Draft revision to approved baseline methodology AM0030

“PFC emission reductions from anode effect mitigation at primary aluminium smelting facilities”

I. SOURCE AND APPLICABILITY

Source

This baseline methodology is based on the “Baseline methodology for PFC emission reductions from anode effect mitigation at a primary aluminium smelting facility” submitted by MGM International on behalf of Aluar Aluminio Argentino.

For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0124-rev: “PFC emission reductions from anode effect mitigation at a primary aluminium smelting facility” on http://cdm.unfccc.int/methodologies/approved

The selected approach from paragraph 48 of the CDM modalities and procedures is:

“Existing actual or historical emission, as applicable”

Applicability

This methodology is applicable to project activities:

- Primarily aimed at measures that reduce the ~~avoidance of~~ PFC emissions[1] in Aluminium smelting facilities that use center work pre-bake cell technology with bar brake (CWPB) or point feeder systems (PFPB);
- At Aluminium smelting facilities that started operations before 31 December 2002;
- Where at least three years of historical data are available regarding current efficiency, anode effect and Aluminium production of the industrial facility from 31 December 2002 onwards or, in case of project activities with a starting date before 31 December 2005, from 3 years prior to the implementation of the project activity onwards, until the starting date of the project activity;
- At facilities where the existing number of potlines and pots within the system boundary is not increased during the crediting period. The methodology is only applicable up to the end of the lifetime of existing potlines if this is shorter than the crediting period;
- Where it is demonstrated that, due to historical improvements carried out, the facility achieved an “operational stability associated to a PFC emissions level” that allows increasing the Aluminium production by simply increasing the electric current in the pots”. This can be demonstrated for example by providing results of pilot tests carried out by the company.

II. BASELINE METHODOLOGY

Project boundary

The geographical delineation of the project boundary encompasses the physical site of the potlines involved in the project activity at the Aluminium production facility. Only PFC (CF_4 and C_2F_6) emissions from anode effects are included in the project boundary.

The emission sources included in or excluded from this methodology are listed below.

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[1] In contrast to activities primarily aiming at increasing aluminium production, with emission avoidance as a side-effect.

Table1: Emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Anode effects in pots	CF_4	Yes	This methodology is limited to project activities aimed primarily at reducing PFC emissions through anode effect mitigation measures.
		C_2F_6	Yes	
	Carbon anode reaction	CO_2	No	These additional GHG emissions are not included in this methodology and can be properly taken into account using another methodology
	Use of Na_2CO_3	CO_2	No	
	Use of cover gas	SF_6	No	
	Internal transport	CO_2	No	
		CH_4	No	
		N_2O	No	
	Electricity consumption	CO_2	No	Electricity consumption is typically reduced to some extent but it is not the main objective of this type of project activity. Thus, conservatively they are excluded from further considerations.
		CH_4	No	
		N_2O	No	
Project Activity	Anode effects in pots	CF_4	Yes	This methodology is limited to project activities aimed primarily at reducing PFC emissions through anode effect mitigation measures.
		C_2F_6	Yes	
	Carbon anode reaction	CO_2	No	These additional GHG emissions are not included in this methodology and can be properly taken into account using another methodology.
	Use of Na_2CO_3	CO_2	No	
	Use of cover gas	SF_6	No	
	Internal transport	CO_2	No	
		CH_4	No	
		N_2O	No	
	Electricity consumption	CO_2	No	Electricity consumption is typically reduced in some extent but it is not the main objective. .
		CH_4	No	
		N_2O	No	

Baseline Scenario

Steps of the latest approved version of the "Tool for the demonstration and assessment of additionality" shall be used in order to identify the baseline scenario.

Step 1: Identification of baseline scenario candidates

Identify all realistic and credible baseline scenario candidates.

Baseline candidates can be at least the following:

1. The proposed project activity not undertaken as a CDM project activity (e.g. to fulfill voluntary initiatives as part of the IAI PFC initiative);
2. All other plausible and credible anode effect mitigation alternatives to the project activity that deliver outputs with comparable quality, properties, and application areas; for example:

- Control measures:
    - Automatic control system improvements. These improvements could be focused on the following aspects: feeding system, anode change, metal tapping, anode effect occurrence, etc;
    - Improvements in the manual control focused on those aspects not embraced by the current automatic control system: increasing sampling frequency, increasing the manual killing of anode effect by green poling, etc.
- Quality measures:
    - Changing the type of alumina processed in order to improve alumina quality to avoid dissolution problems.

