**

Parameter	Value
Installed capacity	141 MW
Energy generation	407,420 MWh
Plant Load Factor	33%
Firm capacity	11.3MW
Energy price	75.5 USD/MWh
Firm capacity price	9.2 USD/kW-month
NCRE price	12.4 USD/MWh
Total CAPEX	MMUSD 413.7
Annual Costs	MUSD 3,438
Depreciation	7 years

The period of the financial analysis is 20 years and considering the data presented above, the result of the financial parameter IRR is: 6.1%. Therefore, the IRR does not reach the benchmark minimum (12.8%).

#### ***Sub-step 2d: Sensitivity analysis***

According to the "Guidelines on the Assessment of Investment Analysis" version 05, only variables, (including the initial investment cost) that constitute more than 20% of either total project costs or total project revenues should be subjected to reasonable variation (at least a range of +10% and –10%, is recommended by this guidance).

According to the economic evaluation of the project activity, the following parameters are included in the sensitivity analysis:

- Energy Generation
- Energy price
- NCRE price
- CAPEX

The IRR post-tax is analyzed for a fluctuation of +10% for energy generation, energy price and NCRE price and -10% CAPEX; the four parameters are analyzed independently and the results are shown in the following table:

**Table 6: Sensitivity analysis results**

Parameter	Fluctuation (%)	IRR (%)
a) Energy Generation	+10%	7.2
b) Energy price	+10%	8.1
c) NCRE price	+10%	6.4
d) CAPEX	-10%	7.4

Therefore, the conclusion that CDM project activity is not the most economically attractive alternative is robust to reasonable variations in the critical assumptions. Consequently it is possible to state that the project is financially additional.

#### **Step 3: Barrier analysis**

Project activity doesn't considerer a barrier analysis to demonstrate additionality.

**Step 4. Common Practice analysis**

The “Tool for demonstration and assessment of additionality” version 07 suggests on this step that the above generic additionality tests shall be complemented with an analysis of the extent to which the proposed project type has already diffused in the relevant sector and region. This test is a credibility check to complement the investment analysis (Step 2) or barrier analysis (Step 3).

This test considers to provide an analysis of any other activities that are operational and that are similar to the proposed project activity, considering similar if they are in the same country/region and/or rely on a broadly similar technology, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, financing, etc. Other CDM project activities (registered project activities and project activities which have been published on the UNFCCC website for global stakeholder consultation as part of the validation process) are not to be included in this analysis

According to the “Tool for demonstration and assessment of additionality” v.07 if a CDM project activity corresponds to one of the measures listed in the definitions section of the tool, the Common Practice analysis should be assessed in accordance to Sub-step 4a, following the latest version of the “Guidelines on common practice”; if not it should be followed Sub-step 4b. Since the measure of Los Andes photovoltaic farm corresponds to “switch of technology”, which is listed in the tool, the step wise approach for common practice detailed in the “Guidelines on common practice” version 02 is applied:

**Step 1:** Calculation of the applicable output range.

The output range is calculated based in the CDM project design capacity of 141 MW, then the calculated applicable output range is:

-50%: 70.5 MW  
+50%: 211.5 MW

**Step 2:** Calculation of  $N_{all}$

In the Common Practice spreadsheet there are identified all plants that deliver the same capacity, within the applicable output range of the project activity as calculated in Step 1 (70.5 – 211.5 MW) and have started commercial operation before the start date of the project activity. Then, the calculated number  $N_{all}$  is 39.

The following table details the information of each  $N_{all}$  plant considered for this analysis.

**Table 7. List of all plants that are within the output range calculated based on the design capacity**

System	Power Plant	Registered CDM Projects/Under validation <sup>6</sup>	Energy source / fuel	Gross Capacity (MW)
SIC	Alfalfal	No	Hydro	178.00
SIC	Machicura	No	Hydro	95.00
SIC	Rucúe	No	Hydro	178.40
SIC	Canutillar	No	Hydro	172.00
SIC	Sauzal	No	Hydro	76.80
SIC	Cipreses	No	Hydro	106.00
SIC	Abanico	No	Hydro	136.00

<sup>6</sup> Information obtained from CDM website at July 2013. Web page: <http://cdm.unfccc.int/Projects/projsearch.html>



System	Power Plant	Registered CDM Projects/Under validation <sup>6</sup>	Energy source / fuel	Gross Capacity (MW)
SIC	Peuchén	No	Hydro	85.00
SIC	Curillinque	No	Hydro	92.00
SIC	Ventanas 1	No	Coal	120.00
SIC	Los Vientos	No	Diesel	132.00
SIC	Santa Lidia	No	Diesel	139.00
SIC	Nehuenco 9B	No	Natural Gas	108.00
SIC	Antilhue TG	No	Diesel	102.50
SIC	Los Pinos	No	Diesel	104.19
SIC	Yungay (ex campanario)	No	Diesel	199.13
SIC	Bocamina	No	Coal	130.00
SIC	Taltal 1	No	Natural Gas	123.40
SIC	Taltal 2	No	Natural Gas	121.50
SIC	El Peñón	No	Diesel	81.00
SIC	Trapén	No	Diesel	81.00
SIC	Termopacífico	No	Diesel	81.22
SIC	Cardones	No	Diesel	153.04
SIC	Los Espinos	No	Diesel	124.00
SIC	Petropower	No	Petcoke	75.00
SIC	Olivos	No	Diesel	115.20
SIC	Renca	No	Diesel	100.00
SING	TERMOLÉCTRICA ANDINA - CTA	No	Coal	168.80
SING	TERMOELÉCTRICA TARAPACÁ - CTTAR	No	Coal	158.00
SING	TERMOELÉCTRICA MEJILLONES - CTM1	No	Coal + Petcoke	165.90
SING	TERMOELÉCTRICA MEJILLONES - CTM2	No	Coal + Petcoke	175.00
SING	DIESEL TAMAYA - SUTA	No	Fuel Oil	103.68
SING	TERMOELÉCTRICA TOCOPILLA - U12	No	Coal	85.30
SING	TERMOELÉCTRICA TOCOPILLA - U13	No	Coal	85.50
SING	TERMOELÉCTRICA TOCOPILLA - U14	No	Coal	136.40
SING	TERMOELÉCTRICA TOCOPILLA - U15	No	Coal	132.40
SING	TERMOELÉCTRICA HORNITOS - CTH	No	Coal	170.10
SING	TERMOELÉCTRICA NORGENER - NTO1	No	Coal + Petcoke	136.30
SING	TERMOELÉCTRICA NORGENER - NTO2	No	Coal + Petcoke	141.04

**Step 3:** Calculation of  $N_{diff}$ 

In this step, from the plants identified in Step 2, there should be identified all the plants that use a different technology than the technology applied in the proposed project activity ( $N_{diff}$ ).



