**MONITORING REPORT FORM (CDM-MR) ***
**Version 01 - in effect as of: 28/09/2010**

## *CONTENTS*



* as contained within the document entitled "Guidelines for completing the monitoring report form (CDM-MR)" (EB 54 meeting report, annex 34).

**MONITORING REPORT**
**Version 01 16/12/2011**

**Chile: Quilleco Hydroelectric Project**
**Project 1265**
**Monitoring Period 2 (09/07/2009 – 30/11/2011)**

## SECTION A. General description of the project activity

### A.1. Brief description of the project activity: >>

>>

The Quilleco Hydroelectric Project consists of a run-of-river power plant of 70 MW run-of-the-river hydropower plant that utilizes the water discharged by the Rucúe hydropower plant ($130m^3$/sec). The project generates approximately 422 GWh per year and injects 47 MW of firm power to the SIC electric grid (Sistema Interconectado Central). The estimates were based on long-term observations of water conditions of the Laja River.

The project developer and operator is Colbún S.A., the second largest electric holding company in Chile, with a total installed capacity of 2,364 MW, from which 48% are hydraulic power units. In the third quarter of 2005 Colbún acquired Cenelca S.A. and Hidroeléctrica Guardia Vieja S.A. (HGV). The latest company was one the first private companies worldwide to submit hydroelectric projects under the Kyoto Protocol CDM, this is the case of the Chacabuquito 26 MW power plant, operating since 01/07/2002. HGV still operates as a subsidiary of Colbún and will be acting as the project sponsor, representing Colbún S.A. for all CDM activities.

Quilleco uses well-proven technologies for run-of-river power generation. The project considers a 4.4 km concrete channels, 3.2 km aqueduct tunnel, 105 m pressure penstock of 59.4 m height, a power house with two sets of 35 MW vertical Francis turbines/generators, 13.8/220 kV power transformer and a 220 kV double circuit transmission line connected to the existing 220 kV double circuit transmission line to the high voltage Charrúa substation in the Central Interconnected System (SIC).

This project contributes to the sustainable development in Chile through:

- Use of local renewable energy resources (small hydro) to displace coal and natural gas thermal power generation in the SIC.
- Increased commercial activity through clean and renewable source of power.
- Employment generation in the 8th Region where the project is located, improving economic benefits it the surrounding communities such as Tucapel, Antuco and Quilleco.

The total amount of emission reductions during the second monitoring period is 517,317 tCO2e.

**Table A.1: Implementation of the Project**

| Date | Key events |
|---|---|
| 20/01/05 | The construction activities started |
| 17/04/07 | Commissioning date |
| 17-23/04/07 | Internal tests |
| 30/04/07 | Start of commercial operation |
| 09/07/2008 | Registration date and starting date of the crediting period |

## A.2. Project Participants

>>

**Table A.2: Project Participants**

| Name of party involved (*) (host) indicates a host Party | Private and/or public entity(ies) project participants (as applicable) | Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| Chile (host) | Hidroeléctrica Guardia Vieja S.A. | No |
| Government of Netherlands | International Bank for Reconstruction and Development (IBRD) as Trustee of the Netherlands Clean Development Mechanism Facility (NCDMF) | Yes |

## A.3. Location of the project activity:

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Quilleco Hydroelectric Project is located in the 8th region of Bio-Bío of Chile, at about 35 km east from Los Angeles city and 500 km south from Santiago. All project facilities are sited on the south bank of a branch of the Laja River, 8 km downstream of existing Rucúe power plant, receiving the waters from this plant in hydraulic series.

The road from Los Angeles to Antuco is the main road in the entire area. Secondary and rural roads connect the communes of Quilleco and Tucapel.

**Table A.3: Project Coordinates**

| | Latitude | Longitude |
|---|---|---|
| Power house | 37°20'10"S | 71°56'59"W |
| Intake | 37°21'26"S | 71°52'39"W |

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

**Figure A.1.a - Project Location. Geographic position**

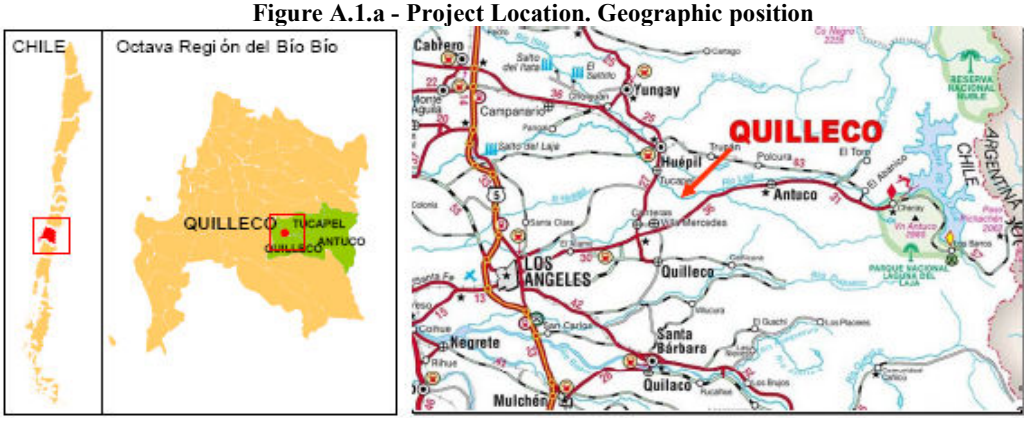
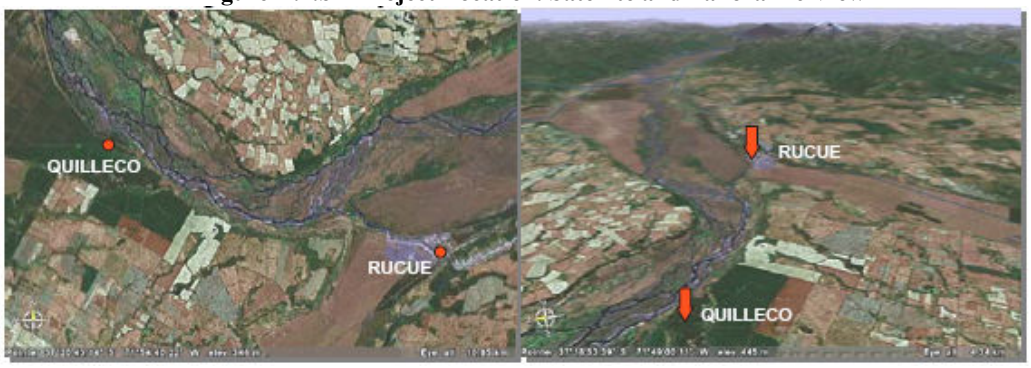