3. No implementation of any anode effect mitigation measure. This alternative might include:
    - The implementation of any other measures focused on the improvement of the performance of equipment and/or the increase of the aluminium production due to business-strategy practices;
    - The continuation of the current situation (neither anode effect mitigation measures nor business-strategy practices are undertaken).

The baseline scenario alternatives shall be in compliance with all applicable legal and regulatory requirements - taking into account EB decisions with respect to national and/or sectoral policies and regulations in determining a baseline scenario - even if these laws and regulations have objectives other than GHG reductions, e.g. to mitigate local air pollution. If this cannot be shown for an alternative, then eliminate the alternative from further consideration.

Step 2: Identification of the baseline scenario

The steps 2 and 3 of the "Tool for the demonstration and assessment of additionality" shall be used to assess which of the alternatives selected in the first step should be excluded from further consideration (e.g., alternatives where barriers are prohibitive or which are clearly economically unattractive). If more than one credible and plausible alternative remains, project participants shall, as a conservative assumption, use the alternative that results in the lowest baseline emissions as the most likely baseline scenario.

If the resulting scenario does not correspond to no implementation of any anode effect mitigation measure, then this baseline methodology does not apply and another methodology should be used.

This does not prevent the company for carrying out modifications that are within the methodology applicability conditions and that are different from anode effect mitigation measures.

Additionality

Additionality shall be demonstrated using the latest approved version of the "tool for the demonstration and assessment of additionality". However, in order to adapt the tool to the specific project activity covered by this methodology, a number of considerations are incorporated to ensure consistency between the procedure to identify the most plausible baseline scenario and the determination of additionality.

~~***Step 0: Starting date of the project activity:***~~

~~As per the latest approved version of the "Tool for the demonstration and assessment of additionality".~~

Step 1. Identification of alternative scenarios
As per the latest approved version of the "Tool for the demonstration and assessment of additionality".

Step 2. Investment analysis

As per the latest approved version of the "Tool for the demonstration and assessment of additionality". Such analysis shall consider the benefits associated with energy savings, increase of the alumina production, reduction of cost per tonne of aluminium, project aluminium cost, etc resulting from project activity.

Step 3: Barrier Analysis

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

Such barriers may include, among others:

- Investment barriers, other than the economic/financial barriers in Step 2 above, inter alia:
    - Debt funding is not available for such innovative project activities;
    - No access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented.
- Technological barriers, inter alia:
    - Skilled and/or properly trained labor to operate and maintain the technology is not available and no education/training institution in the host country provides the needed skill, leading to equipment disrepair and malfunctioning;
    - Lack of infrastructure for implementation of the technology.
- Barriers due to prevailing practice, inter alia:
    - The project activity is the "first of its kind": No project activity of this type is currently operational in the aluminium industry.

Once the increase of the aluminium production by means of increasing electric current is demonstrated to be the most likely practice, this alternative shall be compared with the impact on the production costs due to the implementation of the project activity. In order to do this, saving in electricity consumption that would be required in the most likely scenario to increase production shall be considered for calculating reduction in costs due to efficiency improvements due to implementation of the project activity. In order to provide an objective assessment of this barrier, project participants shall demonstrate that the project activity is less attractive than simply increasing the aluminium production (e.g. through increasing the electric current) even when including the benefits obtained from reduction costs due to efficiency improvements. This shall be done through the analysis of these two options following the prescriptions of Step 2 of latest approved version of the "Tool for the demonstration and assessment of additionality", and comparing most likely practice and project activity using the NPV as the appropriate financial indicator.

Sub-step 3 b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity)

As per the latest approved version of the "*Tool for the demonstration and assessment of additionality*".

Step 4: Common Practice Analysis.

As per the latest approved version of the "*Tool for the demonstration and assessment of additionality*".

Step 5: Impact of CDM registration

As per the latest approved version of the "*Tool for the demonstration and assessment of additionality*".

Baseline emissions

The applicability conditions of the methodology requires that historical data of the facility with respect to current efficiency, aluminium production, and anode effect are available for three or more years prior to the project implementation. The stability of the anode effect should be observed taking into account specific PFC emission trends. These emissions shall be calculated using Tier 2 or Tier 3~~b~~ using the available data. The data used shall be from 31 December 2002 until the implementation of the project activity, or in the case of project activities with a starting date before 31 December 2005, from 3 years prior to the implementation of the project activity until the starting date of the project activity. To determine the baseline emission factor, data shall be selected for a period of measurement corresponding to the most stable and lowest anode effect (anode effect frequency, duration and/or over-voltage). The minimum period shall be 6 months, with the number of measurements statistically representative for that period.