According to the definition of different technologies stated in paragraph 9 of the “Tool for demonstration and assessment of additionality” v.07.0.0, in the context of the current project activity would be plants that deliver the same output and that differ by:

a) Energy source.

The project activity uses solar power as energy source, therefore projects that use geothermal, hydro, biomass, wind, diesel, gas, coal or other energy source are considered as different technologies.

Then, as it can be seen in the table above, the calculated number  $N_{diff}$  is 39.

**Step 4:** Calculation of factor  $F=1-N_{diff}/N_{all}$ .

This Factor (F) represents the share of plants using technology similar to the technology used in the proposed project activity in all plants that deliver the same output or capacity as the proposed project activity.

Considering the values calculated above,  $F= 1-39/39= 0$

Finally, according to the “Tool for the demonstration and assessment of additionality” version 07.0 the proposed project activity is a common practice within a sector in the applicable geographical area if both the following conditions are fulfilled:

- (a) The factor F is greater than 0.2, and
- (b)  $N_{all}-N_{diff}$  is greater than 3.

Considering the above calculations, the result of  $N_{all}-N_{diff}$  is equal to 0 and the calculated factor F is 0, which means that there aren't any similar technologies operating in Chile as the used in the project activity.

As a result of the previous analysis, Los Andes photovoltaic farm has proved not to be a “common practice”.

## **B.6. Emission reductions**

### **B.6.1. Explanation of methodological choices**

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According to the ACM0002 v. 14.0, the baseline scenario of Los Andes project activity is the electricity delivered to the grid 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 “Tool to calculate the emission factor for an electricity system” v.04.

The emission reductions are calculated as the difference between the emission of the baseline scenario and the emissions due to the Los Andes Photovoltaic Project and the associated leakage.

### **Baseline emissions**

Baseline emissions include only CO<sub>2</sub> emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity. The methodology assumes that all project electricity generation above baseline levels would have been generated by existing grid-connected power plants and the addition of new grid-connected power plants. The baseline emissions are to be calculated as follows:

**Equation 1: Baseline emissions**

$$BE_y = EG_{BL,y} \times EF_{CO_2,grid,y}$$

Where:

$BE_y$ : Baseline emissions in year  $y$  (tCO<sub>2</sub>/yr)

$EG_{BL,y}$ : Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the CDM project activity in year  $y$  (MWh/yr)

$EF_{CO_2,grid,y}$ : CO<sub>2</sub> emission factor of the grid in year  $y$  (tCO<sub>2</sub>/MWh)

Calculation of  $EG_{PJ,y}$ 

The calculation of  $EG_{PJ,y}$  is different for: Greenfield plants, retrofits and replacements, and replacements; and capacity additions. Since the Los Andes project is a Greenfield renewable energy power plant because of the installation of a new grid-connected renewable power plant/unit at a site where no renewable power plant was operated prior to the implementation of the project activity, then:

**Equation 2. Project Activity electricity generation**

$$EG_{PJ,y} = EG_{facility,y}$$

Where:

$EG_{PJ,y}$ : Quantity of net electricity generation that is produced and fed into the grid as a result of the implementation of the project activity in year  $y$  (MWh)

$EG_{facility,y}$ : Quantity of net electricity generation supplied by the project plant/unit to the grid in year  $y$  (MWh)

$EG_{facility,y}$  is the quantity of net electricity generation supplied by the project plant/unit to the grid. It shall be determined as a difference between (i) quantity of electricity supplied by the project plant/unit to the grid and (ii) quantity of electricity consumed by the project plant/unit from the grid.

Calculation of  $EF_{grid\ CM,y}$ 

The emission factor is calculated ex-ante in a transparent and conservative manner as a Combined Margin (CM). CM consists in the combination of operating margin and build margin in accordance with the “Tool to calculate the emission factor of an electricity system”, v.04, which includes six steps to be applied:

- Step 1. Identify the relevant electricity systems.
- Step 2. Choose whether to include off-grid power plants in the project electricity system (optional)
- Step 3. Select a method to determine the operating margin (OM).
- Step 4. Calculate the operating margin emission factor according to the selected method.
- Step 5. Calculate the build margin (BM) emission factor.
- Step 6. Calculate the combined margin (CM) emissions factor.

The steps and formulae used to estimate baseline emissions and project emissions of the proposed project activity are described below:

**Step 1. Identify the relevant electric systems**

There are five electricity systems in Chile; SING, SIC, Aysen, Magallanes and Isla de Pascua systems which cover different geographical locations along the country. All of them operate independently and





do not transfer electricity to each other, so neither imports nor exports are observed in any of the mentioned systems.

The electricity systems to which this project activity is connected is the SING grid therefore all the necessary information of the power plants within the SING will be considered to calculate the build margin and the operating margin emission factor for each electricity system.

### Step 2. Choose whether to include off-grid power plants in the project electricity system

To calculate the operating margin and build margin emission factors, the chosen method is Option I: Only grid power plants are included in the calculation.

### Step 3. Select a method to determine the operating margin (OM).

The selected OM emission factor method from the “Tool to calculate the emission factor of an electricity system” version 04 is Option (d) Average OM. In this method the emission factor is calculated as the average emission rate of all power plants serving the grid.

The data vintage chosen for the calculation of the OM emission factor is the ex-ante option, where calculations are based on a 3-year generation-weighted average and the most recent data (2012, 2011, and 2010) available at the time of submission of the PDD to the DOE for validation, without requirement to monitor and recalculate the emission factor during the crediting period.

### Step 4. Calculate the operating margin emission factor according to the selected method.

The Average OM may be calculated by one of the following two options:

Option A: Based on the net electricity generation and a CO<sub>2</sub> emission factor of each power unit; or  
Option B: Based on the total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

Option A is selected. Under this option, the Average OM emission factor is calculated based on the net electricity generation of each power unit and an emission factor for each power unit, as follows:

**Equation 3. Operating Margin Emission factor**

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

Where:

- $EF_{grid,OMave,y}$  : Average operating margin CO<sub>2</sub> emission factor in year  $y$  (tCO<sub>2</sub>/MWh).  
 $EG_{m,y}$  : Net quantity of electricity generated and delivered to the grid by power plant / unit  $m$  in year  $y$  (MWh).  
 $EF_{EL,m,y}$  : CO<sub>2</sub> emission factor of power unit  $m$  in year  $y$  (tCO<sub>2</sub>/MWh)  
 $m$  : All power units serving the grid in year  $y$ .  
 $y$  : The three most recent years for which data is available at the time of submission of the CDM-PDD to de DOE for validation (ex-ante option).

The CO<sub>2</sub> emission factor of each power unit is determined using options A1, A2 or A3, as indicated in the “Tool to calculate the emission factor of an electricity system” version 04, using the most recent historical year (2012, 2011, and 2010) for which power generation data is available.