**Figure A.1.b – Project Location. Satellite and Panoramic View**



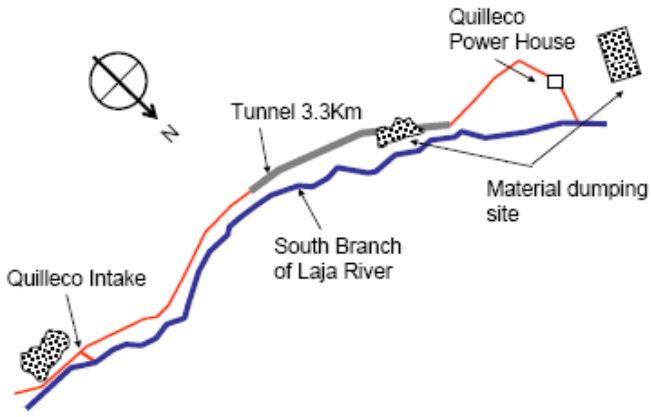

## A.4. Technical description of the project

The technical design of the Quilleco Hydroelectric Project uses a simple layout and technologies well proven in Chile and worldwide and used in other Colbún operating power units. The table A.3 below shows a brief description of the project technology.

**Table A.4: Project**

| PHYSICAL INFRASTRUCTURE | POWER PLANT |
|---|---|
| - 4.4 km of open channel<br>- 3.2 km aqueduct tunnel<br>- 59.4 m pressure penstock<br>- 2 sets of vertical Francis turbines and generators<br>- 0.5 km 220 KV transmission line<br>- Design flow: 130 m3/s<br>- 59.4 m pressure penstock | - Capacity: 70 MW<br>- Average Net Generation: 422 GWh/year<br>- Located 35 km east from Los Angeles city and 500 km south from Santiago<br>- Construction time: 30 months |

**Figure A.2: Project Design**




## A.5. Title, reference and version of the baseline and monitoring methodology applied to the project activity:

>> AM0026 (v.2): "Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid"

>> ACM0002 (v.6): "Consolidated baseline methodology for grid-connected electricity generation from renewable sources"

## A.6. Registration date of the project activity:

>> July 9th 2008

**A.7. Crediting period of the project activity and related information (start date and choice of crediting period):**

>> July 09th 2008 – July 8th 2015 (Renewable)

**A.8. Name of person(s)/entity(ies) responsible:**

>> **Project Participants**:

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## SECTION B. Implementation of the project activity

### B.1. Implementation status of the project activity

The project activity was commissioned on April 17th 2007.

The project started generating with Unit 1 on 17/04/07, on 30/04/07 Unit 1 was officially delivered to CDEC-SIC, afterwards, on 28/05/07 Unit 2 was also delivered. During the second monitoring period Quilleco power plant has continuously operated, with some exceptions regarding the special events that are detailed in the table below. However, it is worth to mention that none of the following events are considered as a serious situation, and most of them are part of the normal events faced by power plants like Quilleco:

| Unit | Start Time | Start Date | End Time | End date | Type event |
|---|---|---|---|---|---|
| U1 | 3:05 | 23-10-2009 | 8:00 | 23-10-2009 | Scheduled repair |
| U1 | 7:28 | 09-11-2009 | 13:10 | 15-11-2009 | Scheduled maintenance |
| U2 | 7:48 | 17-11-2009 | 21:35 | 28-11-2009 | Scheduled maintenance |
| U1 | 20:52 | 20-11-2009 | 23:20 | 20-11-2009 | Failure |
| U1 | 7:51 | 16-12-2009 | 13:03 | 16-12-2009 | Scheduled maintenance |
| U1 | 8:52 | 09-03-2010 | 17:22 | 09-03-2010 | Fire network instalation |
| U1 | 7:50 | 10-03-2010 | 10:30 | 13-03-2010 | Fire network instalation |
| U2 | 7:50 | 22-03-2010 | 18:00 | 24-03-2010 | Fire network instalation |
| U2 | 15:32 | 23-04-2010 | 15:41 | 23-04-2010 | Arrangements without generation losses |
| U1 | 15:48 | 23-04-2010 | 16:02 | 23-04-2010 | Arrangements without generation losses |
| U1 | 8:05 | 28-06-2010 | 13:00 | 28-06-2010 | Scheduled maintenance |
| U2 | 8:06 | 04-07-2010 | 12:39 | 04-07-2010 | Scheduled maintenance |
| U1 | 0:00 | 02-10-2010 | 23:05 | 09-10-2010 | Scheduled maintenance |
| U2 | 10:35 | 11-10-2010 | 13:10 | 20-10-2010 | Scheduled maintenance |
| Plant | 19:50 | 15-11-2010 | 3:36 | 16-11-2010 | Scheduled detention |

| | | | | | |
|---|---|---|---|---|---|
| U2 | 12:55 | 23-11-2010 | 13:59 | 23-11-2010 | Failure |
| U1 | 9:07 | 26-11-2010 | 11:45 | 26-11-2010 | Internal tests |
| U2 | 12:08 | 26-11-2010 | 17:45 | 26-11-2010 | Internal tests |
| U1 | 1:09 | 03-02-2011 | 3:13 | 03-02-2011 | Failure |
| U2 | 3:09 | 10-04-2011 | 18:36 | 15-04-2011 | Failure |
| U3 | 5:37 | 26-06-2011 | 6:01 | 26-06-2011 | Failure |
| U4 | 8:30 | 28-07-2011 | 12:16 | 28-07-2011 | Failure |
| U5 | 11:36 | 08-08-2011 | 12:00 | 08-08-2011 | Failure |
| U6 | 13:26 | 08-08-2011 | 13:34 | 08-08-2011 | Failure |
| U7 | 11:17 | 17-08-2011 | 11:28 | 17-08-2011 | Scheduled detention |
| U8 | 20:30 | 24-09-2011 | 23:33 | 24-09-2011 | Black out SIC |
| U9 | 0:01 | 24-10-2011 | 20:10 | 27-10-2011 | Scheduled maintenance |

### B.2. Revision of the monitoring plan

>> N/A

### B.3. Request for deviation applied to this monitoring period

>> I-DEV0405, "Use of redundant energy measurements instead of primary measurements for estimating baseline emissions".