Baseline emissions are difference of emissions of the baseline alternative and average value of "PFC emission per tonne of Aluminium produced". The later value should be taken from the most recent published IAI Survey for the PFPB technology. The PFC emission shall be expressed in tCO_{2e}.

Should the procedure to identify the most plausible baseline scenario reveal that the baseline corresponds to no implementation of any anode effect mitigation measures, baseline emissions (*BE*) are to be given by Equation (1):

$$\overline{\overline{BE}}\,(tCO_{2e}/tAl) = \left(\frac{EF_{CF_4}\cdot GWP_{CF_4} + EF_{C_2F_6}\cdot GWP_{C_2F_6}}{1000}\right)$$

$$If:\overline{\overline{BE}} \le BE_{IAI}, BE = \overline{\overline{BE}}.P_{Al} \qquad \textbf{(1)}$$

$$If:\overline{\overline{BE}}\rangle BE_{IAI}, BE = BE_{IAI}.P_{Al}$$

Where:

$\overline{\overline{BE}}$ = Baseline emissions per tonne of Aluminium produced (t CO_{2e}/tAl)

BE_{IAI} = Average value of "PFC emission per tonne of Aluminium produced" according to the most recent published IAI Survey for the PFPB technology (t CO_{2e}/tAl). In year 2003 this value was rated as 0.65 t CO_{2e}/ t Al.

BE = Baseline Emissions (t CO_{2e}/year)

EF_{CF_4} = Emission factor of CF_4 (kg CF_4/t Al), discounted by the uncertainty range as specified by the IAI/USEPA Protocol.

$EF_{C_2F_6}$ = Emission factor of C_2F_6 (kg C_2F_6/t Al), discounted by the uncertainty range as specified by the IAI/USEPA Protocol.

GWP_{CF_4} = Global Warming Potential of CF_4

$GWP_{C_2F_6}$ = Global Warming Potential of C_2F_6

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

The GWP values for the GHGs should be based on values reported in IPCC Second Assessment report. In case, the values are not provided in the Second Assessment Report, then values provided in the Third Assessment Report can be used.
The 2006 IPCC Guidelines describe three general methods for estimating PFCs emission factors from aluminium production (Vol. 3, Section 4.4.2.3, Choice of method for PFCs from primary aluminium production).

To monitor smelter emissions, project developer can use the following IPCC methods[2]:

1. Tier 3 Method;
2. Tier 2 Method.

The method to be adopted is dependent on whether anode effects are terminated manually prior to the implementation of the project activity or not, consistent with the EPA-IAI protocol[3]. Tier 2 is applicable if it can be proven and documented that 95% of the anode effects are manually terminated (cell hood must be opened during termination of the anode effect), while in all other cases, tier 3 is applicable.

Tier 3 Method: based on anode effect performance

This method uses measurements to establish a smelter-specific relationship between operating parameters (i.e. frequency and duration of anode effects or Anode Effect Over-voltage) and emissions of CF_4 and C_2F_6. These emission factors are multiplied by smelter-specific production (tonnes of aluminium) to estimate smelter emissions.

The optimum calculation method, (slope vs. over-voltage) depends largely on the type of anode effect kill practices used in plants.

1. The slope method should be used with aggressive fast kill anode effect practices;
2. The over-voltage method should be used with slow, repetitive anode effect kill practices.

Slope Method:

This method uses a regression analysis to estimate a linear relationship between anode effect (AE) and PFC emissions. The measurement could be periodic or continuous measurements and should be done as per the International Aluminium Institute GHG Protocol (IAI, 2005). The emission factor (EF) is then estimated as follows:

$$\begin{aligned} EF_{CF4} &= Slope \times AE \\ EF_{C2F6} &= EF_{CF4} \times F_{C2F6/CF4} \end{aligned} \tag{2}$$

Where:

EF_{CF4} = Emission factor of CF_4 (kg CF_4/t Al

EF_{C2F6} = Emission factor of C_2F_6 (kg C_2F_6/t Al)

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[2] Tier 1 approach provides default emission factors by technology type. The level of uncertainty in the Tier 1 method is much larger than for estimations using Tier II or Tier III methods.
[3] This Protocol is recommended in the corresponding monitoring methodology.