For power plants where data on fuel consumption and electricity generation is available, the emission factor should be determined using Option A1 as follows:

**Equation 4. CO<sub>2</sub> emission factor of power units. Option A1**

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \times NCV_{i,y} \times EF_{CO_2,i,y}}{\sum_m EG_{m,y}}$$

Where:

- $EF_{EL,m,y}$  : CO<sub>2</sub> emission factor of power unit  $m$  in year  $y$  (tCO<sub>2</sub>/GWh)  
 $FC_{i,m,y}$  : Amount of fossil fuel type  $i$  consumed by power unit  $m$  in year  $y$  (mass or volume unit)  
 $NCV_{i,y}$  : Net calorific value (energy content) of fossil fuel type  $i$  in year  $y$  (GJ / mass or volume unit)  
 $EF_{CO_2,i,y}$  : CO<sub>2</sub> emission factor of fossil fuel type  $i$  in year  $y$  (tCO<sub>2</sub>/GJ)  
 $EG_{m,y}$  : Net quantity of electricity generated and delivered to the grid by power unit  $m$  in year  $y$  (MWh)  
 $m$  : All grid power units serving the grid in year  $y$   
 $i$  : All fossil fuel types combusted in power unit  $m$  in year  $y$   
 $y$  : The three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex-ante option).

When using option A1, data on fuel consumption of a particular power plant/unit ( $FC_{i,m,y}$ ) can be obtained from the total amount of fuel in mass or volume units (kg or m<sup>3</sup>), from CDEC-SING;

In cases where power units haven't got available data of fuel consumption, the emission factor for those power plants was determined using option A2 and the following equation:

**Equation 5. CO<sub>2</sub> emission factor of power units. Option A2**

$$EF_{EL,m,y} = \frac{EF_{CO_2,m,i,y} \times 3.6}{\eta_{m,y}}$$

Where:

- $EF_{EL,m,y}$  : CO<sub>2</sub> emission factor of power unit  $m$  in year  $y$  (tCO<sub>2</sub>/MWh)  
 $EF_{CO_2,m,i,y}$  : Average CO<sub>2</sub> emission factor of fuel type  $i$  used in power unit  $m$  in year  $y$  (tCO<sub>2</sub>/GJ)  
 $\eta_{m,y}$  : Average net energy conversion efficiency of power unit  $m$  in year  $y$  (ratio)  
 $m$  : All grid power units serving the grid in year  $y$   
 $i$  : All fossil fuel types combusted in power unit  $m$  in year  $y$   
 $y$  : The three most recent years for which data is available at the time of submission of the CDM-PDD to the DOE for validation (ex-ante option).

**Option A3.** If for a power unit  $m$  only data on electricity generation is available, an emission factor of 0 tCO<sub>2</sub>/MWh can be assumed as a simple and conservative approach.

Since the required information about fuel consumption and electricity generation is available for all power plants/units, only option A1 is used.

**Step 5. Calculate the build margin (BM) emission factor.**

The BM emission factor is determined in accordance to Option 1 of the “Tool to calculate the emission factor of an electricity system” v.04, where for the first crediting period the build margin emission factor is calculated ex-ante based on the most recent information available (2012) on units already built for sample group  $m$  at the time of CDM-PDD submission to the DOE for validation. For the second crediting period, the BM emission factor should be updated based on the most recent information available on units already built at the time of submission of the request for renewal of the crediting period to the DOE. For the third crediting period, the BM emission factor calculated for the second crediting period should be used. This option does not require monitoring the emission factor during the crediting period.

The sample group of power units  $m$  used to calculate the build margin is determined as per the following procedure provided in the “Tool to calculate the emission factor for an electricity system” v.04:

- (a) Identify the set of five power units, excluding units registered as CDM project activities, that started to supply electricity to the grid most recently ( $SET_{5-units}$ ) and determine their annual electricity generation ( $AEG_{SET_{5-units}}$  in MWh);
- (b) Determine the annual electricity generation of the project activity system, excluding power units registered as CDM project activities ( $AEG_{total}$ , in MWh). Identify the set of power units, excluding power units registered as CDM project activities, that started to supply electricity to the grid most recently and that comprise 20% of  $AEG_{total}$  (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) ( $SET_{\geq 20\%}$ ) and determine their annual electricity generation,  $AEG_{SET_{\geq 20\%}}$  in MWh)
- (c) From  $SET_{AEG_{SET_{5-units}}}$  and  $SET_{\geq 20\%}$  select the set of power units that comprises the larger annual electricity generation ( $SET_{sample}$ );  
Identify the date when the power units in  $SET_{sample}$  started to supply electricity to the grid. If none of the power units in  $SET_{sample}$  started to supply electricity to the grid more than 10 years ago, then use  $SET_{sample}$  to calculate the build margin. Ignore steps (d), (e) and (f).

Otherwise:

- (d) Exclude from  $SET_{sample}$  the power units which started to supply electricity to the grid more than 10 years ago. Include in that set the power units registered as CDM project activities, starting with power units that started to supply electricity to the grid most recently, until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation) to the extent is possible. Determine for the resulting set ( $SET_{sample-CDM}$ ) the annual electricity generation ( $AEG_{SET_{sample-CDM}}$ , in MWh).

If the annual electricity generation of that set is comprises at least 20% of the annual electricity generation of the project electricity system (i.e.  $AEG_{SET_{sample-CDM}} \geq 0.2 \times AEG_{total}$ ), then use the sample group  $SET_{sample-CDM}$  to calculate the build margin. Ignore steps (e) and (f).

Otherwise:

- (e) Include in the sample group  $SET_{sample-CDM}$  the power units that started to supply electricity to the grid more than 10 years ago until the electricity generation of the new set comprises 20% of the annual electricity generation of the project electricity system (if 20% falls on part of the generation of a unit, the generation of that unit is fully included in the calculation);
- (f) The sample group of power units  $m$  used to calculate the build margin is the resulting set ( $SET_{sample-CDM->10yrs}$ ).



None of the power units in  $SET_{\text{sample}}$  started to supply electricity to the grid more than 10 years ago, then  $SET_{\text{sample}}$  is used to calculate the build margin. Steps (d), (e) and (f) are ignored.

