GHG emission reductions at ALUAR Aluminio Argentino Project

ALUAR, Argentina

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CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
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Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

GHG emission reductions at ALUAR Aluminio Argentino

A.2. Description of the project activity:

ALUAR's smelter is located in Puerto Madryn, Argentina, 1400 km south of Buenos Aires. It started operation in 1974. The primary aluminium plant consists of 6 rooms with 544 electrolytic cells (400 Point Feeder Prebake - PFPB (Potlines A and B) and 144 Aluminium Pechiney AP18 PFPB (Potline C)). The total aluminium production in 2003 was 272,000 tonnes. The electricity consumption of ALUAR is 3,980,000 MWh/year (2003). The electricity requirements for this process are covered by: Futaleufú hydroelectric plant of 472 MW (ALUAR consumption 273MW), a 120 MW combined cycle natural gas power plant and six open-cycle gas turbines totalling 168 MW, also operating on natural gas.

There are several greenhouse gas emissions resulting from the primary aluminium production process. Carbon dioxide (CO_2) is produced from anode consumption. Also two perfluorocarbons (PFCs), tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6), are produced intermittently during brief process upset periods known as anode effect.

The objective of this project is to reduce GHG emissions through the installation of a new algorithm in the Automatic Control System (ACS) in 400 pots (potlines A and B). The implementation of this process control algorithm would be funded through the sale of carbon credits in the context of the Clean Development Mechanism (CDM) of the Kyoto Protocol. The income derived from the sale of carbon credits will allow ALUAR to pay for the development and the installation of the algorithm and to invest in R&D in order to optimise the control system in the following years.

The project has the capacity to produce around **870,000 tonnes of CO_2 equivalent emission reductions** over a 10-year time frame.

The project also brings social (better health and labour conditions for workers) and environmental benefits thus contributing to sustainable development (See Annex 6). The project has been presented to the Argentina CDM Office (Oficina Argentina del Mecanismo para un Desarrollo Limpio, OAMDL) for fulfilling the national approval procedures.

A.3. Project participants:

1	Project Developer:	**ALUAR Aluminio Argentino SAIC**
2	Annex I country participant:	**Electric Power Development Co., Ltd.**
3	PDD Consultant:	**MGM International SRL**

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A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Argentina

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

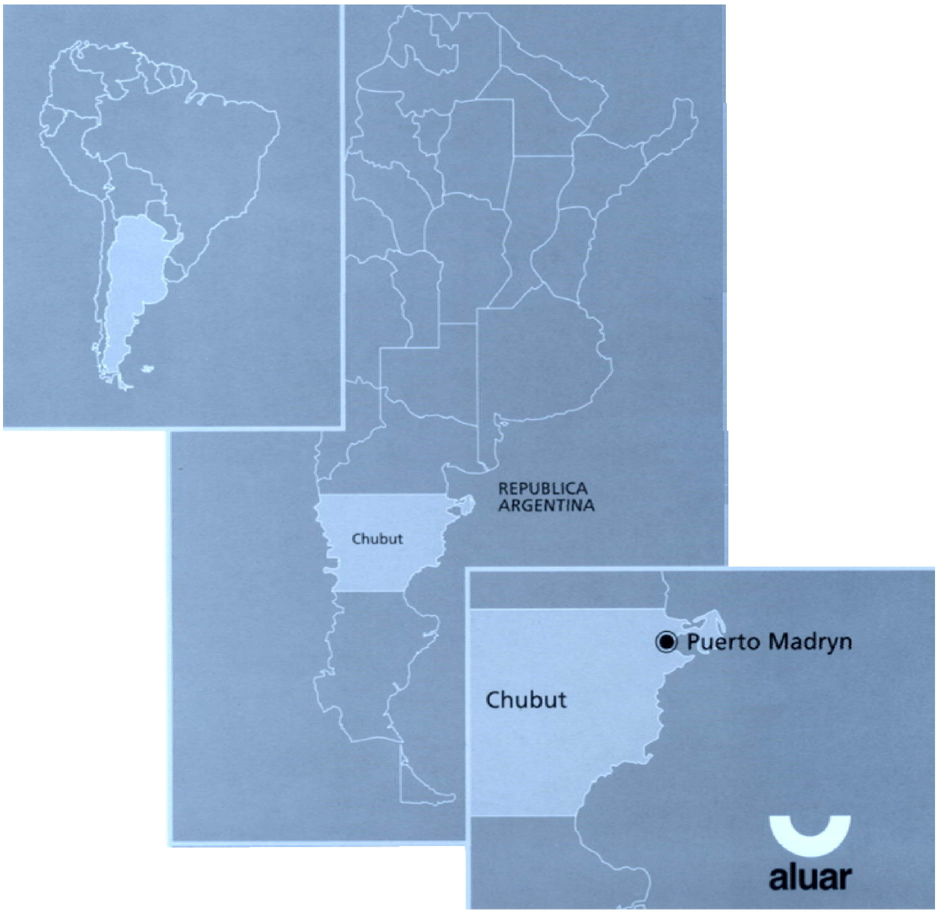
Chubut (province)

A.4.1.3. City/Town/Community etc:

Puerto Madryn

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

ALUAR's smelter is located in Puerto Madryn, Argentina, 1400 km south of Buenos Aires. The population is approximately 70,000 inhabitants.



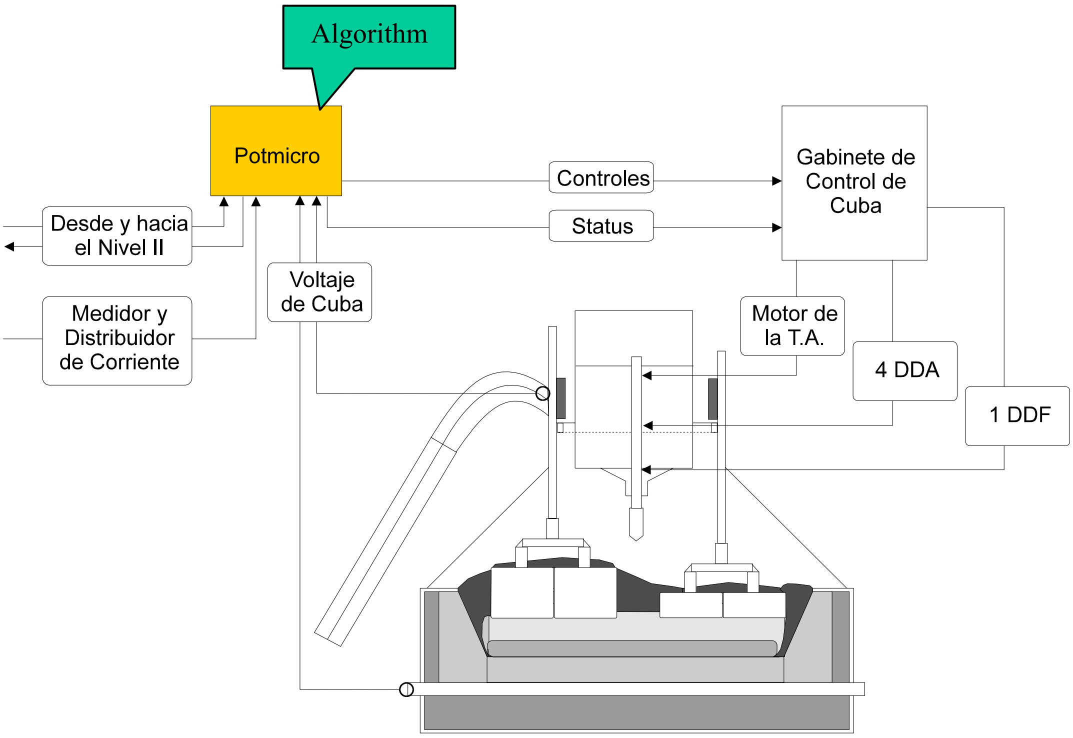
A.4.2. Category(ies) of project activity:

The UNFCCC CDM web site appears not to provide a list of categories of project activities, from which one might choose that applicable for this proposed project.

If we use the "Sectoral Scope" classification as applied for Designated Operational Entities, a possible category might be: ***Metal production***.

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

The objective of this project is to reduce GHG emissions through the installation of a new algorithm in the Automatic Control System (ACS) in 400 pots (potlines A and B). The technology of these pots is Point Feeder Prebake (PFPB). The algorithm is a new anode effect quenching procedure developed by ALUAR technical team. This is an experimental procedure that was published in *Light Metal 2003* (P. Navarro *et al*., Light Metal 2003, pp. 479-486, see Annex 5 for more details.). This algorithm will permit a reduction of over-voltage of the anode effect.



The most common methods for the automatic quenching of anode effect consist of tilting or pumping the anode system, or lowering it until it touches the metal pad. These methods did not render satisfactory results in ALUAR's pots and forced the workers to rely on manual killing by green poling.

A new anode effect quenching procedure was developed based on the principle that each pot technology has a characteristic anode-cathode distance in which a wave in the metal-bath interface develops very quickly. In this case the wave is used to produce local short-circuits to the anodes, allowing a fast removal of the isolating layer and a replenishment of alumina in the interpolar volume.