### B.4. Notification or request of approval of changes

>>N/A

## SECTION C. Description of the monitoring system

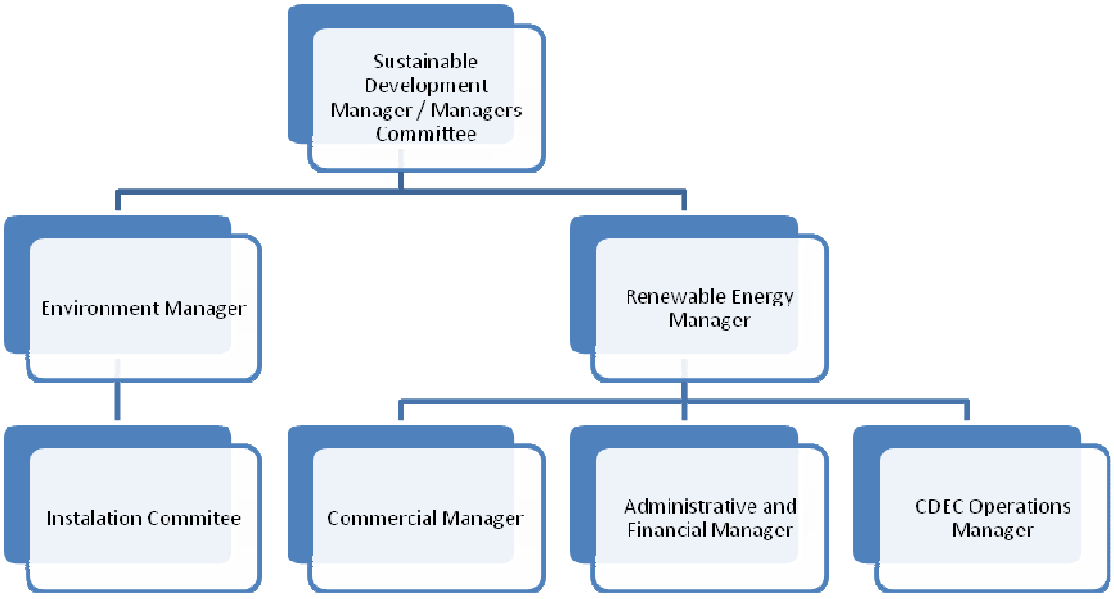
**Responsibilities concerning CDM**

During year 2005, Colbún S.A. merged with Hidroeléctrica Cenelca S.A., including the assets that belonged to this company, which considered the set of hydroelectric power plants owned by Hidroeléctrica Guardia Vieja S.A.

Consequently, the administration, operation, maintenance, commercial aspects and environmental management of the Quilleco Power Plant is currently conducted by Colbún S.A.

In order to fulfil the commitments established in the Quilleco Project Design Document, and the ones associated to the related Emission Reduction Purchase Agreement, Colbún S.A. has the following CDM functional management structure:

**Figure C.1: CDM responsibilities structure**




**Monitoring system**

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

The monitoring methodology involves the monitoring of the following:

- Electricity generated and fed into the grid by the proposed CDM project, and other CDM registered projects (data available at CDEC-SIC).
- Public data on dispatch of electricity and other relevant information from the CDEC-SIC. This data is used to calculate the emission factor for the operating margin based on a dispatch increment analysis.
- Data needed to calculate the emission factor consistent with the Consolidated Baseline methodology for grid-connected electricity generation from renewable sources (AM0026).

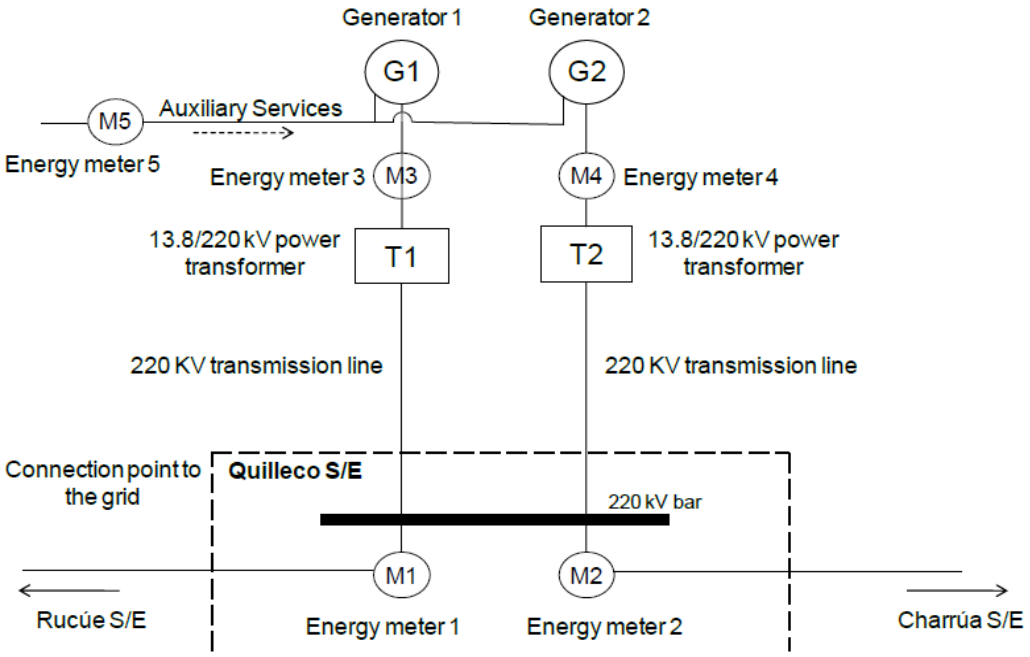
**Monitoring equipments**

At Quilleco substation there are two primary energy meters, presented as M1 and M2. Electricity generation supplied to the grid shall be measured at Quilleco substation owned and operated by Colbún S.A., where the project connects to the grid (primary measurement).