The build margin emission factor is the generation-weighted average emission factor (tCO<sub>2</sub>/MWh) of all power units  $m$  during the most recent year  $y$  (2012) for which power generation data is available, calculated as follows:

**Equation 6. Build Margin emission factor**

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

Where:

$EF_{\text{grid},\text{BM},y}$ :	Build margin CO <sub>2</sub> emission factor in year $y$ (tCO <sub>2</sub> /MWh)
$EG_{m,y}$ :	Net quantity of electricity generated and delivered to the grid by power unit $m$ in year $y$ (MWh)
$EF_{\text{EL},m,y}$ :	CO <sub>2</sub> emission factor of power unit $m$ in year $y$ (tCO <sub>2</sub> /MWh)
$m$ :	Power units included in the build margin
$y$ :	Most recent historical year for which power generation data is available

The CO<sub>2</sub> emission factor of each power unit  $m$  ( $EF_{\text{EL},m,y}$ ) is determined using option A1 (represented by Equation 4), using for  $y$  the most recent historical year (2012) for which power generation data is available, and using for  $m$  the power units included in the build margin.

**Step 6. Calculate the combined margin (CM) emissions factor.**

The calculation of the combined margin (CM) emission factor ( $EF_{\text{grid},\text{CM},y}$ ) is based on method (a) Weighted average CM as follows:

**Equation 7. Combined Margin emission factor**

$$EF_{\text{grid},\text{CM},y} = EF_{\text{grid},\text{OM},y} \times w_{\text{OM}} + EF_{\text{grid},\text{BM},y} \times w_{\text{BM}}$$

Where:

$EF_{\text{grid},\text{CM},y}$ :	Combined margin CO <sub>2</sub> emission factor in year $y$ (tCO <sub>2</sub> /MWh)
$EF_{\text{grid},\text{BM},y}$ :	Build margin CO <sub>2</sub> emission factor in year $y$ (tCO <sub>2</sub> /MWh)
$EF_{\text{grid},\text{OM},y}$ :	Operating margin CO <sub>2</sub> emission factor in year $y$ (tCO <sub>2</sub> /MWh)
$w_{\text{OM}}$ :	Weighting of operating margin emissions factor (%)
$w_{\text{BM}}$ :	Weighting of build margin emissions factor (%)

The default values established in the “Tool to calculate the emission factor for an electricity system” version 04 for the weighting of the OM ( $w_{\text{OM}} = 75\%$ ) and for the weighting of the BM ( $w_{\text{BM}} = 25\%$ ), are used in the calculation of the baseline emission factor.

**Project emissions**

According to the applicable methodology ACM0002: “Grid-connected electricity generation from renewable sources” version 14.0.0 for most renewable power generation project activities,  $PE_y = 0$ . However, some project activities may involve project emissions that can be significant. These emissions shall be accounted for by using the following equation:

**Equation 8. Project Emissions**

$$PE_y = PE_{FF,y} + PE_{GP,y} + PE_{HP,y}$$

Where:

$PE_y$ :	Project emissions in year $y$ (tCO <sub>2</sub> e/yr)
$PE_{FF,y}$ :	Project emissions from fossil fuel consumption in year $y$ (tCO <sub>2</sub> /yr)
$PE_{GP,y}$ :	Project emissions from the operation of geothermal power plants due to the release of non-condensable gases in year $y$ (tCO <sub>2</sub> e/yr)
$PE_{HP,y}$ :	Project emissions from reservoirs of hydro power plants in year $y$ (tCO <sub>2</sub> e/yr)

Accordingly for this project activity,  $PE_{GP,y}$  and  $PE_{HP,y}$  are not applicable. Regarding,  $PE_{FF,y}$ , the only fossil fuel involved will be for back up or emergency purposes which can be neglected according to the ACM0002 v.14.0.

**Leakage**

Under the methodology ACM0002 version 14.0 no leakage emissions are considered. The main emissions potentially giving rise to leakage in the context of electric sector projects are emissions arising due to activities such as power plant construction and upstream emissions from fossil fuel use (e.g. extraction, processing, transport, etc). These emissions sources are neglected.

**Emission reductions**

Emission reductions of the project activity are calculated as follows:

**Equation 9. Emission Reductions**

$$ER_y = BE_y - PE_y - LE_y$$

Where:

$ER_y$ :	Emission reductions for the year $y$ (tCO <sub>2</sub> /yr)
$BE_y$ :	Baseline emissions for the year $y$ (tCO <sub>2</sub> /yr)
$PE_y$ :	Project emissions for the year $y$ (tCO <sub>2</sub> /yr)
$LE_y$ :	Leakage emissions for the year $y$ (tCO <sub>2</sub> /yr)

**B.6.2. Data and parameters fixed ex ante**

<b>Data / Parameter</b>	<b>EG<sub>m,y</sub></b>
<b>Unit</b>	MWh
<b>Description</b>	Net quantity of electricity generated and delivered to the grid by power unit <i>m</i> in year <i>y</i> .
<b>Source of data</b>	CDEC-SING Annual Reports
<b>Value(s) applied</b>	Please refer to values in Table 10 of Appendix 4.
<b>Choice of data or Measurement methods and procedures</b>	Data from CDEC represents the most recent and reliable information available.
<b>Purpose of data</b>	Calculation of Baseline emissions.
<b>Additional comment</b>	N/A

<b>Data / Parameter</b>	<b>FC<sub>i,m,y</sub></b>
<b>Unit</b>	For Diesel and Coal: kg/year, for Natural Gas: m <sup>3</sup> /year.
<b>Description</b>	Amount of fossil fuel type <i>i</i> consumed by power plant / unit <i>m</i> in year <i>y</i>
<b>Source of data</b>	CDEC-SING data.
<b>Value(s) applied</b>	Please refer to values in Table 11 of Appendix 4.
<b>Choice of data or Measurement methods and procedures</b>	Data from CDEC-SING represents the most recent and reliable information available.
<b>Purpose of data</b>	Calculation of Baseline emissions.
<b>Additional comment</b>	-



<b>Data / Parameter</b>	NCV <sub>i,y</sub>
<b>Unit</b>	For Diesel and Coal: [GJ/kg] and For Natural Gas: [GJ/m <sup>3</sup> ]
<b>Description</b>	Net calorific value (energy content) of fossil fuel type <i>i</i> in year <i>y</i>
<b>Source of data</b>	CNE Annual Energy Balance Report 2011 and IPCC revised guidelines (2006).
<b>Value(s) applied</b>	Values in Table 13 of Appendix 4.
<b>Choice of data or Measurement methods and procedures</b>	Data from CNE represent the most reliable information available for national fuels, and IPCC represent the most reliable information available for default values and methodological requirements.
<b>Purpose of data</b>	Calculation of Baseline emissions.
<b>Additional comment</b>	CNE Energy Balance Report includes Gross Calorific Values (GCV) for different types of fuel. These values were corrected to Net Calorific Values (NCV) based on IPCC assumption stating that for liquid and solid fuels NCV is 5% lower than GCV, and for gas fuels NCV is 10% lower than GCV.