The procedure was tested in different pot technologies and showed very low values of anode effect over-voltage and duration, a minimum disturbance to the anode crust, and a high success rate, providing a significant reduction of perfluorocarbons emissions.

The set of experiments of the new algorithm was carried out manually by ALUAR's technical team. The "algorithm" has to pass the testing stages at the simulator and the pilot test at the plant in order to eliminate bugs in the code and to optimise working parameters, prior to installation of the fully operational automatic control system.

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

The project involves the installation of a new algorithm in the automatic control system of potlines A and B. As a result of project implementation, there would be a significant reduction of over-voltage of the anode effect as well as a small improvement in energy efficiency.

Project additionality is demonstrated using the "Draft consolidated tools for the demonstration of additionality," published by the CDM Executive Board at their 15th Meeting, early in September 2004. Details are provided in Section B.3 of this PDD.

The new control system developed by ALUAR is in an experimental phase. The installation of the algorithm would not lead to an increase in aluminium production. The baseline adopted for the project is based on the assumption that in the absence of carbon finance the company would continue operating its plant with the current control system without any modification. Thus the proposed project activity is not the baseline and the estimated emission reductions would not occur in the absence of it. Additionality is established through barriers analysis: (a) economic; (b) technological; and (c) institutional barriers. Each are discussed in detail in Sec. B.3. Our analysis indicates that the proposed project faces a number of barriers and its implementation would not have been considered at all if not for the possibility of emission reduction credits. Thus, the proposed project is additional.

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

The estimated amount of emission reductions over 10 years crediting period are shown in the following table.

Table 1. Estimated emission reductions

Period	Estimated emission reductions (tCO_2/year)
2005	80,860
2006	80,860
2007	84,032
2008	87,739
2009	87,739
2010	87,739
2011	88,563
2012	88,563
2013	88,563
2014	88,563
Total	**863,221**

A.4.5. Public funding of the project activity:

ALUAR will not receive any national or international public funding whatsoever for the development of this project.

SECTION B. Application of a baseline methodology

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

The baseline methodology is a new methodology being submitted together with this PDD. The new baseline methodology is designated:

"Changes in industrial process, energy efficiency, fuel switching, cogeneration and self-generation equipment at an aluminium smelting facility".

The baseline methodology adopted for this Project fits within option 48(a) of the modalities and procedures for the CDM insofar as the baseline is based on *"existing actual or historical emissions"*.

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

This methodology is applicable to a wide range of mitigation measures including industrial process changes, energy efficiency improvements, fuel switching, cogeneration and self-generation in the aluminium smelting industry.

The proposed project involves improvements in the smelting process in order to reduce anode effects, in turn reducing emissions of perfluorocarbons and carbon dioxide, which are GHGs.

A new methodology is being proposed together with this PDD and is intended for project activities including that proposed here.

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

The methodology "Changes in industrial process, energy efficiency, fuel switching, cogeneration and self-generation equipment at an aluminium smelting facility" is applicable to a variety of possible mitigation measures.

This project is limited to GHG emissions reductions through industrial process changes that lead to a reduction of PFC emissions from the anode effect, as well as process CO_2 emissions from carbon anode consumption.

The methodology proposes two alternative procedures for determining PFC emissions: the slope method (PFC emissions is a product of frequency and duration of anode effects) and the Pechiney over-voltage method. These procedures are based on IPCC recommendations. For this project, the Pechiney over-voltage method is selected as being more accurate.

Therefore, the basic assumptions of the baseline methodology are met in the context of the proposed project activity.

In the following Sections of this PDD we strictly follow the key methodological steps in determining the baseline scenario.

According to the proposed baseline methodology, the key data used to determine the baseline scenario are given in Table 2 and detailed in Section D of this PDD.

Table 2: Key data

Parameters	Data sources
CF_4 emission factor, EF_{CF4} (kg CF_4/tAl)	IPCC – Tier 2 Method
C_2F_6 emission factor, EF_{C2F6} (kg C_2F_6/tAl)	IPCC – Tier 2 Method
Variables	**Data sources**
Aluminium annual production, P_{Al} (tonnes)	ALUAR
Current Efficiency , *CE* (%)	ALUAR
Anode Effect Over-voltage, *AEO* (mV/cell.day)	ALUAR

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

Additionality is demonstrated following the series of steps of the "Draft consolidated tools for demonstration of additionality."[1]

Step 0. Preliminary screening of projects started after 1 January 2000 and prior to 31 December 2005

This Step is applicable to retroactive projects. The Draft consolidated tools state:

> *"If the starting date of the project activity falls between 1 January 2000 and the date of the registration of a first CDM project activity and prior to 31 December 2005, evidence should be publicly provided that the incentive provided by the CDM was seriously considered in the decision to proceed with the project activity."*

This project has not yet started and CDM is being considered prior to any decisions that might be taken leading to project implementation. Thus, this step does not apply for the ALUAR project.

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

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

The International Aluminium Institute conducts the "Global Aluminium Sustainable Development Initiative". The Initiative combines the knowledge and skills of the Member Companies (http://www.world-aluminium.org/iai/links.html) of the International Aluminium Institute to establish goals to improve the global performance of the Primary Aluminium Industry and to guarantee its sustainable long term future. The Initiative comprises global voluntary objectives focused on key issues in sustainability —climate change, efficient use of resources, recyclability, employee and community health and safety, and accountability. Performance is monitored and measured annually on a global basis against a set of 22 key indicators.

The Initiative applies to the primary aluminium divisions of IAI Member Companies, including the project proponent, ALUAR. The objectives are designed as a collective effort to bring the average performance closer to the best performers in each technology type.

Once of these voluntary objectives is an 80% reduction in Perfluorocarbons (PFCs) emissions per tonne of aluminium produced by the industry as a whole by 2010 compared to 1990 levels. Note that this objective covers all producers worldwide (both Annex 1 and non Annex 1) that are part of the IAI.

[1] Executive Board 15 Report - Annex 3, page 1

The International Aluminium Institute carries out annual surveys of PFC emissions and sends out benchmarking reports, so individual plants can compare their performance with other de-identified plants using the same technology. The 2002 survey is the fifth in a series of surveys covering anode effect data from global aluminium producers over the period from 1990 through 2002. The surveys have been shown to be a useful tool in communicating the results that the primary aluminium industry has made over the period from 1990 in reducing greenhouse gas emissions and have provided survey participants with valuable benchmarking information with which to judge their current anode effect performance.

Table 3 shows a breakdown of production by reduction technology type for 2002. Participation in the 2002 survey accounted for 65 percent of overall global primary production and is essentially the same as for the 2001 year survey. Anode effect data in the 2002 survey accounted for 16.9 million tonnes of primary aluminium production, 64.6% of the 26.1 million tonnes of primary aluminium produced in 2001. Chinese and Russian producers do not yet participate in the survey leaving the largest gaps in coverage in the two Søderberg technology categories (VSS and HSS).

Table 3. 2002 Anode Effect Survey Participation by Technology Type

	PFPB	CWPB	SWPB	VSS	HSS	All
Participating in Survey (tonnes)	12,758,423	1,107,008	742,721	1,816,439	470,569	16,895,160
Non Participants (tonnes)	3,759,713	749,742	433,482	2,487,157	1,814,000	9,244,094
Participants (Percent of total)	77.2%	59.6%	63.1%	42.2%	20.6%	64.6%

PFPB – Point Feed Prebake; CWPB – Bar Broken Center Work Prebake; SWPB – Side Work Prebake; VSS – Vertical Stud Søderberg; HSS – Horizontal Stud Søderberg

Figure 1 shows that global annual primary aluminium production rose over the period from 1990 when total primary production was 19.5 million tonnes to 26.1 million tones in 2002[2]. Figure 1 also illustrates that the increases in production over that time period are mainly due to increases in the lowest PFC emitting PFPB technology. Over the same period of time there have been some decreases in the amount of bar broken CWPB and SWPB production. Finally, the level of VSS and HSS Søderberg production has remained about constant from 1990 to 2002.

[2] Chinese and Russian production by technology are included in Figure 1 from experts' estimates.

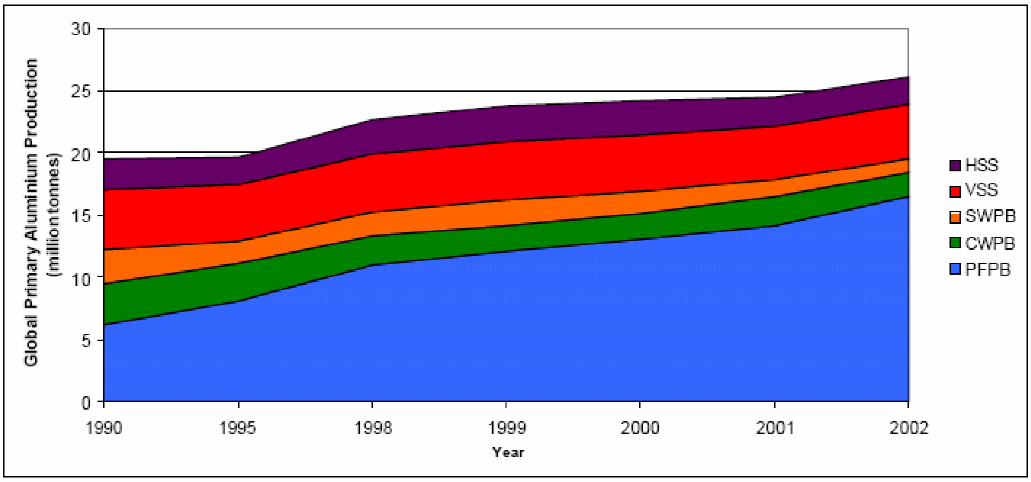


Figure 1 – Global Primary Aluminium Production by Technology Type from 1990 through 2002

The participation rate in the 2002 survey is highest for the facilities operating with Point Feeder Prebake technology while less than half of those operating with Søderberg technology participated in the survey. Figure 2 shows the breakdown of the 116 reporting facilities by technology type. The PFPB technology is best represented, accounting for 71 of the reporting facilities.