At Quilleco Power Plant (the project site) there are also two energy meters located at the generator units, which are defined as redundant energy meters and are presented in the figure as M3 and M4. These meters are used for cross-checking tasks (secondary measurement) for CDM purposes.

Also, the Project requires electricity for auxiliary services (own consumptions of the power plant), which is fed through a separate direct power line. This electricity is measured by a dedicated electricity meter (M5), so what is read by M1 to M4 exclude the auxiliary service consumptions.

A simplified diagram below illustrates the connection lines for Quilleco Hydroelectric Power Plant to the grid and the specific line for auxiliary services:




For the current monitoring period the generation is calculated in two different ways:

- Monitoring Period between 09/07/2009 to 14/08/2010:

Following the accepted deviation, for this monitoring period, the PP, will consider the following:

1. In the absence of registered data from the primary meters, to use the measurements of the redundant (secondary) meters M3 & M4 located at Quilleco Power Plant minus conservatively estimated losses between secondary meters (M3&M4) and primary meters (M1&M2).
2. To apply the maximum error established by the manufacturer for auxiliary services meter (M5), Class 0.2S, for obtaining the measurements corrected as the most conservative data.

The Generation is estimated using the following equation:

$$Generation_{h,dev\,app.} = (M3 + M4) - losses - (M5 + 0.4\%M5)$$

- Monitoring Period between 15/08/2010 to 30/11/2011:

From 15/08/2010 the generation, is measured considering the two primary energy meters, presented as M1 and M2. Therefore, electricity generation supplied to the grid is measured at Quilleco substation, using the following equation:

$$Generation_h = (M1 + M2) - M5$$

**Energy Measurement Equipment Periodic Verification**

The calibration meters certificates for the monitoring period are presented in the following table.

**Table 2: Electricity meters info**

| Date | Certifier | Equipment | Serial number |
|---|---|---|---|
| **M1** | | | |
| December 15th, 2009 | CAM | JEMStar Electricity Meter | 06 48 07775 |
| January 07th, 2010 | CAM | Ion 7650 | PJ-0911A507-02 |
| October 19th, 2011 | CAM | Ion 7650 | PJ-0911A507-02 |
| **M2** | | | |
| December 15th, 2009 | CAM | JEMStar Electricity Meter | 06 48 07772 |
| December 22th, 2010 | CAM | Ion 7650 | PJ-0911A683-02 |
| October 19th, 2011 | CAM | Ion 7650 | PJ-0911A683-02 |
| **M3** | | | |
| November 5th, 2008 | CAM | JEMStar Electricity Meter | 06 48 07773 |
| **M4** | | | |
| November 5th, 2008 | CAM | JEMStar Electricity Meter | 06 48 07774 |
| **M5** | | | |
| February 09th, 2010 | CAM | Ion 7650 | PJ-0911A866-02 |
| October 20th, 2011 | CAM | Ion 7650 | PJ-0911A866-02 |

## SECTION D. Data and parameters

### D.1. Data and parameters determined at registration and not monitored during the monitoring period, including default values and factors

| Data / Parameter: | Fuel Carbon Content |
|---|---|
| Data unit: | tC/ TJ |
| Description: | Determination of carbon content for different fuels |
| Source of data used: | IPCC 2006 revised guidelines |
| Value (s): | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline /Project/ Leakage emission calculations): | Baseline emissions |
| Additional comment: | |

| Data / Parameter: | Combustion efficiency |
|---|---|
| Data unit: | % |
| Description: | Determination combustion efficiency of different fuel based generation technologies |
| Source of data used: | IPCC revised guidelines |
| Value (s): | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline /Project/ Leakage emission calculations): | Baseline emissions |

| Data / Parameter: | **Combustion efficiency** |
|---|---|
| Additional comment: | |

| Data / Parameter: | **CO2 conversion factor** |
|---|---|
| Data unit: | % |
| Description: | Molecular weight of carbon dioxide relative of that of carbon |
| Source of data used: | IPCC revised guidelines |
| Value (s): | 44/12 = 3.67 |
| Indicate what the data are used for (Baseline/Project/ Leakage emission calculations): | Baseline emissions |
| Additional comment: | |

## D.2. Data and parameters monitored:

| Data / Parameter: | $Generation_h$ |
|---|---|
| Data unit: | MWh |
| Description: | Energy Generation of the Project for each hour ***h*** |
| Measured/ Calculated/ Default: | Measured |
| Source of data: | On-site metering system (same data submitted to CDEC-SIC) |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | On 2009, the energy generation was monitored by JEMStar Electricity Meter which has the following characteristics:<br><br><u>Meter M1:</u><br>• Type: JEMSTAR<br>• Accuracy class: 0.2%<br>• Serial number: 06 48 07775<br>• Calibration frequency: Every two years<br><br><u>Meter M2:</u><br>• Type: JEMSTAR<br>• Accuracy class: 0.2%<br>• Serial number: 06 48 07772<br>• Calibration frequency: Every two years<br><br><u>Meter M3:</u><br>• Type: JEMSTAR<br>• Accuracy class: 0.2%<br>• Serial number: 06 48 07773<br>• Calibration frequency: Every two years |