<b>Data / Parameter</b>	EF <sub>CO<sub>2</sub>,i,y</sub> and EF <sub>CO<sub>2</sub>,m,i,y</sub>
<b>Unit</b>	tCO <sub>2</sub> /GJ
<b>Description</b>	CO <sub>2</sub> emission factor of fossil fuel type <i>i</i> used in power unit <i>m</i> in year <i>y</i> .
<b>Source of data</b>	IPCC revised guidelines (2006). Available in Web Page: <a href="http://www.ipcc-nggip.iges.or.jp/public/2006gl/">http://www.ipcc-nggip.iges.or.jp/public/2006gl/</a>
<b>Value(s) applied</b>	Values in Table 13 of Appendix 4.
<b>Choice of data or Measurement methods and procedures</b>	No other data is publicly available. For estimating emission factor for different fossil fuel-based generation technologies, IPCC guidelines have been used in a conservative manner
<b>Purpose of data</b>	Calculation of Baseline emissions.
<b>Additional comment</b>	N/A



<b>Data / Parameter</b>	$EF_{grid,CM,y}$
<b>Unit</b>	tCO <sub>2</sub> /MWh
<b>Description</b>	Combined margin CO <sub>2</sub> emission factor for SING grid connected power generation in year <i>y</i> calculated using the latest version of the “Tool to calculate the emission factor for an electricity system v.04”
<b>Source of data</b>	Calculated as per the “Tool to calculate the emission factor for an electricity system” version 04 based on: <ul style="list-style-type: none"> <li>- CDEC-SING data.</li> <li>- Energy National Balance 2011, Energy National Commission (CNE)</li> <li>- Revised 2006 IPCC Guidelines</li> <li>- Defaults values from "Tool to calculate the emission factor for an electricity system v.04" page 33</li> </ul>
<b>Value(s) applied</b>	0.888
<b>Choice of data or Measurement methods and procedures</b>	This data is used to calculate the combined emission factor of the SING grid. All data is available from public national sources like CDEC-SING (fossil fuel consumption), CNE (specific fossil fuel consumption) or international available data like IPCC Guideline
<b>Purpose of data</b>	Calculation of Baseline emissions.
<b>Additional comment</b>	The $EF_{grid,CM,y}$ value will be fixed ex- ante

### B.6.3. Ex ante calculation of emission reductions

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#### Baseline Emissions

The CO<sub>2</sub> emission factor of the grid ( $EF_{CO_2grid,y} = 0.888$  tCO<sub>2</sub>/MWh) was calculated in a transparent and conservative manner as a combined margin consisting in a combination of operating margin (OM) and a build margin (BM) according procedures prescribed in the “Tool to calculate the Emission Factor for an electricity system” version 04.

#### *Operating Margin (OM) Emission Factor*

A transparent ex-ante calculation of the OM emission factor is presented below, applying all relevant equations presented in section B.6.1 above, provided in the “Tool to calculate the emission factor for an electricity system” version 04 and using the data presented in Appendix 4.

The values used for estimating the emission factor for each power plant included in the OM are exposed in the tables presented in Appendix 4 and depending on annual fuel consumption or specific fuel consumption data availability option A1 is applied, using Equation 4.

An example of the calculation considering Option A1 is provided using 2010 data for Gas Atacama, which consumes Natural Gas and Diesel:

$$EF_{EL,m,y} = \frac{275,938,500kg \times 0.043(GJ/kg) \times 0.0726(tCO_2/GJ) + 302,170,000(m^3) \times 0.035(GJ/m^3) \times 0.0543(tCO_2/GJ)}{2,887,650.35(tCO_2/MWh)}$$





$$EF_{EL,m,y} = 0.50tCO_2 / MWh$$

The OM emission factor is calculated using Equation 3 for each year (2010, 2011 and 2012).

As an example of the calculation of the operating margin emission factor for year 2010 using Equation 3 is provided below:

$$EF_{ave,2010} = \frac{11,229,928.64tCO_2}{14,284,391.06MWh}$$

According to the data vintage chosen in Step 3 (ex-ante option), the Operating Margin emission factor is calculated as a 3-year generation-weighted average of the values for years 2010, 2011 and 2012.

**Table 8. Operational Margin Emission Factors**

Year	Operational Margin Emission Factor
	EF <sub>grid,OM-adj,y</sub> [tCO <sub>2</sub> /MWh]
2010	0.7862
2011	0.8491
2012	0.9258

Finally, the full generation-weighted average operating margin emission factor for the most recent 3 years is 0.856 tCO<sub>2</sub>/MWh.

#### ***Build margin (BM) emission factor***

A transparent ex-ante calculation of the BM emission factor is presented below, applying all relevant equations presented in section B.6.1 above, provided in the “Tool to calculate the emission factor for an electricity system” version 04 and using the data presented in Appendix 4.

The values used for estimating the emission factor for each power unit included in the BM are presented in Appendix 4 and depending on annual fuel consumption or specific fuel consumption data availability option A1 was applied, using Equation 4. The BM emission factor is calculated for year 2012 using Equation 6.

The option selected to calculate the build margin was option (b) of the tool. The option was selected since power plant capacity additions in the electricity system that include the 20% of the system net generation and have been built most recently comprises a larger annual generation than the five power units that have been built most recently as it can be seen in Appendix 4.

The BM factor is calculated by using the values presented in Appendix 4.

An example of the calculation considering Option A1 is provided for Hornitos, considering its coal and diesel consumption (using data from the year 2012):

$$EF_{EL,m,y} = \frac{371,010,000(kg) \times 0.028(GJ / kg) \times 0.0873(tCO_2 / GJ) + 652,3300(kg) \times 0.043(GJ / kg) \times 0.0726(tCO_2 / GJ)}{870,622(MWh)}$$



$$EF_{EL,m,y} = 1.038tCO_2 / MWh$$

Using the values presented in Appendix 4 the following value for the BM emission factor is calculated by applying equation 6:

$$EF_{grid,BM,y} = \frac{4,99,343tCO_2}{5,064,022MWh} = 0.987tCO_2 / MWh$$

Finally the Build Margin Emission factor of the grid is 0.987 tCO<sub>2</sub>/MWh.

### **Combined margin (CM) emission factor**

Using the EF<sub>grid,OM</sub> value, the EF<sub>grid,BM</sub> value and the weighting values of the OM ( $w_{OM} = 75\%$ ) and the BM ( $w_{BM} = 25\%$ ), the CM emission factor estimation is calculated as follows:

$$EF_{grid,CM,y} = 0.856tCO_2 / MWh \times 0.75 + 0.987tCO_2 / MWh \times 0.25 = 0.888tCO_2 / MWh$$

Finally, the baseline emission factor of the grid is 0.888 tCO<sub>2</sub>/MWh

### **Project Emissions**

Emissions during the project activity are equal to zero ( $PE_y = 0$ ).

### **Leakage**

There is no energy generating equipment being transferred from another activity, therefore leakage is not considered in the project activity ( $LE_y=0$ ).