The survey requested participants to report annual primary production, average anode effect frequency, average anode effect duration and, if applicable[3], average over-voltage. This anode effect performance data allows for the calculation of specific emission rates for tetrafluoromethane, CF_4, and hexafluoroethane, C_2F_6, by the Intergovernmental Panel on Climate Change (IPCC) Tier 2 method[4]. Total PFC emissions were then calculated by multiplying specific emissions, i.e. emissions per tonne primary aluminium times the production level in tonnes. In a continuing effort to improve the accuracy of the survey results, participants were also requested to report if a facility specific PFC measurement had been conducted and if a IPCC Tier 3b coefficient were available for calculating PFC emissions for the facility. Of the 116 reporting facilities, seven respondents reported facility specific Tier 3b coefficients and these data were used in calculating specific PFC emissions for those facilities. The remainder of the specific emissions data was calculated using IPCC Tier 2 methodology with industry average coefficients[5].

[3] Over-voltage was specifically requested if operators employed AP-18, AP-30 Point Feed Prebake Cells and if Sidework cells were used that utilized Pechiney control technology recording over-voltage.

[4] IPCC 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Section 3.39, http://www.ipccnggip.iges.or.jp/public/gp/english/3_Industry.pdf.

[5] IAI 2002 Anode Effect Survey Results and Analysis Greenhouse Gas Emissions Monitoring and Reporting by the Aluminium Industry, http://www.world-aluminium.org/environment/climate/ghg_protocol.pdf, p22, May 2003.

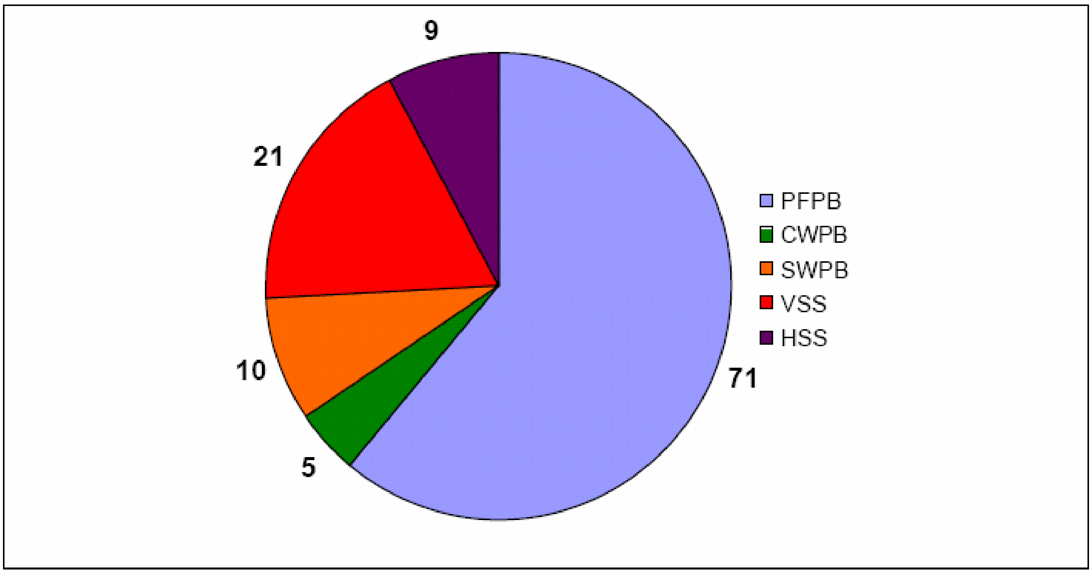


Figure 2 – Breakdown of Survey Reporting Facilities by Technology Type

Overall progress in specific emissions reductions is shown in Figure 3. The production weighted average combined emissions of CF_4 and C_2F_6 are expressed as tonne CO_2 equivalent per tonne of aluminium by multiplying each PFC component's specific emissions by the Global Warming Potential values reported in the IPCC Second Assessment Report of 6500 for CF_4 and 9200 for C_2F_6. These GWP values are those applicable to the Kyoto Protocol, including the CDM. The total tonne equivalent CO_2 emissions for all reporting facilities were determined by summing the CO_2 equivalent emissions for all facilities. The survey participants' average tonne equivalent CO_2 emissions per tonne aluminium produced was then calculated for those reporting anode effect data by dividing the sum total of CO_2 equivalent emissions for all reporting facilities by the sum of the total production for those facilities. Figure 3 shows that IAI survey participants have reduced specific emissions from 4.03 tonne equivalents CO_2 per tonne aluminium in 1990 to 1.28 in 2002, a reduction of 68.1%.

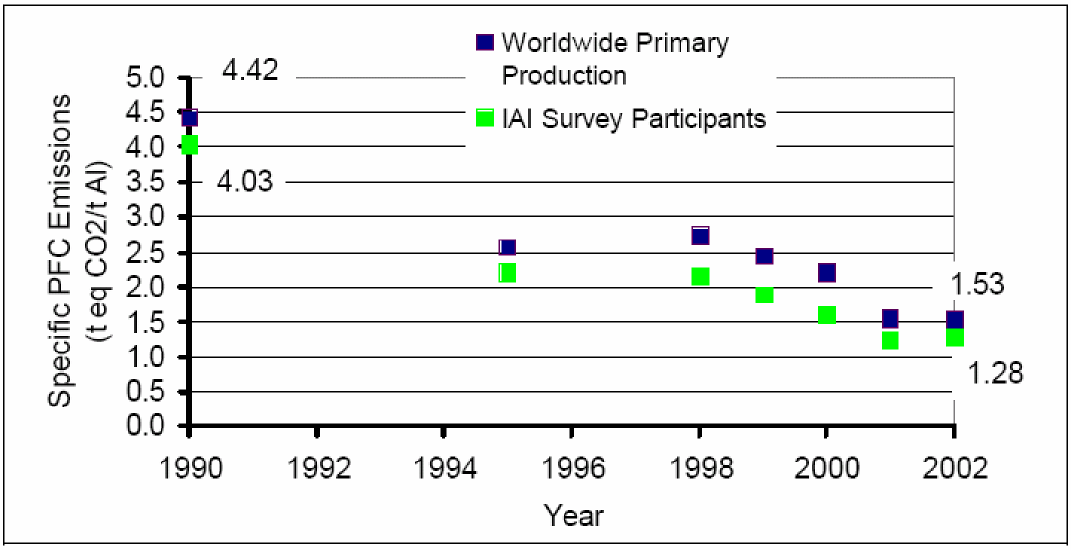


Figure 3 – Trend in Reduction in Specific PFC Emissions from 1990 to 2002

Global specific PFC emissions as expressed as CO_2 equivalents were estimated by multiplying the median specific emission value, as tonne CO_2 equivalent per tonne aluminium, for each of the five reduction technology types by the number of tonnes of primary production for each technology type that did not respond to the survey data request. The additional tonnes CO_2 equivalents for the non participating production were then added to the tonnes CO_2 equivalents from survey participants. The total CO_2 equivalent from both survey participants and non participants were then divided by the total global primary production to obtain an estimate of global specific emissions. Figure 3 shows that global emissions have been reduced from 4.42 tCO_2e/tAl in 1990 to 1.53 tCO_2e/tAl in 2002, a reduction of 65.4%. The slightly higher global specific emission values relative to survey participants reflect the fact that the higher emitting Søderberg facilities are underrepresented in the survey results.

Calculated results for the total PFC emissions per year released to the atmosphere over the period from 1990 through 2002 is shown in Figure 4. The total emissions are a function of both the annual specific emissions of the PFCs and the total primary aluminium production levels for each year. It is notable that the total emissions have been reduced from 86.1 million tCO_2e in 1990 to 40.0 million tCO_2e in 2002, a reduction of 53.5%, even though the total primary production has increased over that same period from 19.5 to 26.1 million tonnes, an increase of 33.8%. The small up tick in 2002 for both PFC specific emissions and total emissions is the first increase noted in a series of decreases in both specific emissions and total emissions year by year since 1998.