| | |
|---|---|
| | Meter M4:<br>• Type: JEMSTAR<br>• Accuracy class: 0.2%<br>• Serial number: 06 48 07774<br>• Calibration frequency: Every two years<br><br>Since 2010 JEMStar Electricity Meters were replaced for Ion 7650 meters. These meters were replaced between January 07th 2010 to February 09th 2010; and has the following characteristics:<br><br>Meter M1:<br>• Type: Ion 7650<br>• Accuracy class: 0.2%<br>• Serial number: PJ-0911A507-02<br>• Calibration frequency: Every two years<br><br>Meter M2:<br>• Type: Ion 7650<br>• Accuracy class: 0.2%<br>• Serial number: PJ-0911A683-02<br>• Calibration frequency: Every two years<br><br>Meter M5:<br>• Type: Ion 7650<br>• Accuracy class:<br>• Serial number: PJ-0911A866-02<br>• Calibration frequency: Every two years<br><br>The last calibration for these meters during the monitoring period was carried out during October 2011, which for the local industry standard is valid for two years. |
| Measuring / Reading /Recording frequency: | Hourly measurement |
| Calculation method (If applicable): | • For the monitoring period between 09/07/2009 to 14/08/2010 the $Generation_h$ is obtained following the accepted deviation:<br><br>$Generation_h = (M3 + M4) – losses – auxiliary\ consumption*(1+0.4\%)$<br><br>• For the monitoring period between 15/08/2010 to 30/11/2011 the $Generation_h$ is obtained as follow:<br><br>$Generation_h = (M1+ M2) - M5$ |
| QA/QC procedures applied: | Meter should have a maximum error of 0.2% and be calibrated periodically according to local standards for electricity transactions in CDEC-SIC.<br>Metering data is sent regularly to CDEC-SIC where a balance is made for energy transactions between power generators. |

| **Data / Parameter:** | $\boldsymbol{COEF_{i,y}}$ |
|---|---|
| Data unit: | tCO2 per mass or volume |
| Description: | CO2 emission factor of each plant by fuel type used, taking into account the carbon content of the fuels used by relevant power sources ***i*** and percent of oxidation of fuel in year ***y*** |
| Measured/ Calculated/ Default: | Calculated |
| Source of data: | IPCC Guidelines and CNE Node Price Reports |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Yearly or twice a year |
| Calculation method (If applicable): | Calculated based in net calorific value of fuel i, carbon emission factor of i, and fraction of carbon in fuel i oxidized during combustion. Verification procedure shall be applied based on historical data per fuel type. . |
| QA/QC procedures applied: | Internal validation check should be performed contrasting historical data for existing plants. For new plants, validation should be accomplished through fuel type normal emission factors form similar plants. |

| **Data / Parameter:** | $\boldsymbol{EF_y}$ |
|---|---|
| Data unit: | tCO2e/MWh |
| Description: | Emission factor of the displaced grid electricity |
| Measured/ Calculated/ Default: | Calculated |
| Source of data: | Calculated based on formula **f10** |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading | Annually |

| | |
|---|---|
| /Recording frequency: | |
| Calculation method (If applicable): | Calculated based on formula **f10** |
| QA/QC procedures applied: | Automatic calculation. |

| **Data / Parameter:** | **$EF_{OM,y}$** |
|---|---|
| Data unit: | tCO2e/MWh |
| Description: | Operating Margin Emission Factor |
| Measured/ Calculated/ Default: | Calculated |
| Source of data: | Calculated based on formula **f1** using CDEC-SIC data |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Annually |
| Calculation method (If applicable): | Calculated based on formula **f1** using CDEC-SIC data |
| QA/QC procedures applied: | Automatically calculated from CDEC-SIC databases and AM0026 procedures. |

| **Data / Parameter:** | ***$EF_{j,h}$*** |
|---|---|
| Data unit: | tCO2e/MWh |
| Description: | Operating Margin Emission Factor of hour ***h*** |
| Measured/ Calculated/ Default: | Calculated |
| Source of data: | Calculated based on formula **f2** using CDEC-SIC data |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |

| | |
|---|---|
| Measuring / Reading /Recording frequency: | Hourly |
| Calculation method (If applicable): | Calculated based on formula **f2** using CDEC-SIC data |
| QA/QC procedures applied: | Automatically calculated from CDEC-SIC databases and AM0026 procedures.<br>Calculation should be done after CDEC-SIC energy balance to ensure data validity |

| **Data / Parameter:** | ***D(j,i)*** |
|---|---|
| Data unit: | MWh |
| Description: | Electricity displaced by $j^{th}$ CDM project from $i^{th}$ marginal plant in the system |
| Measured/ Calculated/ Default: | Calculated |
| Source of data: | Calculated based on formula **f4** using CDEC-SIC data |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Hourly |
| Calculation method (If applicable): | Calculated based on formula **f4** using CDEC-SIC data |
| QA/QC procedures applied: | Automatically calculated from CDEC-SIC databases and AM0026 procedures. |

| **Data / Parameter:** | $d_i$ |
|---|---|
| Data unit: | $tCO_2e/MWh$ |
| Description: | Emission factor of the marginal plant '***i***', |
| Measured/ Calculated/ Default: | Calculated |
| Source of data: | IPCC manual and CNE node price report |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, | N/A |

| | |
|---|---|
| serial number, calibration frequency, date of last calibration, validity) | |
| Measuring / Reading /Recording frequency: | Hourly |
| Calculation method (If applicable): | Calculated based on formula **f4.** |
| QA/QC procedures applied: | Calculation based on official data. |

| **Data / Parameter:** | $SFC_i$ |
|---|---|
| Data unit: | Ton/MWh or TJ/MWh |
| Description: | Specific fuel consumption per unit of electricity produced in the '$i^{th}$' marginal plant |
| Measured/ Calculated/ Default: | Estimated |
| Source of data: | CNE node price report |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Twice a year |
| Calculation method (If applicable): | N/A, the parameter is not calculated |
| QA/QC procedures applied: | Data is obtained from official reports. Historic comparison of each unit can provide data validation for existing and new units in the system. |

| **Data / Parameter:** | $M$ |
|---|---|
| Data unit: | Number |
| Description: | Number of electricity generation plants on margin, that would supply to the system in the absence of the CDM projects in the system |
| Measured/ Calculated/ Default: | Estimated |
| Source of data: | Calculation based on **f2** and CDEC-SIC data |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for | Baseline emissions |

| | |
|---|---|
| (Baseline/Project/ Leakage emission | |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Hourly |
| Calculation method (If applicable): | Calculation based on **f2** and CDEC-SIC data, following AM0026 procedures. |
| QA/QC procedures applied: | Automatic calculations are done in spreadsheets |