### **Project activity Emission reductions**

The following table summarizes the results for OM and BM emission factors. These values are used to obtain an estimation of the CM emission factor of 0.888 tCO<sub>2</sub>/MWh and considering that the project activity expects to displace an average of 407,420 MWh of electricity per year, the emission reductions come approximately up to 361,788 tCO<sub>2</sub>e per year.

**Table 9. Emissions Reductions Estimation Data**

Variable	Unit	Value
OM Emissions Factor (EF <sub>grid,OM-ave,y</sub> )	tonnes CO <sub>2</sub> e/MWh	0.856
BM Emissions Factor (EF <sub>grid,BM,y</sub> )	tonnes CO <sub>2</sub> e/MWh	0.987
CM Emissions Factor (EF <sub>grid,CM,y</sub> )	tonnes CO <sub>2</sub> e/MWh	0.888
Average Electricity Generated by the project	MWh/year	407,420
Emissions Reduction (ER <sub>y</sub> )	tonnesCO <sub>2</sub> e/year	361,788

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

<b>Year</b>	<b>Baseline emissions (t CO<sub>2</sub>e)</b>	<b>Project emissions (t CO<sub>2</sub>e)</b>	<b>Leakage (t CO<sub>2</sub>e)</b>	<b>Emission reductions (t CO<sub>2</sub>e)</b>
2015	361,788	0	0	361,788
2016	361,788	0	0	361,788
2017	361,788	0	0	361,788
2018	361,788	0	0	361,788
2019	361,788	0	0	361,788
2020	361,788	0	0	361,788
2021	361,788	0	0	361,788
<b>Total</b>	361,788	0	0	361,788
<b>Total number of crediting years</b>	7			
<b>Annual average over the crediting period</b>	361,788	0	0	361,788

**B.7. Monitoring plan****B.7.1. Data and parameters to be monitored**



<b>Data / Parameter</b>	$EG_{P,J,y} = EG_{\text{facility}}$
<b>Unit</b>	MWh
<b>Description</b>	Quantity of net electricity generation supplied by Los Andes Photovoltaic Farm to the SING grid in year $y$ .
<b>Source of data</b>	On-site metering system. Meter located at the project site's substation before the grid injection point
<b>Value(s) applied</b>	407,420
<b>Measurement methods and procedures</b>	The electricity exported by the project activity and imported from the grid will be continuously measured by a bi-directional meter to be installed at the power plant substation and recorded monthly.  The electricity meter should have a maximum error of 0.2% according with Chilean regulations "Manual de procedimientos N°13 Instalación, lectura, sincronización y mantenimiento de equipos de medida utilizados en la valorización de transferencias entre integrantes del CDEC-SING" <sup>7</sup> According to this Manual, e-meters should be calibrated every 5 years.
<b>Monitoring frequency</b>	The net electricity of the project activity will be continuously measured by a bidirectional meter (class 02) and recorded monthly.
<b>QA/QC procedures</b>	The measurements will be crosschecked with the electricity records for sold electricity obtained from the grid operator and the smaller value of the two will be considered in a conservative manner.
<b>Purpose of data</b>	Calculations of baseline emissions
<b>Additional comment</b>	The data will be archived electronically and kept until two years after the end of the crediting period or the last issuance of CER for this project activity, whichever occurs later.

### B.7.2. Sampling plan

>>

It is not necessary a sampling plan for the project activity since there is no sampling data

### B.7.3. Other elements of monitoring plan

>>

The monitoring plan to be applied is based on the net electricity to be delivered by the project activity to the SING grid.

## 1. Monitoring organization

The monitoring organization of AES Gener for Los Andes project will be based in the current functions and responsibilities of the Operations Department of the company and also will designate a CDM manager which will be in charge that all the information required by the CDM monitoring plan is performed in accordance to the applicable methodology and also will be responsible of ensuring that the operating staff members are properly trained in the CDM matters.

The Operations Department is in charge of the data collection of each power plant of AES Gener, which is registered every hour automatically and every 2 hours by phone to its internal dispatch center. This data is showed by a meter placed in the generators exit. It's also in charge of coordinating maintenance or replacement of meters with an external company.

<sup>7</sup>Document available at Web site: [http://cdec2.cdec-sing.cl/pls/portal/cdec.pck\\_web\\_cdec\\_pages.pagina?p\\_id=3009](http://cdec2.cdec-sing.cl/pls/portal/cdec.pck_web_cdec_pages.pagina?p_id=3009)



## 2. Monitoring equipment and installation

The main electricity meter for the measurement of the electricity supplied to the grid will be installed at the Andes substation which connects the project to the SING grid.

This meter will have a maximum error of 0.2% in accordance with Chilean regulations. The calibrations will be performed in accordance to the grid Standard “Manual de procedimientos N°13 Instalación, lectura, sincronización y mantenimiento de equipos de medida utilizados en la valorización de transferencias entre integrantes del CDEC-SING”<sup>8</sup>. According to this Manual, electricity meters should be calibrated every 5 years.

The data measured d will be crosschecked with the records for sold electricity and in cases where any differences are detected, in a conservative manner the smaller value of the two will be considered

## 3. Data recording procedure

### a) Metering Electricity delivered to the Grid

- The net electricity generation data,  $EG_{PJ,y}$ , is received electronically and will be collected and registered every month and saved for CDM verification.
- The data will be archived electronically and kept for at least two years after the end of the last crediting period or the last issuance of CER for this project activity, whichever occurs later

### b) Electricity meter failure.

In case the electricity meters are found to be beyond the permissible error then the error encountered will be discounted to all meter readings since the last verification of equipment accuracy was performed as a conservative approach. However, the meter will be repaired or replaced as soon as possible once the error is detected.

## SECTION C. Duration and crediting period

### C.1. Duration of project activity

#### C.1.1. Start date of project activity

>> 15/03/2014

This is the date when the construction contract is expected to be signed

#### C.1.2. Expected operational lifetime of project activity

>>

20 years

### C.2. Crediting period of project activity

#### C.2.1. Type of crediting period

>>

Renewable, first period.

#### C.2.2. Start date of crediting period

>>

15/03/2015

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<sup>8</sup>Document available at Web site: [http://cdec2.cdec-sing.cl/pls/portal/cdec.pck\\_web\\_cdec\\_pages.pagina?p\\_id=3009](http://cdec2.cdec-sing.cl/pls/portal/cdec.pck_web_cdec_pages.pagina?p_id=3009)



### C.2.3. Length of crediting period

7 years, 0 months (2 times renewable).