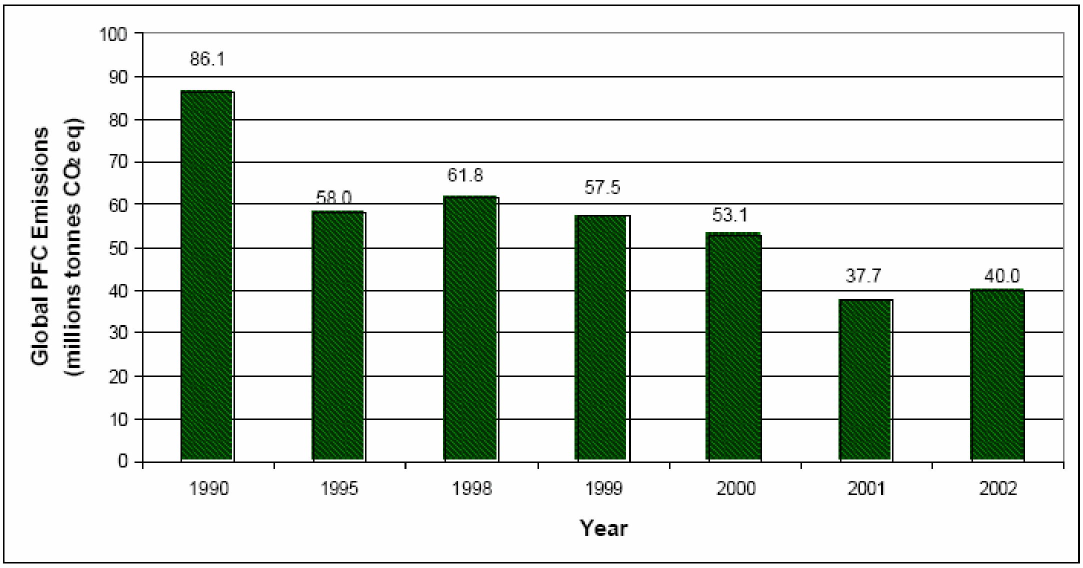


Figure 4 – Total PFC Emissions from Primary Aluminium Production by Year

Figure 5 shows the trend in median specific emissions of CF_4 over the period from 1990 through 2002 for each of the major 5 reduction technology types.

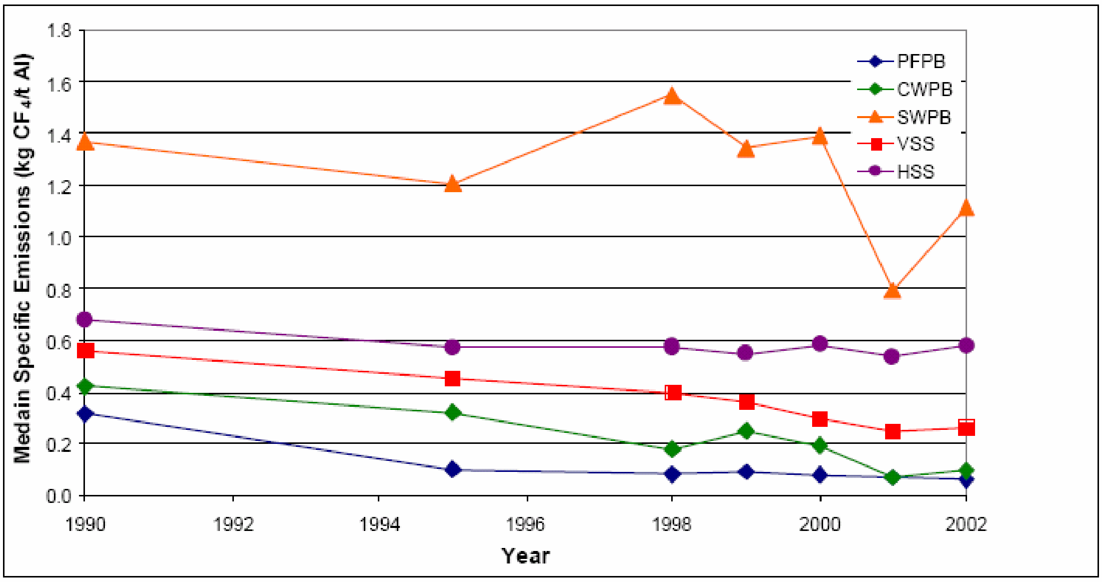


Figure 5 – Median Specific CF_4 Emissions by Reduction Technology Type from 1990 through 2002

While the overall trend in progress over the period from 1990 to 2002 is seen for all technology types, the up tick in median CF_4 emissions was recorded in 2002 for all technology types except the PFPB facilities where the record of unbroken reductions remains for each of the survey years.

ALUAR started operation in 1974 with two potlines of 200 SWPB pots per line. The primary aluminium plant consists of 6 rooms with 544 electrolytic cells (400 Point Feeder Prebake - PFPB (Potlineas A and B) and 144 Aluminium Pechiney AP18 PFPB (Potline C)).

The original pots (Potlines A and B) were 150kA Montecatini design in an end-to-end configuration, side-worked, non-compensated, with 16 two-block anode assemblies. During the following years they underwent several upgrades. The most important were: an external magnetic compensation loop, a hooding system, gas collection and treatment centres, a point breaking and feeding system, and automatic control system (1 individual computer each 16 cells). The feeding system is made up of two reacted alumina hoppers and one aluminium fluoride hopper, four breakers, four reacted alumina feeders and one aluminium fluoride feeder. The reacted alumina is transported to the pots by means of a dense-phase transport system. The weight of the reacted alumina shots is approximately 1 kg

In 1999 a new control automatic system was installed with a proprietary algorithm made up of one individual computer per pot and a central supervisory system. This control algorithm allowed for an important reduction of the specific over-voltage anode effect (3.38 mV/cell day; average of the period 2002-2003). The pots are presently running at 178kA with a current efficiency of 94.5%.

The following table shows the efforts made by ALUAR in order to reduce the anode effect from 1990 to 2003, determined using the Pechiney Over-Voltage Method.

Table 4 Aluminium production and PFC emissions at ALUAR, 1990 and 2003

Year	Production (tAl/month)	AEO Anode effect Over-voltage (mV/cell.day)	Current efficiency (%)	CF_4 (kg/tAl)	C_2F_6 (kg/tAl)	PFC emission (tCO_2equiv/year)
1990	165,608	61.50	90.670	1.289	0.12887	1,583,618
2003	194,396	3.203	94.091	0.065	0.00650	93,292

Table 4 shows that CF_4 emissions at ALUAR fell from a value of 1.289 kg CF_4/tAl in 1990 to a value of 0.065 kgCF_4/tAl in 2003, a reduction of 94%. A similar % reduction applies to C_2F_6 as well. We can clearly see that ALUAR has met and exceeded the 80% PFC emissions reductions suggested by the voluntary IAI initiative. Note, further that the IAI guidelines are voluntary, and ALUAR is subject to no national legislation or other requirements to reduce PFC emissions. Thus, ALUAR could continue to operate without further reductions in emissions.

Without any reason to do otherwise, the baseline for ALUAR would be to continue using the current automatic control system without additional modifications. This business-as-usual situation is thus the baseline and the only reasonable alternative to the project activity. The project activity, involving the implementation of the algorithm in process control, represents a technological innovation, which is risky due to its untested performance. The implementation of the algorithm will lead to environmental and social benefits, although it will bring insignificant economic benefits, without counting potential CDM revenues, since improvements in process control do not affect aluminium production.

Sub-step 1b. Enforcement with applicable laws and regulations

Argentina does not have regulations on PFC emissions. Thus, the project activity is not required by any laws of regulations.

The consolidated tools then offer two options: Step 2 (Investment Analysis) or Step 3 (Barrier Analysis), with a third option of applying both Steps. For this project we use Step 3.

Step 3. Barrier Analysis

Sub-step 3a. Identify barriers that would prevent a wide spread implementation of the proposed project activity:

The Draft consolidated tools suggest a variety of possible barriers "that would prevent the proposed project activity from being carried out if the project were not registered as a CDM activity. Such barriers may include, among others

1) Investment barriers
2) Technological barriers
3) Barriers due to prevailing practice
4) Other barriers

Barriers specific to the proposed project activity are described below.

Investment and Institutional barriers:

ALUAR has no legal obligation to implement the proposed project, which represents an economic burden without providing any direct economic benefit (in the absence of the CDM). The lack of regulations requiring the execution of the project activity clearly shows that without CDM benefits the project would not be implemented and operating procedures would continue unchanged. Furthermore, as explained in Step 1.a, ALUAR's PFC emissions from the anode effect are already within the values proposed by "The Global Aluminium Sustainable Development Initiative" of International Aluminium Institute (IAI).

ALUAR will not have any relevant economic benefit as a result of project implementation, since there will neither be production increase nor any significant energy savings. The implementation of this new algorithm would be funded through the sale of carbon credits in the context of the CDM.

Besides a lack of incentive for project implementation, the process modification implied by the project activity would change operating practices. Such changes are likely to face institutional barriers.

Therefore, in the absence of CDM benefits, the company would continue operating as usual without investing in the new experimental algorithm implementation or changing operating practices.