| **Data / Parameter:** | ***N*** |
|---|---|
| Data unit: | Number |
| Description: | List of CDM registered plants in the system |
| Measured/ Calculated/ Default: | N/A |
| Source of data: | CDEC-SIC and UNFCCC registered projects for the country |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | As required |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Data is obtained from official reports. |

| **Data / Parameter:** | $C_j$ |
|---|---|
| Data unit: | MWh |
| Description: | Electric energy of the $j_{th}$ CDM project of the system ($j$ = 1 .. N) in the hour $h$ |
| Measured/ Calculated/ Default: | Measured/Estimated |
| Source of data: | CDEC-SIC |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |

| | |
|---|---|
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Hourly |
| Calculation method (If applicable): | Calculated from CDEC-SIC databases and AM0026 procedures. |
| QA/QC procedures applied: | Automatic calculation procedure through a revised worksheet. |

| **Data / Parameter:** | $A_i$ |
|---|---|
| Data unit: | MWh |
| Description: | Generation capacity of $i^{th}$ plant on margin during hour $h$ |
| Measured/ Calculated/ Default: | Measured |
| Source of data: | Determined from CDEC-SIC CDEC-SIC databases |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Hourly |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Data is obtained from official CDEC-SIC databases |

| **Data / Parameter:** | $B_i$ |
|---|---|
| Data unit: | MWh |
| Description: | Electric energy of the $i_{th}$ plant on the margin during hour $h$ |
| Measured/ Calculated/ Default: | Measured |
| Source of data: | Determined from CDEC-SIC databases |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data | Baseline emissions |

| | |
|---|---|
| are used for (Baseline/Project/ Leakage emission | |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Hourly |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Data is obtained from official CDEC-SIC databases |

| **Data / Parameter:** | $EF_{BM,y}$ |
|---|---|
| Data unit: | tCO2e/MWh |
| Description: | Build Margin Emission Factor of the grid for the year ***y*** |
| Measured/ Calculated/ Default: | Calculated |
| Source of data: | Calculated based on formula **f6** based on CNE Node Price Report and IPCC manual |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Annually |
| Calculation method (If applicable): | Calculated based on formula **f6** using CDEC-SIC databases and AM0026 procedures |
| QA/QC procedures applied: | Automatic calculation using CDEC-SIC and official databases and CNE Node Price report values. |

| **Data / Parameter:** | $EF_{BM,i}$ |
|---|---|
| Data unit: | tCO2e/MWh |
| Description: | Emission Factor for the $i^{th}$ plant in the Build Margin Cohort for the year y |
| Measured/ Calculated/ Default: | Calculated |
| Source of data: | Calculated according formula **f9**, based on CNE Node Price Report, IPCC manual, CDEC-SIC |

| | |
|---|---|
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Annually |
| Calculation method (If applicable): | Calculated from CDEC-SIC databases and AM0026 procedures, based on formula **f9** |
| QA/QC procedures applied: | Official data is used |

| **Data / Parameter:** | $Gen_{BM,i}$ |
|---|---|
| Data unit: | MWh |
| Description: | Energy generation of the $i^{th}$ plan on the Build Margin cohort |
| Measured/ Calculated/ Default: | Estimated |
| Source of data: | Determined from CDEC-SIC databases (for ex-post calculation) |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Annually |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Automatic calculation using official CDEC-SIC databases. |

| **Data / Parameter:** | ***Plant name*** |
|---|---|
| Data unit: | Text |
| Description: | Identification of power source/ plant |
| Measured/ Calculated/ Default: | Estimated |
| Source of data: | Determined from CDEC-SIC databases |

| | |
|---|---|
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Yearly, when new power plants are available in the system |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Modify, if a new plant is available in the system. |

| **Data / Parameter:** | $\underline{CEF_i}$ |
|---|---|
| Data unit: | TC pert ton of fuel or TJ |
| Description: | Carbon emission factor of fuel used in the $i^{th}$ plant of the Build Margin cohort |
| Measured/ Calculated/ Default: | Estimated |
| Source of data: | Estimated based on official data form CNE node price reports and IPCC default values |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Annually |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Official data is used |

| **Data / Parameter:** | $Oxid_i$ |
|---|---|
| Data unit: | % |
| Description: | Fraction of fuel oxidized on combustion |
| Measured/ Calculated/ | Estimated |

| | |
|---|---|
| Default: | |
| Source of data: | IPCC Guidelines |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | As required |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Official data is used |

| **Data / Parameter:** | **$SFC_{BM,i}$** |
|---|---|
| Data unit: | ton of fuel /MWh or TJ of fuel /MWh |
| Description: | Specific fuel consumption of the $i^{th}$ electricity generation plant |
| Measured/ Calculated/ Default: | Estimated |
| Source of data: | Determined from IPCCC guidelines and official data form CNE node price report and CDEC-SIC |
| Value(s) of monitored parameter: | Please refer to emission factor calculation spreadsheet |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Yearly or twice a year |
| Calculation method (If applicable | N/A the parameter is not calculated |
| QA/QC procedures applied: | Internal validation check should be performed contrasting historical data for existing plants. For new plants, validation should be accomplished through fuel type normal emission factors for similar plants. |

| **Data / Parameter:** | **$W_{BM}$** |
|---|---|
| Data unit: | % |
| Description: | Weight for Build Margin emission factor |
| Measured/ Calculated/ Default: | Estimated |
| Source of data: | AM0026 default value = 50% |
| Value(s) of monitored parameter: | 50% |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Annually |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Official data is used |

| **Data / Parameter:** | **$W_{OM}$** |
|---|---|
| Data unit: | % |
| Description: | Weight for Operating Margin emission factor |
| Measured/ Calculated/ Default: | Estimated |
| Source of data: | AM0026 default value = 50% |
| Value(s) of monitored parameter: | 50% |
| Indicate what the data are used for (Baseline/Project/ Leakage emission | Baseline emissions |
| Monitoring equipment (type, accuracy class, serial number, calibration frequency, date of last calibration, validity) | N/A |
| Measuring / Reading /Recording frequency: | Annually |
| Calculation method (If applicable): | N/A the parameter is not calculated |
| QA/QC procedures applied: | Official data is used |

## SECTION E. Emission reductions calculation

## E.1. Baseline emissions calculation

The Central Interconnected System (SIC) is coordinated by an independent entity called Load Economic Dispatch Centre (CDEC-SIC). The CDEC-SIC is responsible for optimal operation of the system based on the principle of lowest marginal costs.