## SECTION D. Environmental impacts

### D.1. Analysis of environmental impacts

>>

The Environment Evaluation Service (SEA<sup>9</sup>) is in charge of the Environmental Impact Assessment System (SEIA<sup>10</sup>), instrument that serves to analyze the environmental impact of different project initiatives and prevent the deterioration of the national environment. The SEIA relies on defined and specific criteria, as stated on the National Law N°19300/1994<sup>11</sup> and the SEIA Regulation DS N°95/2001<sup>12</sup> in order to determine whether a project requires to be subject matter to the system or not. If the project activity requires to be submitted to the SEIA and it results to be authorized, the proper authorities will make public their response through an authorization document (RCA<sup>13</sup>) published on the SEA Web page ([www.sea.gob.cl](http://www.sea.gob.cl)) and if the project activity does not require to be subject matter to the SEIA, a written letter expressing this matter is elaborated and presented to the project activity developer.

AES Gener S.A submitted to the national authorities all required evidence related to Los Andes Photovoltaic Farm in an Environmental Impact Statement (DIA<sup>14</sup>).

Los Andes Photovoltaic Farm's DIA was approved and obtained it's corresponding RCA N°151/2012 on July 3<sup>rd</sup> 2012 by resolution of the Regional Commission for the Environment (Antofagasta Region).

The project development and implementation does not consider significant environmental effects and those identified comply with the actual national and regional environmental regulation.

### D.2. Environmental impact assessment

>>

As mentioned in section D.1, all different stages of Los Andes Photovoltaic Farm fulfil the applicable national environmental regulations and requirements.

## SECTION E. Local stakeholder consultation

### E.1. Solicitation of comments from local stakeholders

>>

AES Gener performed a meeting at Los Andes substation (which is next to the project) with the persons that will be involved in the project and additionally it performed a meeting in the city of Antofagasta with the personnel of the company that will be affected by the project.

The meetings were performed on August 6<sup>th</sup> 2013 with the Substation operators at the facilities of Los Andes Substation and on August 7<sup>th</sup> 2013 with the offices personnel at the companies facilities in Antofagasta.

AES Gener invited the stakeholders to the meetings through a personal invitation and through an e-mail.

In total, between the two meetings, participated 20 persons.

<sup>9</sup> Spanish acronym for "Servicio de Evaluación Ambiental"

<sup>10</sup> Spanish acronym for "Sistema de Evaluación de Impacto Ambiental"

<sup>11</sup> Available in Web page: <http://www.leychile.cl/Navegar?idNorma=30667>

<sup>12</sup> Available in Web page: [http://www.sinia.cl/1292/articles-37936\\_pdf\\_reglamento\\_seia.pdf](http://www.sinia.cl/1292/articles-37936_pdf_reglamento_seia.pdf)

<sup>13</sup> RCA stands in Spanish for "Resolución de Calificación Ambiental" (Environmental Qualification Resolution)

<sup>14</sup> DIA stands in spanish for "Declaración de Impacto Ambiental". Information available at the SEA's web page: [http://seia.sea.gob.cl/expediente/ficha/fichaPrincipal.php?id\\_expediente=6581267&idExpediente=6581267&modo=ficha](http://seia.sea.gob.cl/expediente/ficha/fichaPrincipal.php?id_expediente=6581267&idExpediente=6581267&modo=ficha)

For both meetings the agenda considered the following topics:

- Project presentation
- Climate change, Kyoto protocol, CDM project, emission reductions and contribution to the sustainable development
- Questions session<sup>15</sup>

Some of the pictures from the stakeholders meetings are presented in the following figure:



Figure 4. Photographs of the Stakeholder's meetings

## E.2. Summary of comments received

>>

During the first meeting, Manuel Obreque, Christian Pizarro and Celin Ríos performed a various questions related to the CDM and nature of the project which were responded and clarified immediately.

The questions were related to understand the CDM, how it is presented a project for registration, if it's an obligation for the company and what can it be done with the bonds (CERs) of the project.

Regarding these questions it was clarified that the project participant submits its project to the CDM voluntarily but once in the process, it has to obey the rules of the UNFCCC. The registration process is regulated by the rules or guidelines of the CDM and that one of the requirements is that the project proves its prior consideration. It was also explained that the CERs of the project can be sold or maintained in the company to it's your own gas emissions (GHG).

<sup>15</sup> If any questions were made during the presentation, these were answered immediately.



Also there were questions related to specific features of the project such as the land that it will be occupied and what happens with the flora and fauna of the area. It was explained that the panels cover approximately 4 ha/MW and regarding the flora and fauna that that was addressed in the DIA of the project which has already been approved and also it was explained that the CDM requires the DNA (Designated National Authority, in Chile is the Ministry of Environment) approval for the project, which is conditioned to the approval of the RCA (environmental approval) of the project

During the second meeting Julio Morales, Juan Carlos Acosta, Juan Aracena and Mauricio Cereceda performed more general questions related how are performed the national inventories, what is the quantity of emissions generated at a city level in Chile, if the 20/20 commitment presented by Chile (20% of reduction by 2020) is mandatory and the about the procedure to determine the emission factor of the SING grid.

Regarding the national inventories, it was explained that they are performed in accordance to the IPCC guidelines, that these are reviewed by the UNFCCC which some times make some comments and that in case of the Energy sector, the emissions are calculated based in fuel consumption and emission factors reported by the country or, in its absence, the emission factor stated in the IPCC guidelines. In relation to the emissions by city, in Chile the GHG inventory is performed by sector at a country level, therefore there is no information by city. On another hand it was explained that the 20/20 commitment stated by Chile is voluntary and that it will be based in the emissions generated in 2007. Finally it was explained how the emission factor is calculated based in the calculation of the average operating margin, which is based in data of operation of the power plants from the last three years (2012, 2011 and 2010), and the building margin, which takes into account the data from the last year (2012).

### **E.3. Report on consideration of comments received**

>>

There were many encouraging comments from the participants. The questions were immediately answered at the meeting by the project developer.

### **SECTION F. Approval and authorization**

>>

The letter of approval is not available at the time of submitting the PDD to the validating DOE. It will be available before submitting the PDD for project registration.

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**Appendix 1: Contact information of project participants**

<b>Organization name</b>	AES Gener S.A.
<b>Street/P.O. Box</b>	Rosario Norte 532, Piso 19, Las Condes
<b>Building</b>	-
<b>City</b>	Santiago
<b>State/Region</b>	Metropolitana
<b>Postcode</b>	-
<b>Country</b>	Chile
<b>Telephone</b>	56-2-2 686 89 47
<b>Fax</b>	56-2-2 686 89 91
<b>E-mail</b>	-
<b>Website</b>	<a href="http://www.aesgener.cl/AESGenerWebNeo/index.aspx?channel=6139">http://www.aesgener.cl/AESGenerWebNeo/index.aspx?channel=6139</a>
<b>Contact person</b>	Joaquín Meléndez
<b>Title</b>	Project Manager
<b>Salutation</b>	Mr.
<b>Last name</b>	Meléndez
<b>Middle name</b>	-
<b>First name</b>	Joaquín
<b>Department</b>	-
<b>Mobile</b>	-
<b>Direct fax</b>	-
<b>Direct tel.</b>	-
<b>Personal e-mail</b>	<a href="mailto:jmelendez@AES.com">jmelendez@AES.com</a>

**Appendix 2: Affirmation regarding public funding**

Los Andes Photovoltaic Farm does not consider public funding.