Technological barriers and barriers due to prevailing practice:

ALUAR is the only producer of primary aluminium in Argentina. While there are several primary aluminium smelters in Brazil and Venezuela, this project would be the first application of this type of technology in Latin America, with a potential for replicability at other industries in and beyond the region. The "algorithm" has to pass the testing stages at the simulator and the pilot test at the plant in order to eliminate bugs in the code and to optimise working parameters. Later on, Erasable Programmable Read Only Memory (EPROM) in the microprocessor has to be replaced for sections of pots in order to gradually apply the new control tool to the

400 pots of A and B series. The project is a "first of a kind", representing an important advance in the reduction of over-voltage anode effect in aluminium industry. See expert opinions in Section G.

Sub-step 3 b. Show that the identified barriers would not prevent a wide spread implementation of at least one of the alternatives (excepted the proposed project activity already considered in step 3a):

The only alternative available is continuing with the current process control, which represents the baseline. The barriers mentioned above hinder the project activity but do not prevent ALUAR from remaining in the current situation. Therefore, the barriers are prohibitive for the project activity but not for the baseline.

Note that for the project activity there are basically two alternatives to be considered: implementing the project and the business-as-usual scenario.

Step 4. Common Practice Analysis

Sub-step 4a. Analyse other activities similar to the proposed project:

The proposed project involves a technological innovation, which would be implemented for the first time at the ALUAR plant. Thus there are no similar project activities elsewhere.

The aluminium industry worldwide has taken steps to reduce PFC emissions through the reduction in anode effect. The proposed project goes beyond the industry trends, as explained in Step 1a above. Moreover, the project activity represents an industry-wide innovation, as supported by expert opinion in Section G.

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

There are no similar options occurring in the world.

Step 5. Impact of CDM Registration

The implementation of this new algorithm would be entirely funded through the sale of carbon credits in the context of the Clean Development Mechanism (CDM) of the Kyoto Protocol. The income derived from the sale of carbon credits will allow ALUAR to pay for the development and the installation of the new algorithm in the process control system and to cover development costs in order to optimise the control in the following years.

Taking into account the previous step-driven analyses, it is concluded that the proposed CDM project activity is not the baseline scenario, which corresponds to the continuation of the current operation practices at ALUAR's plant.

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

For the purposes of this analysis, the project boundary encompasses the physical, geographical site of the potlines A and B (400 pots) at the aluminium smelting. Schematically, Figure 6 shows the project boundary indicating CO_2 and PFC emissions into the boundary associated with anode effect and anode consumption.

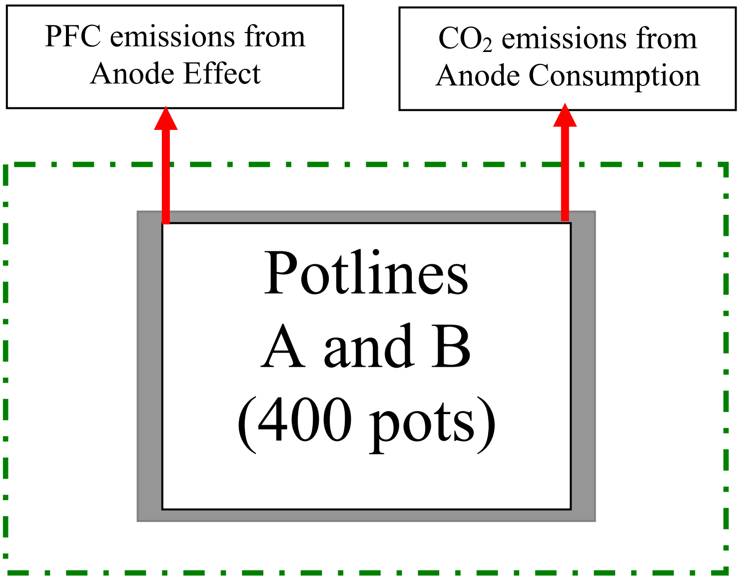


Figure 6. Project boundary for the ALAUR project showing GHG emissions, covering periods both before and after project implementation.

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

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Argentina
Tel. (54 11) 5219.1230
e-mail: icepon@mgminter.com

Eng. Cepón, Dr. Gaioli, and Dr. Dutt are not project participants.

SECTION C. Duration of the project activity / Crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

- November 2004-January 2005: pilot project – algorithm simulation in a few number of pots.
- February 2005: ALUAR final decision about the implementation in the total of the pots.

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

30 years

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

Fixed crediting period

C.2.1. Renewable crediting period

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

C.2.1.2. Length of the first crediting period:

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>
01/03/2005

C.2.2.2. Length:

>>
10 years

SECTION D. Application of a monitoring methodology and plan

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

There is no methodology choice available in the UNFCCC website yet, but this project requires only a straightforward monitoring methodology.

The Project uses the following monitoring methodology, which is included with this PDD as a "new methodology" for submission to and approval by the CDM Executive Board:

The monitoring methodology is designated:

"Changes in industrial process, energy efficiency, fuel switching, cogeneration and self-generation equipment at an aluminium smelting facility."

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

This methodology is applicable to a wide range of mitigation measures including industrial process changes, energy efficiency improvements, fuel switching, cogeneration and self-generation in the aluminium smelting industry.

The proposed project involves improvements in the smelting process in order to reduce anode effects, in turn reducing emissions of perfluorocarbons and carbon dioxide, which are GHGs.

A new methodology is being proposed together with this PDD and is intended for project activities including that proposed here.

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

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

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
D.2.1	*Current efficiency of aluminium production process (CE)*	*Aluar plant*	*%*	*m*	*Monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	
D.2.2	*Anode Effect Over-voltage (AEO)*	*Aluar plant*	*mV/cell.day*	*m*	*Daily*	*100%*	*Paper (field record) Electronic (spreadsheet)*	
D.2.3	*Aluminium production (P_{Al})*	*Aluar plant*	*tonne*	*m*	*Monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	

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

Project GHG emissions *within the project boundary* correspond to emissions from potlines A and B. Project emissions comprise the following components:

a) PFC emissions from anode effect
b) CO_2 emissions from anode consumption

The methodology and formulae for estimating these components of project emissions are described in the new methodology presented with this PDD, and applied below.

PFC Emissions

Two PFCs, tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) are known to be emitted from the process of primary aluminium smelting. These PFCs are formed during the phenomenon known as anode effect (AE), when the aluminium oxide concentration in the reduction cell electrolyte is low.

According to the new methodology, a Tier 2 method is used for this project:

Tier 2 Method – Smelter-specific relationship between emissions and operating parameters based on default technology-based slope and over-voltage[6]

The following estimation relationships will be used:

Pechiney Over-voltage Method: This method uses the Anode Effect Over-voltage as the relevant process parameter. The Anode Effect Over-voltage is the extra cell voltage, above 8V, caused by anode effects, when averaged over a 24-hour period (mV/cell.day):

$$EF_{CF_4} = OVC \cdot AEO / CE \qquad \text{Eq. (1)}$$

Where:

EF_{CF_4} = Emission Factor for CF_4 ($kgCF_4$/tAl)

CE = Current efficiency of aluminium production process (%)

AEO = Anode Effect Over-voltage (mV/cell.day)

OVC = Over-Voltage Coefficient = 1.9 ($kgCF_4$/tAl)/(mV/cell.day); see Table 5

[6] IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories – Page 3.42

Table 5 Default coefficients for the calculation of PFC emissions from Aluminium Production

Technology	Over-voltage coefficient (OVC) (kgPFC/tAl)/(mV/cell.day)	
	CF_4	C_2F_6
Centre Worked Prebaked (CWPB)	1.9	NA
Side Worked Prebaked (SWPB)	1.9	NA

Source: Table 3-9 –IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Page 3.44

The IPCC has not provided any reference about OVC for PFPB technology. Since this technology is just a mechanical evolution of CWPB reacted alumina feeder system, no significant OVC differences between the technologies are expected. Therefore we propose to use the IPCC default value for CWPB.

It is recommended that the default rate for C_2F_6 emissions be 1/10 that of CF_4.[7]

Estimated PFCs emissions of the project, *PE_{PFC}*, are given by:

$$PE_{PFC}\ (tCO_2e/year) = \left(\frac{EF_{CF_4} \cdot GWP_{CF_4} + EF_{C_2F_6} \cdot GWP_{C_2F_6}}{1000} \right) \cdot P_{Al} \qquad \text{Eq. (2)}$$

Where:

EF_{CF_4} = Emission factor of CF_4 from Eq. (1) ($kgCF_4/tAl$)

$EF_{C_2F_6}$ = Emission factor of C_2F_6 (kgC_2F_6/tAl) = 1/10 of EF_{CF_4}

GWP_{CF_4} = Global Warming Potential of CF_4 = 6,500[1]

$GWP_{C_2F_6}$ = Global Warming Potential of C_2F_6 = 9,200[1]

P_{Al} = Total aluminium production of the company (tAl/year)

For ex ante calculation of PFC emissions of the project, the plant will have to provide a justified estimation of the future values of AEO and CE. The future production of aluminum will be determined for the crediting period by the plant. Ex post emissions of the project are obtained by placing the monitored values from Section D.2.1.1 in equations (1) and (2).

[7] 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, page 2.37.