The outcome is the hourly dispatch program and marginal cost for each power unit. The CDEC must coordinate in real time the dispatch at minimum cost of the power units according to the weekly programs. The weekly priority program Excel sheet contains a daily dispatch program which has three hour blocks: from hour 0 to 8, from 9 to 18, and from 19 to 24.

The CDEC-SIC publishes daily reports of the actual operation of the SIC, including the hourly generation for each power unit. The information required is provided by CDEC-SIC and is available publicly through its website at a subscription fee.

In addition, CDEC-SIC publishes an Annual Report with fuel consumption of the mayor power units. On the other hand, the National Energy Commission (CNE) publishes every six months the Node price report with the specific consumption of fuel of most of the power units and the indicative expansion plan of the system. The information is publicly available at www.cne.cl.

Project emission reductions are calculated as a combined margin emission factor (CM), consisting of the weighted average of an operating margin (OM) and a Build Margin (BM), following AM0026 (v.2) approved methodology.

The OM emission factor from the project activity depends on the actual generation data from the SIC. The dispatch data, obtained from the Economic Dispatch Centre (CDEC-SIC), conclusively indicates the type of generation displaced by the addition of Quilleco in the generation mix in the SIC. The monitoring and verification plan for the project uses the data provided by CDEC-SIC.

The BM emission factor is determined as option (i) in AM0026 v2.

The calculation of the project emissions reductions requires gathering and analyzing a considerable quantity of data primarily for the estimation of the emission factor.

The amount of data to be analyzed and processed and the procedures to be followed do not allow the estimation of the Emission Factor to be simple and expedite. In order to make the emissions reduction estimation procedures accessible and efficient, the Project Participant has Scheduled a Mathematical Tool for the Emissions Factor Calculation in Microsoft Office Excel. This Mathematical Tool permits qualified personnel to conduct ex-ante and ex-post emissions factor estimations based on available data.

In general terms, the procedure executed by the Emission Factor Calculation Mathematical Tool consider the following stages:

1. Data Acquisition
2. Operational Margin Emission Factor Calculation
3. Building Margin Emission Factor Calculation
4. Combined Margin Emission Factor Calculation

The first stage consists on gathering the required information for the emissions factor estimation. The data to be gathered for every period is the energy generated and general data of all power plants of the system, the priority of the dispatch, data related to fuel consumption and the information associated to the different fossil fuels being used. This information has to be uploaded in the Mathematical Tool and its sources verified prior to its use.

The second, third and four stage of the estimation use the information previously uploaded, following the estimation procedures stated in the approved baseline and monitoring methodology AM0026 v2.

The Mathematical Tool counts with an audit mode, which allows the Designated Operational Entity to access and verify the assumptions, calculations and procedures.

Finally, and using the Mathematical Tool, the emissions reductions associated to the operation of the project activity can be calculated.

The following steps represent a description of the emissions reduction estimation associated to the project, which are applied in the Mathematical Tool with Microsoft Office Excel.

**Operating Margin calculation**

The operating margin emission factor is calculated as follows:

$$EF_{OM,y} = \frac{\sum_{h=1}^{H} EF_{j,h} \bullet Generation_{j,h}}{\sum_{h=1}^{H} Generation_{j,h}} \qquad \textbf{(f1)}$$

Where,

| | |
|---|---|
| EFj,h | Operating margin Emission factor for proposed CDM project 'j' for hour 'h', expressed in tCO2/MWh, |
| $Generation_{j,h}$ | Generation of proposed CDM project 'j' during hour 'h', expressed in MWh, |
| H | Total number of hours of the year 'y'. |

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

$$EF_{j,h} = \sum_{i=1}^{M} D(j,i) \bullet d_i \Big/ \sum D(j,i) \qquad \textbf{(f2)}$$

Where,

| | |
|---|---|
| D(j,i) | Energy displacement of the marginal plant 'i' due to the proposed CDM project 'j', expressed in MWh, |
| Di | Emission factor of the marginal plant 'i', expressed in tCO2/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:

$$\sum_{j=1}^{N} C_j \le \sum_{i=1}^{M} \left(A_i - B_i\right) \qquad \textbf{(f3)}$$

Where,

| | |
|---|---|
| $C_j$ | Energy generation of the CDM project 'j' expressed in MWh/h, |

| | |
|---|---|
| $N$ | Total number of CDM projects in the system, |
| $A_i$ | Maximum energy generation of the marginal plant 'i' expressed in MWh/h (equivalent to plant capacity in MW) |
| $B_i$ | Actual Energy generation of the CDM marginal plant 'i' expressed in MWh/h |

The difference (Ai – Bi) represents the maximum possible additional electric energy that can be supplied by the ith marginal plant.

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

$$D(j,i) = MIN\left\{C_j - \sum_{l=1}^{i-1} D(j,l); (A_i - B_i) - \sum_{k=j+1}^{N} D(k,i)\right\} \quad \textbf{(f4)}$$

Where,

$D(j,0) = 0$ and $D(N+1,i) = 0$

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

di , the emission factor for displaced marginal plant, is estimated as follows:

$$d_i = SFC_i \bullet CEF_{OM,i} \bullet Oxid_i \quad \textbf{(f5)}$$

Where,

| | |
|---|---|
| $SFC_i$ | Is the specific fuel consumption of ith marginal power plant, expressed as (ton of fuel or TJ)/MWh, |
| $CEF_{OM,i}$ | Is the CO2 emission factor of fuel used in ith marginal power plant, expressed as tCO2/ (ton of fuel or TJ), |
| $Oxid_i$ | Is fraction of carbon in fuel, used in ith marginal plant, oxidized during combustion. |

The marginal plant(s) are those power plants 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 Quilleco power plant is obtained from the metering system which follows a national standard of 0.2% error allowance on a KWh base. Hourly energy data obtained from the metering system is submitted to CDEC-SIC every two hours as for all other generating units of the system.