**Appendix 3: Applicability of selected methodology**

All the information of applicability of the selected methodology is presented in the PDD.

**Appendix 4: Further background information on ex ante calculation of emission reductions**

**SING Emission factor data:****Table 10. Net electricity generation and delivered to the grid by company, 2010-2012**

Net Electricity generation (EG <sub>m,v</sub> ) MWh/yr			
Company	2010	2011	2012
Celta	999,380.00	906,153	778,027
Electroandina	4,544,500.51	3,141,694	4,477,858
E-CL	2,700,074.65	2,768,888	2,319,916
AES Gener	953,208.89	732,533	0
GasAtacama	2,887,650.35	2,055,744	737,993
Norgener	2,120,356.49	2,075,505	2,001,068
Andina	641.20	692,287	15,051
Angamos	249.95	1,786,906	17,797
Cavancha	14,203.63	14,531	7,841
Enernuevas	2,778.97	16,564	8,294
Enorchile	17,223.22	10,378	2,988,349
Inacal	44,123.20	24,225	1,179,585
Hornitos	0	598,225	870,622
Noracid	0	0	25,026
Selray	0	0	440
<b>TOTAL</b>	14,284,391.06	14,823,633	15,427,868

**Table 11. Fuel Consumption per company in the SING grid**

Company	Fuel type	Fuel consumption 2010	Fuel consumption 2011	Fuel consumption 2012
	i	FC <sub>i,m,2010</sub>	FC <sub>i,m,2011</sub>	FC <sub>i,m,2012</sub>
	-	kg or m <sup>3</sup> (for Natural gas)	kg or m <sup>3</sup> (for Natural gas)	kg or m <sup>3</sup> (for Natural gas)
Celta	Coal	413,910,000	375,990,000	330,640,000
	Natural gas	0	0	0
	Diesel	4,368,000	3,983,000	2,725,720
	Fuel oil N° 6	0	0	0
Electroandina	Coal	1,346,520,000	940,760,000	1,230,720,000
	Natural gas	295,830,000	233,410,000	274,100,000
	Diesel	11,205,000	17,894,000	8,201,110
	Fuel oil N° 6	53,435,000	31,239,000	28,773,650
E-CL	Coal	900,040,000	907,420,000	939,490,000
	Natural gas	28,400,000	64,290,000	64,550,000
	Diesel	67,547,690	12,876,420	8,852,350
	Fuel oil N° 6	24,345,000	13,432,000	9,221,900
AES Gener	Coal	0	0	0
	Natural gas	0	0	0
	Diesel	607,600	144,086,150	0
	Fuel oil N° 6	0	0	0
Gas Atacama	Coal	0	0	0
	Natural gas	302,170,000	390,730,000	117,630,000
	Diesel	275,938,500	47,664,700	41,459,300
	Fuel oil N° 6	0	0	0
Norgener	Coal	877,320,000	854,160,000	826,090,000



Company	Fuel type	Fuel consumption 2010	Fuel consumption 2011	Fuel consumption 2012
	i	FC <sub>i,m,2010</sub>	FC <sub>i,m,2011</sub>	FC <sub>i,m,2012</sub>
	-	kg or m <sup>3</sup> (for Natural gas)	kg or m <sup>3</sup> (for Natural gas)	kg or m <sup>3</sup> (for Natural gas)
	Natural gas	0	0	0
	Diesel	299,750	182,870	523,390
	Fuel oil N° 6	234,920	64,010	0
	Coal	0	0	0
Enorchile	Natural gas	0	0	0
	Diesel	3,714,630	2,235,570	1,740,649
	Fuel oil N° 6	0	0	0
	Coal	0	0	0
Inacal	Natural gas	0	0	0
	Diesel	349,710	657,480	451,530
	Fuel oil N° 6	9,356,560	4,699,630	1,410,460
	Coal	0	0	0
Angamos	Natural gas	0	741,230,000	1,225,130,000
	Diesel	64,600	4,900,650	701,670
	Fuel oil N° 6	0	694,020	0
	Coal	0	250,850,000	457,470,000
Andina	Natural gas	0	0	0
	Diesel	3,871,000	1,398,000	1,119,640
	Fuel oil N° 6	0	0	0
	Coal	0	190,220,000	371,010,000
Hornitos	Natural gas	0	0	0
	Diesel	0	4,747,000	652,330
	Fuel oil N° 6	0	0	0
	Coal	0	0	0

Table 12. Build Margin Calculation Data

Company	Power Unit	Starting Year	Power plant Net generation (MWh)	Emissions tCO <sub>2</sub>
NORACID	PAM	2012	25,026.17	0
SELRAY	HUAYCA1	2012	440.33	0
ANDINA		2012	79,193.22	1,115,462.48
ANDINA		2011	3,387.39	
ANDINA		2010	1,097,004.38	
HORNITOS		2012	6,773.36	903,839.70
HORNITOS	CTH	2011	857,079.78	
HORNITOS	CTH	2011	6,768.87	
ANGAMOS	ANG1	2011	1,671,921.08	2,980,041.12
ANGAMOS	ANG2	2011	1,316,427.81	
<b>Total</b>			<b>5,064,022.39</b>	<b>4,999,343.30</b>

**Note:** Since for power units owned by Angamos, Hornitos and Andina (SET of power units included in the BM), fuel consumption data is reported only at a company level, then the emission factor is calculated at a company level.



Table 13. Fuels Data

Fuel type	CO <sub>2</sub> Emission Factor	Gross calorific Value	GCV to NCV	Net Calorific Value
i	EF <sub>CO<sub>2</sub>,i,y</sub>	GCV <sub>i,y</sub>	conversion factor	NCV <sub>i,y</sub>
	[tCO <sub>2</sub> /GJ]	[Kcal/Kg; Kcal/m <sup>3</sup> (gas)]	according to IPCC guidelines	[GJ/kg; GJ/m <sup>3</sup> (gas)]
Coal	0.0895	7,000	0.95	0.027842
Diesel	0.0726	10,900	0.95	0.043354
Fuel Oil N°6	0.0755	10,500	0.95	0.041763
Natural Gas	0.0543	9,341	0.90	0.035198

### Appendix 5: Further background information on monitoring plan

All the information on the monitoring plan is presented in the PDD.

### Appendix 6: Summary of post registration changes

The project activity is currently in validation process