<u>CO_2 emissions from anode consumption</u>

Aluminium is produced by the electrolytic reduction of alumina (Al_2O_3). During the reduction process the aluminium smelting pot acts as the electrolysis cell. The pot itself forms the cathode, while the anode consists of one or more carbon blocks suspended in it. In the pot, Al_2O_3 is dissolved in a bath of fluoride salts, consisting primarily of cryolite, Na_3AlF_6. Passing electrolysis current through the cell also causes Ohmic heating, which maintains the electrolyte in a liquid state. Molten aluminium is produced while the anode is consumed in the reaction. The aluminium forms at the cathode and gathers at the bottom of the pot. Most carbon dioxide is formed in the reaction of the carbon anode with the oxygen from alumina, but some is also formed by anode oxidation with other sources of oxygen (especially air). The proposed project activity is expected to reduce CO_2 emissions from anode consumption by increasing current efficiency.

Estimated anode CO_2 emissions of the project, $PE_{CO_2\ anode}$, are given by:

$$PE_{CO_2 anode} = PE_{CO_2\ MRA}\ (tCO_2/year) = Mass\ Reducing\ Agent \cdot 44/12 \qquad Eq.\ (3)$$

Where:

$$Mass\ Reducing\ Agent = SCC_{Total} \cdot P_{Al} \qquad Eq.\ (4)$$

$$SCC_{Total}\ (tCO_2/year) = SCC_{Stoichiometric} + SCC_{CE} + SCC_{Non\text{-}electrochemical\ oxidation} \qquad Eq.\ (5)$$

$SCC_{Stoichiometric}$ = Specific carbon consumption, given by the following reaction:

$$2Al_2O_3 + 3C \Rightarrow 4Al + 3CO_2 \qquad Eq.\ (6)$$

This value is: 333 kgC/tAl

SCC_{CE} = Specific carbon consumption generated by the current passing through an anode without producing aluminium. Such a value may be estimated by means of the following formula:

$$SCC_{CE}\ (tCO_2/year) = SCC_{Stoichiometric}\ (1 - CE)/CE \qquad Eq.\ (7)$$

The value includes specific carbon consumption during the anode effect, given by the following reactions:

$$4AlNa_3F_6 + 3C \Rightarrow 4Al + 3CF_4 + 12NaF$$
$$4AlNa_3F_6 + 4C \Rightarrow 4Al + 2C_2F_6 + 12NaF$$

Carbon consumption during the anode effect is determined from the specific generation of CF_4 and C_2F_6 (kgPFC/tAl). This value is extremely low and is accounted for in the PFC emissions. Thus, this value needs to be discounted from the SCC_{CE}. The adjusted value, SCC_{CE*}, is given by the following formula:

$$SCC_{CE*}\ (tCO_2/year) = SCC_{CE} - SCC_{AE} \qquad Eq.\ (8)$$

$SCC_{Non\text{-}electrochemical\ oxidation}$ = Carbon consumption produced by air oxidation of the anode. Current circulation causes anode temperature increase, favouring anode oxidation and break-up. Thus there is an additional carbon consumption that is not involved in aluminium production. This term is estimated as follows:

$$SCC_{Non\text{-}electrochemical\ oxidation} = SCC_{Total} - SCC_{Stoichiometric} - SCC_{CE} \qquad Eq.\ (9)$$

Note that of the three terms that contribute to SCC_{Total}, only SCC_{CE} is affected by the project activity.

Ex ante calculations of CO_2 emissions could be obtained from Eq. (3), but $SCC_{Stoichiometric}$ and $SCC_{Non\text{-}electrochemical\ oxidation}$ will not change along project implementation. Thus, only SCC_{CE} and SCC_{AE} will need to be monitored. Thus we redefine CO_2 project emissions as:

$$PE_{CO_2\ anode}\ (tCO_2/year) = SCC_{CE^*} \cdot 44/12 \cdot P_{Al} \qquad \text{Eq. (10)}$$

Ex post baseline emissions will be obtained from Eq. (10).

Project emissions

Estimated CO_2e emissions of the project, *PE*, are given by:

$$PE\ (tCO_2e/year) = PE_{CO_2\ anode} + PE_{PFC} \qquad \text{Eq. (11)}$$

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

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
D.3.1	*Current efficiency of aluminium production process (CE)*	*Aluar plant*	*%*	*m*	*Monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	
D.3.3	*Aluminium production* (P_{Al})	*Aluar plant*	*tonne*	*m*	*Monthly*	*100%*	*Paper (field record) Electronic (spreadsheet)*	

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

>>

Baseline GHG emissions *within the project boundary* correspond to emissions from potlines A and B. Project emissions comprise the following components:

c) PFC emission from anode effect.
d) CO_2 emissions from anode consumption.

The methodology and formulae for estimating of these components of baseline emissions are described in the new methodology presented with this PDD, and applied below.

PFC Emissions

According to the new methodology proposed, a Tier 2 method is used for this project.

Estimated PFCs emissions of the baseline, *BE_{PFC}*, are given by:

$$BE_{PFC}\,(tCO_2e/year) = \left(\frac{EF_{CF_4}\cdot GWP_{CF_4} + EF_{C_2F_6}\cdot GWP_{C_2F_6}}{1000}\right)\cdot P_{Al} \qquad \textit{Eq. (12)}$$

Where:

EF_{CF_4} = Emission factor of CF_4 from Eq. (1) ($kgCF_4/tAl$) (determined ex-ante from Eq. (1) using historic data of AEO and CE)

$EF_{C_2F_6}$ = Emission factor of C_2F_6 (kgC_2F_6/tAl) = 1/10 of EF_{CF_4}

GWP_{CF_4} = Global Warming Potential of CF_4 = 6,500[1]

$GWP_{C_2F_6}$ = Global Warming Potential of C_2F_6 = 9,200[1]

P_{Al} = Total aluminium production of the company (tAl/year)

By using historical data of the plant (AEO and CE), ex ante CF_4 and C_2F_6 emission factor are set and will remain constant throughout the project activity. Ex ante baseline emissions will be estimated from Eq. (12) using the production data estimated by the plant for the crediting period.

Ex post baseline emissions will be obtained from Eq. (12) taking into consideration that the production data will be a piece of information that will be monitored throughout the project activity.

CO_2 emissions from Anode consumption

Estimated CO_2 emissions of the project, $BE_{CO2anode}$, are given by:

As explained above, only SCC_{CE} is affected by the project activity. Ex ante baseline emissions will be estimated from Eq. (13) using the production data estimated by the plant for the crediting period.

$$BE_{CO_2\ anode}\ (tCO_2/year) = SCC_{CE*} \cdot 44/12 \cdot P_{Al} \qquad Eq.\ (13)$$

Ex post baseline emissions will be obtained from Eq. (13) taking into consideration that the aluminium production, PFC emissions and CE will be monitored throughout project activity.

Baseline emissions

Estimated CO_2e emissions of the baseline, ***BE***, are given by:

$$BE\ (tCO_2e/year) = BE_{CO_2\ anode} + BE_{PFC} \qquad Eq.\ (14)$$

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

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

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

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

>>

D.2.3. Treatment of leakage in the monitoring plan

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

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

No significant leakage (***LE***) is envisaged in this project.

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

>>
No significant leakage (***LE***) is envisaged in this project.

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

>>
Emission reductions

Estimated CO_2e emission reductions of the project, *ER*, are given by:

$$ER\ (tCO_2e/year) = BE - PE \qquad \text{Eq. (15)}$$

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary*.
D.2.1	*Low*	*ALUAR has a series of internal procedures that ensures data have low uncertainties during monitoring process*
D.2.2	*Low*	*ALUAR has a series of internal procedures that ensures data have low uncertainties during monitoring process*
D.2.3	*Low*	*ALUAR has a series of internal procedures that ensures data have low uncertainties during monitoring process*

*See Section D.4 below

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

>>

The following sectors of the functional organization chart of ALUAR are involved in QC and QA of this Project: Environmental Control Department, Industrial Engineering Department, Series A/B Electrolysis Department, Software Development Department, Quality Control Department and Electrochemical process Department.

ALUAR has implemented and certified systems of environmental (ISO 14001), quality (ISO 9001) and risk (OHSAS 18001) management. The documentation of these systems (register location, corrective and preventive actions accomplished and under development, objectives, environmental aspects, audit reports) is computerized based on data administered by Lotus Notes.

The operation of these management systems allow to unify and put into order the procedures of production and administration activity, to keep records and to investigate deviations, to take actions in order to prevent future deviations, and to carry out a management program within the framework of continuous improvement.

The documents (procedures, working instructions, standard conditions and specifications) associated to this project are:

Type	**Number**	**Title**	**Comments**
General Procedure	PG-1200	Documentation control	
General Procedure	PG-1276	Internal audit of management system	
General Procedure	PG-0905	Record control	
Specific Procedure	PE-0939	Development and maintenance of systems and record back up	
Working Instructions	IT-3369	The quenching of anode effect by using green pool	

Specific procedure	PE-1681	Anode exchange	
Working Instructions	IT-2368	Anode exchange	
	Draft	CDM project monitoring	
Listing of sectoral registers of control	LR-2463	Register listing of environmental control (COAM)	It has the listing procedure for determination of values set in the chart of sustainability indicators linked to environmental protection
Specific Procedure	PE-3504	Investigation of accidents and incidents	Sustainability indicator
Standard Condition	CE-1699	Operation parameters	Linked to general performance of electrolytic cell.
Working instructions	IT-1741	Actions of process control	Linked to general performance of electrolytic cell.
Specific Procedure	PE-1685	Control of electrolysis parameters	Linked to general performance of electrolytic cell.