The Official Annual Report by CDEC-SIC from year 2008, the semi-annual Node Price Report from CNE for 2008 April, the National Energy Balance from CNE for year 2007 and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories provide all the information to calculate the emission factors for all the power plants within the Central Interconnected System.

Finally, $EF_{OM} = 0.692\ tCO_2/MWh$.

**Build Margin calculation**

The emission factor for the build margin was calculated using option (i) from AM0026.

$$EF_{BM,y} = \frac{\sum_{i,m} F_{i,m,y} \bullet COEF_{i,m}}{\sum_{m} Gen_{m,y}} \qquad \textbf{(f6)}$$

Where,

$F_{i,m,y}$ is the amount of fuel i (in mass or volume unit) consumed by relevant power sources "m" in year(s) y,

M the sample group m consists of either the five power plants that have been built most recently or the power plant capacity additions in the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently. Project participants should use from these two options that sample group that comprises the larger annual generation,

$COEF_{i,m,y}$ is the $CO_2$ emission coefficient of fuel i ($tCO_2$/mass or volume unit of fuel), taking into account the carbon content of the fuel used by relevant power sources "m" and the percent oxidation of the fuel in year(s) y,

$Gen_{m,y}$ is the electricity (MWh) delivered to the grid by source "m".

The $CO_2$ emission coefficient $COEF_i$ is obtained as:

$$COEF_i = NCV_i \bullet EF_{CO2,i} \bullet Oxid_i \qquad \textbf{(f7)}$$

Where,

$NCV_i$ is the net calorific value (energy content) per mass or volume unit of a fuel I,

$Oxid_i$ is the oxidation factor of the fuel,

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

Finally, $EF_{BM}$ = 0.385 $tCO_2$/MWh.

**Combined Emission Factor calculation**

The combined emission factor for the proposed Chacabuquito project, according to AM0026 v2.0, is calculated with the weighted average for both the Operating Margin (OM) and the Build Margin (BM) as follows:

$$EF_y = w_{OM} \bullet EF_{OM,y} + w_{BM} \bullet EF_{BM,y} \qquad \textbf{(f10)}$$

Where,

$EF_{OM}$,y Emission factor for operating margin power generation sources, in tCO2/MWh,

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

$EF_{BM}$ Emission factor for build margin power generation sources, in tCO2/MWh,

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

| | Quilleco |
|---|---|
| $EF_{BM}$ ($tCO_2$/MWh) | 0.385 |
| $W_{BM}$ | 0.5 |
| $EF_{OM,}$ ($tCO_2$/MWh) | 0.692 |
| $W_{OM}$ | 0.5 |
| | |
| $EF_{CM}$ ($tCO_2$/MWh) | 0.539 |

**Baseline emissions calculation**

The baseline emissions for the project are calculated as follows:

$$BE_y = EF_y * Generation_y \quad \textbf{(f11)}$$

Where,

$EF_y$ Baseline emission factor, in $tCO_2$/MWh

$Generation_y$ Electricity generated by the proposed CDM Project in year y (in MWh).

$Generation_y$ = 960,775.1 MWh

$BE_y$ = 517,317 $tCO_2$

**E.2. Project emissions calculation**

>> Since the Quilleco Hydroelectric Project consists of a run-off river power plant without reservoir, there are no Project Emissions (*PEy*).

**E.3. Leakage calculation**

>> According to the applied methodology ACM0026 version 02 and the registered PDD, leakage is not considered in this project.

**E.4. Emission reductions calculation / table**

>> Finally, the project mainly reduces $CO_2$ emissions through substitution of power generation supplied by the existing generation sources connected to the grid and likely future additions to the grid. The emission reduction (ERy) by the project activity during year y is equal to the Baseline Emissions. Since the Quilleco Hydroelectric Project consists of a hydro power plant, there are no Project Emissions (PEy). Additionally, as per AM0026 (v.2), no leakage was identified for this project activity (Ly=0). The emission reduction can be expressed as follows:

$$ER_y = BE_y - PE_y - L_y = BE_y \quad \textbf{(f13)}$$

**Estimation of Emission Reductions (Period: July 09th 2009 – November 30th 2011)**

| From | To | Estimation of baseline emissions reductions (tonnes of $CO_2$/MWh) | Estimation of project activity emissions reductions (tonnes of $CO_2$e) | Estimation of Leakage (tonnes of $CO_2$e) | Estimation of Emission Reduction (tonnes of $CO_2$e) |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 09/07/2009 | 30/11/2011 | 517,317 | 0 | 0 | 517,317 |
| **Total (tonnes of $CO_2$ e)** | | **517,317** | **0** | **0** | **517,317** |

Total baseline emissions: **517,317 $tCO_2$ e**
Total project emissions: **0**
Total leakage: **0**
Total emission reductions: **517,317 $tCO_2$ e**

**E.5. Comparison of actual emission reductions with estimates in the CDM-PDD**

>>

| From | To | Values applied in ex-ante calculation of the registered CDM-PDD ($tCO_2e$) | Actual values reached during the monitoring period ($tCO_2e$) |
|---|---|---|---|
| 09/07/2009 | 30/11/2011 | 412,751 | 517,317 |
| **Total Emission Reductions ($tCO_2$ e)** | | **412,751** | **517,317** |

**E.6. Remarks on difference from estimated value in the PDD**

>> Hydroelectric projects are highly dependent to the annual hydrology level, so the annual electricity generation is subject to significant changes from year to year.

The ex-ante energy generation declared in the PDD was of 422,000 MWh/year. This means that during the current monitoring period, the ex-ante energy generated could be 1,011,644 MWh for the period from 09/07/2009 to 30/11/2011. In the same period the actual energy generated 960,775 MWh, which is lower than the ex-ante energy generation of the PDD.

On the other hand, the emission factor from the PDD is 0.408 tCO2/MWh, which is lower than the actual emission factor.

**History of the document**

| Version | Date | Nature of revision |
|---|---|---|
| 01 | EB 54, Annex 34<br>May 28, 2010 | Initial adoption. |
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