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

>>

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Ing. Cepón, Dr. Gaioli, and Dr. Dutt are not project participants.

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

>>

Project GHG emissions *within the project boundary* correspond to emissions from potlines A and B. Project emissions comprise the following components:

a) PFC emissions.
b) CO_2 emissions from anode consumption.

PFC Emissions

Year	P_{Al} (Aluminium production; tAl/month)	AEO (Anode effect over-voltage; mV/cell.day)	CE (Current efficiency) %	EF_{CF4} (CF_4 emission factor; $kgCF_4/tAl$)	EF_{C2F6} (C_2F_6 emission factor; kgC_2F_6/tAl)	Project emissions ($tCO_2e/year$)
2005	196,300	0.44	95	0.009	0.0009	**12,818**
2006	196,300	0.44	95	0.009	0.0009	**12,818**
2007	204,000	0.44	95	0.009	0.0009	**13,320**
2008	213,000	0.44	95	0.009	0.0009	**13,908**
2009	213,000	0.44	95	0.009	0.0009	**13,908**
2010	213,000	0.44	95	0.009	0.0009	**13,908**
2011	215,000	0.44	95	0.009	0.0009	**14,039**
2012	215,000	0.44	95	0.009	0.0009	**14,039**
2013	215,000	0.44	95	0.009	0.0009	**14,039**
2014	215,000	0.44	95	0.009	0.0009	**14,039**
					Total	**136,834**

From the Figure 9 of Annex 5 we obtain that the average of over-voltage with the new algorithm will be 0.24 Vh, and then:

$$0.24(Vh/AE)\cdot 0.04(AE/cell.day)\cdot 1000(mV/V)/24(h/day)=0.4mV/cell$$

CO_2 emissions from anode consumption

Year	Aluminium Production (tAl/year)	CE (Current efficiency)	$SCC_{Stoichiometric}$ (kgC/tAl)	SCC_{AE} (kgC/tAl)	SCC_{CE} (kgC/tAl)	SCC^*_{CE} (kgC/tAl)	Project emission (tCO_2e/year)
2005	196,300	0.95	333	0.0014	17.5	17.52	**12,614**
2006	196,300	0.95	333	0.0014	17.5	17.52	**12,614**
2007	204,000	0.95	333	0.0014	17.5	17.52	**13,109**
2008	213,000	0.95	333	0.0014	17.5	17.52	**13,687**
2009	213,000	0.95	333	0.0014	17.5	17.52	**13,687**
2010	213,000	0.95	333	0.0014	17.5	17.52	**13,687**
2011	215,000	0.95	333	0.0014	17.5	17.52	**13,816**
2012	215,000	0.95	333	0.0014	17.5	17.52	**13,816**
2013	215,000	0.95	333	0.0014	17.5	17.52	**13,816**
2014	215,000	0.95	333	0.0014	17.5	17.52	**13,816**
						Total	**134.659**

E.2. Estimated leakage:

>>
No leakage is envisaged in this project.

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

>>
Total project emissions are: (136,834 + 134,659 + 0) tCO_2e = **271,493 tCO_2e**.

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

>>
Baseline GHG emissions *within the project boundary* correspond to emissions from the potlines A and B. Baseline emissions comprise the following components:

a) PFC emission.
b) CO_2 emissions from anode consumption.
c) CO_2 emissions from Na_2CO_3 consumption.
d) CO_2 emissions from the transport.
e) CO_2 emissions from electricity consumption.
f) SF_6 emissions may be released during servicing of rectifiers that convert AC power delivered to the facility to DC necessary for electrolysis of alumina.

PFC Emissions

Year	P_{Al} (Aluminium production; tAl/month)	AEO (Anode effect over-voltage; mV)	CE (Current efficiency; %)	EF_{CF4} (CF_4 emission factor; $kgCF_4/tAl$)	EF_{C2F6} (C_2F_6 emission factor; kgC_2F_6/tAl)	Baseline emissions ($tCO_2e/year$)
2005	196,300	3.140	94.4	0.063	0.0063	**92,056**
2006	196,300	3.140	94.4	0.063	0.0063	**92,056**
2007	204,000	3.140	94.4	0.063	0.0063	**95,666**
2008	213,000	3.140	94.4	0.063	0.0063	**99,887**
2009	213,000	3.140	94.4	0.063	0.0063	**99,887**
2010	213,000	3.140	94.4	0.063	0.0063	**99,887**
2011	215,000	3.140	94.4	0.063	0.0063	**100,825**
2012	215,000	3.140	94.4	0.063	0.0063	**100,825**
2013	215,000	3.140	94.4	0.063	0.0063	**100,825**
2014	215,000	3.140	94.4	0.063	0.0063	**100,825**
					Total	**982,738**

The average anode effect over-voltage (AEO) for the period from Jan-02 to Dec-03 was 3.38 mV/cell.day. This information results from taking the average of 867,000 values (corresponding to two years with 396 cells working all days in average and with three shifts per day). From the mean value and its standard deviation we can derive the 95% confidence interval (applying a t-Student distribution for infinite degrees of freedom) is given by: 3.20 mV/cell.day < *AEO* < 3.57 mV/cell.day.

We conclude that the proposed baseline AEO is given with high accuracy.

CO_2 emissions from anode consumption

Year	Aluminium Production (tAl/year)	CE	$SCC_{Stoichiometric}$ (kgC/tAl)	SCC_{AE} (kgC/tAl)	SCC_{CE} (kgC/tAl)	SCC^*_{CE} (kgC/tAl)	Project emission ($tCO_2e/year$)
2005	196,300	0.95	333	0.0014	17.5	17.52	12,614
2006	196,300	0.95	333	0.0014	17.5	17.52	12,614
2007	204,000	0.95	333	0.0014	17.5	17.52	13,109
2008	213,000	0.95	333	0.0014	17.5	17.52	13,687
2009	213,000	0.95	333	0.0014	17.5	17.52	13,687
2010	213,000	0.95	333	0.0014	17.5	17.52	13,687
2011	215,000	0.95	333	0.0014	17.5	17.52	13,816
2012	215,000	0.95	333	0.0014	17.5	17.52	13,816
2013	215,000	0.95	333	0.0014	17.5	17.52	13,816
2014	215,000	0.95	333	0.0014	17.5	17.52	13,816
						Total	**134,659**

Emission of CO_2 from Na_2CO_3 used in Aluminium Production Processes

Na_2CO_3 consumption in A/B Series is approximately 1.9 kg/ton Al. Na_2CO_3 is used to correct the relation of AlF_3/NaF concentrations in electrolytic bath. The objective is to exceed AlF_3 by 11% of NaF. After reconstruction of the cathodic coating, pot bottom absorbs NaF increasing AlF_3 proportion in the bathroom. Na_2CO_3 is also added when surplus of AlF_3 increases for some reason and it is necessary to correct diversion. However, this last cause is not frequent since there are other measures to control deviation.

This circumstance (i.e. high surplus of AlF_3 in the bathroom) has an effect on the thermal balance of the pot. The temperature of the bath goes down and current performance also decreases. Less aluminium produced by kA and passed through the pot. Then Na_2CO_3 is added to transform AlF_3 into NaF in accordance with the following reaction:

$$2AlF_3 + 3Na_2CO_3 \Rightarrow 6NaF + Al_2O_3 + 3CO_2$$

Estimated CO_2 emissions of the project, $PE_{Na_2CO_3}$, are given by:

$$PE_{Na_2CO_3}\ (tCO_2) = SC \cdot 44/106$$

Where:

SC = quantity of soda consumed (t)

The consumption of 1.9 kgNa_2CO_3/tAl involves an emission of 1.18 kgCO_2/tAl. For a production of 215,000 tAl/year emissions would be 253.7 tCO_2. Since these emissions are unaltered by the project activity, monitoring Na_2CO_3 emissions will be omitted for this project.

CO_2 emissions from transport

Currently, there are CO_2 emissions from internal transport of anodes within the plant location. For each year *y*, these emissions are expressed as:

$$CO_2\_Transport_y = FT_y \cdot E\_F_y$$

Where

$CO_2\_Transport_y$: CO_2 emissions from internal transport (tCO_2e/year)

FT_y: *Quantity of fuel consumed by the heavy-duty vehicles (MJ/year)*

E_F_y: *Emission factor of fuel consumed by heavy-duty vehicles (tCO_2e/MJ of fuel)*

Input data:

(1) Volume of diesel consumed by heavy-duty vehicles: 201,574 litres/year

(2) Diesel density: 0.849 kg/litre

(3) Lower heating value of diesel: 43.33 MJ/kg

(4) Emission factor of diesel: 0.074 kgCO_2/MJ

Output:

(5) Quantity of fuel consumed by heavy-duty vehicles: (1) × (2) × (3) = 7,415,328 MJ/year

CO_2 emissions from internal transport: (4) · (5)/1000 = **543 tCO_2e/year**

These emissions are not considered in this PDD, since the number of anodes transported by heavy-duty vehicles will be the same before and after project implementation. In consequence, CO_2 emissions from internal transport will not be affected by the proposed project activity.

CO_2 emissions from electricity consumption

The implementation of the project activity will have a very low impact on emissions from electricity consumption, since the algorithm contributes to reduce anode effect over-voltage, which occurs with a very low daily frequency. Thus, the electricity saved through this improvement in the control process is negligible. Specifically:

During the period January-June 2004 the specific energy consumption was 13,867 kWh/tAl. Along the 182 days of this period 97,197 tAl were produced in potlines Series A/B. Following P. Navarro *et al.*, *Light Metal 2003*, Fig. 8, the anode effect energy difference was 146 kWh/AE (=(194-48) kWh/AE). The anode effect frequency (AEF) in this period was 0.066 AE/cell.day, for 392 cells working on average. Assuming that the AEF remains unaltered by the implementation of the new algorithm, the energy saved is given by:

Energy saved = 146 kWh/AE·0.066 AE/cell.day·392 cell·182 day / 97,197 tAl = 7.1 kWh/tAl

Taking into account this value and considering a typical annual production of 196,000 tAl/year, the energy saved per year is around 1,392 MWh/year. For the sake of conservativeness, by considering a higher emission factor for the interconnected grid (0.6 tCO_2/MWh) than the one occurring for the Argentina national grid,[8] the total amount of CO_2 saved has an upper bound of around 835 tCO_2/year. These emission reductions are negligible compared to the PFC emission reductions achieved by the proposed project activity. Since these emission reductions would give an additional benefit to project participants, it was decided conservatively to not ask for accreditation of these emission reductions.

SF_6 emissions

In the aluminium industry SF_6 is infrequently used as a cover gas only for special foundry products. Since SF_6 is assumed to be inert, SF_6 emissions should equal consumption.

Estimated CO_2 emissions of the project, PE_{SF_6} , are given by:

PE_{SF_6} = *consumption of SF_6*

Emission of SF_6 (tCO_2e) = consumption of SF_6 (kg)· CO_2 Conversion Factor ($tCO_2/kgSF_6$)

ALUAR consumption was 150 kg SF_6 in 2002.

[8] We have estimations showing that this emission factor is around 0.4 tCO_2/MWh. To show this calculation here exceeds the scope of this PDD.

Emission of SF_6 (tCO_2e) = 150 kg · 23.9 $tCO_2/kgSF_6$ = ***3,585 tCO_2e***

This value will be not affected for the implemented of the project activity, thus monitoring Na_2CO_3 emissions will be omitted for this project.

Summarizing, total baseline emissions are: (1,058,921 + 152,203) tCO_2e = **1,211,124 tCO_2e**.

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

>>

Total emission reductions are: (1,734,715 – 271,494) tCO_2e = **863,221 tCO_2e**.

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

	Year	Baseline emissions (tCO_2e/year)	Project emissions (tCO_2e/year)	Emission reductions (tCO_2e/year)
1	2005	106,292	25,431	**80,860**
2	2006	106,292	25,431	**80,860**
3	2007	110,461	26,429	**84,032**
4	2008	115,334	27,595	**87,739**
5	2009	115,334	27,595	**87,739**
6	2010	115,334	27,595	**87,739**
7	2011	116,417	27,854	**88,563**
8	2012	116,417	27,854	**88,563**
9	2013	116,417	27,854	**88,563**
10	2014	116,417	27,854	**88,563**
			Total	**863,221**

SECTION F. Environmental impacts

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

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Environmental Impact Assessment (ALUAR Internal Procedure No. 2488)

1. Since the project in question is not reached by Law No. 4032 and Decree 1153/95, it is not worth initiating the Environmental Impact Assessment before the pertinent authorities dealing with environmental matters in the Province of Chubut. Section 1 of the Law states that: "**projects,** activities or works, either public or private, **able of degrading the environment,** will have to undergo an environmental impact assessment as foreseen in the following sections.". The objective of this project is to reduce GHG emissions (mainly PFC emissions) corresponding to A/B Series of Electrolysis, therefore this project CANNOT degrade the environment; on the contrary, it will reduce the industrial impact on global warming.
2. The environmental aspects of the project activity itself (development and implementation of a new version of the algorithm of the automatic control of A/B Series pots) correspond to "Demand of Goods and Services" and "Human Resources Demand" (see PE 2744). Said aspects present insignificant impacts.
3. However, if the development and implementation of the project are successful, this will have as a consequence a considerable reduction of impacts related to ELEC-038; ELEC-039; ELEC-040 and ELEC-042 Aspects (see ELEC Aspects in the environmental aspect module of SGA –Lotus Notes System), since the project is oriented to reduce PFC emissions by reducing anode effect over-voltage, i.e. variable that controls PFC emissions.

Conclusion: As far as it is economically feasible, it is recommended to progress towards the development and implementation of the proposed project.

Suggestions: Submitting a project within the Clean Development Mechanism (MDL) as foreseen by the Kyoto Protocol may help to make the proposal economically viable.

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

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No negative environmental impact is expected from project activities and an environmental impact study is not required by Argentinean authorities.

SECTION G. Stakeholders' comments

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

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Local Stakeholder Comments

The process followed to collect stakeholder comments of the ALUAR Project will be through a survey during November.

International Stakeholder Comments

The process followed to collect stakeholder comments of the ALUAR Project was through a survey during October.

ALUAR sent a survey to the international experts of aluminium industry. The main concept expressed in the survey was the following:

"ALUAR is developing a project concerned with the Clean Development Mechanism (CDM - http://cdm.unfccc.int), established at the Protocol of Kyoto. This project is meant to reduce PFC emissions using a new procedure that kills anode effect, and which is described by Mr Pablo Navarro in the paper.

During the process of stakeholders comments of Aluar's CDM project, our company has to submit technical opinions made by experts in the aluminium industry regarding the procedure described by Mr Navarro.

Therefore, we would be very grateful if you could send us your technical opinion concerning said project. A few lines or even a paragraph with your comments would be perfect."

G.2. Summary of the comments received:

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Local Stakeholder Comments

International Stakeholder Comments

The following table show extracts of the comments received at the moment:

	Comment
Dr. Alton Tabereaux Manager Process Technology Alcoa Primary Metals	Thank you for asking me to comment on the project at Aluar to kill anode effects more efficiently using a new procedure developed by Mr. Pablo Navarro. The new procedure is very innovative and reflects a high level of comprehension of the electrochemical phenomena that occur in aluminum electrolysis cells during anode effects… …Thus I am in complete agreement with the proposed "aggressive, but controlled" anode effect kill strategy proposed by Mr. Navarro. It has the potential to substantially reduce the emission of PFC gases from aluminum reduction cells.
Dr. Jomar Thonstad Professor of Department of Materials Technology and Electrochemistry Faculty of Chemistry and Biology Norwegian University of Science and Technology (NTNU) Norway	The new technique for anode effect quenching that was described by Mr. Navarro in "Light Metals 2003" is quite unique, since it involves a drastic reduction in anode effect frequency and duration. This implies that the emissions of the so-called PFC gases, CF_4 and C_2F_6, are reduced substantially compared to standard practice used elsewhere in the aluminium industry.
Dr. Barry Welch Professor of Department of	I have previously seen Pablo's procedure, including his presentation at TMS, and I must say I am extremely impressed with it and its

Chemical and Materials Engineering University of Auckland New Zealand	technical soundness. It is on a good scientific basis and obviously proven. It differs from some of the other techniques used in that it does not necessarily rely on short circuiting but better mixing and alumina dissolution. This is consistent with some of my own findings.

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

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Only three international comments have been received so far, and they were very positive with respect to project implementation.

ALUAR is inviting comments from other stakeholders. Depending on the comments, proper account will be taken, if necessary.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No funds from public national or international sources were used in any aspect of the proposed project.

Annex 3

BASELINE INFORMATION

See Annex3_ALUAR_271004.xls.

Annex 4

MONITORING PLAN

The Monitoring Plan describes the procedures for data collection, and auditing required for the project, in order to determine and verify emissions reductions achieved by the project. This project will require only very straightforward collection of data, described below, most of which is already collected routinely by the staff of ALUAR Plant, where the proposed CDM project is to be implemented.

GHG related data:

- Current efficiency of aluminium production process
- Anode Effect Over-voltage
- Aluminium production

Non GHG-related data:

- Company's safety record: the company will monitor occupational safety in order to detect if the project has substantially improved the safe condition of its employees. This program will be based on safety records; and records of absenteeism due to sickness. (Not to be considered for emission reduction calculations)
- In addition, the company will aim at maintaining its existing internal programs related to social and environmental quality, which also serve as indicators of the company's commitment to social and environmental quality. Annex 6 shows the main sustainability indicators used in this project. These are not relevant to emissions reduction calculations.

The new methodology describes the procedure and equations for calculating project and baseline emissions from monitored data. For the specific project, the methodology is applied through a spreadsheet model: Annex4_ALUAR_271004.xls.

Annex 5

PAPER: A NEW ANODE EFFECT QUENCHING PROCEDURE

See Annex5_ALUAR_271004.xls.

Annex 6

SUSTAINABILITY INDICATORS

See Annex6_ALUAR_271004.xls.

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