$Slope$ = Slope coefficient (kg PFC/t Al)/(AE-minute/cell.day)
AE = Anode Effect (min/cell.day[4]) estimated as per equation 3.1
$F_{C2F6/CF4}$ = Weight fraction of C_2F_6/CF_4 (kg C_2F_6/kg CF_4)

To develop an accurate estimate of the slope, simultaneous measurements of CF_4 or C_2F_6 emissions and anode effect data over an appropriate period of time are collected.

$$AE = AEF \times AED \tag{3}$$

Where:
AE = Anode effect (min/cell.day)[5]
AEF = Number of anode effects per cell.day, measured as per details provided in the monitoring section
AED = Anode effect duration in minutes (min), measured as per details provided in the monitoring section

Over-voltage Method:

This method uses the anode effect over-voltage as the relevant process parameter. The anode effect over-voltage is the cell voltage above 8V caused by anode effects, summed over a 24-hour period (mV/day).

$$EF = \frac{OVC \times AEO}{CE} \tag{4}$$

Where:
EF = Emission factor for CF_4 (kg CF_4/t Al) or C_2F_6 (kg C_2F_6/t Al)
OVC = Over-voltage coefficient (kg PFC/t Al)/(mV/cell.day), measured as per details provided in the monitoring section for the existing capacity
AEO = Anode effect over-voltage (mV/cell.day), measured as per details provided in the monitoring section for the existing capacity
CE = Aluminium production process current efficiency (%), measured as per details provided in the monitoring section for the existing capacity

The CF_4 and C_2F_6 emission factors determined using above value will remain constant throughout all the crediting period. The emission factors and the results of the measurements should be documented transparently in the CDM-PDD.

Tier 2 Method: based on anode effect performance

If measurement data are not available to determine smelter-specific slope or over-voltage coefficients, default coefficients may be used together with smelter-specific operating parameters (CE, AVO, AED,

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[4] The ‘cell.day’ term really means ‘the number of cells operating multiplied by the number of days of operation.’ At a smelter this would more usually be calculated (for a certain period of time, e.g. a month or a year) using ‘the average number of cells operating across the smelter over a certain period of days multiplied by the number of days in the period.’

[5] The ‘cell.day’ term really means ‘the number of cells operating multiplied by the number of days of operation.’ At a smelter this would more usually be calculated (for a certain period of time, e.g. a month or a year) using ‘the average number of cells operating across the smelter over a certain period of days multiplied by the number of days in the period.’

and AEF). Good practice default coefficients are listed in Table 1, Default coefficients for the calculation of PFC emissions from aluminium production (Tier 2 Methods).

Table 2: Technology-specific relationship between emissions & operating parameters based on default technology-based slope and over-voltage coefficients based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories (*to be updated as when new guideline is available)*

Technology	**Slope Coefficient [(kg PFC/tAl) / (AE-Mins/cellday)**		**Overvoltage Coefficient [(kg CF4/tAl) / (mV)]**		**Weight Fraction C2F6 / CF4**	
	CF4	**Uncertainty (+/-%)**	**CF4**	**Uncertainty (+/-%)**	**C2F6/CF4**	**Uncertainty (+/-%)**
CWPB	0.143	6	1.16	24	0.121	11
SWPB	0.272	15	2.65	43	0.252	23
VSS	0.092	17	NR	NR	0.053	15
HSS	0.099	44	NR	NR	0.085	48

Note 1: In order to determine the emission factor, along with the data from above table, the historic data on over-voltage (AEO) and CE or duration (AED), frequency (AEF) and CE, would be needed to estimate emission factor. The historic data is used to estimate the average of a quantity of values (corresponding to weekly or monthly data of the cells working all days in average and with, commonly, three shifts per day) and its standard deviation. To account for uncertainty use the 95% confidence interval (applying a Student's t-distribution for á degrees of freedom) values to estimate the emission factors. The lower or upper bound of 95% for a particular variable should be so chosen to result in conservative value of the emission factor. The uncertainty associated with AEF and AED or AEO, when measured, is expected to be low but will depend on computer scan rates (e.g. long scan rates will yield higher uncertainties) and data collection systems at each site. However, statistical error estimates for AEF and AED or AEO should be reported in the CDM-PDD.

Note 2: If Tier 2 Method is used, in order to ensure conservativeness, the lower limit for the emission factor should be chosen. For example, if using slope method for HSS technology the value of slope chosen from the able should be 0.05544 (= 0.099*(1-0.44)).

~~The *Revised 1996 IPCC Guidelines* describe three general methods for estimating PFC emission factors from aluminium production (Vol. 3, Section 2.13.6, PFC from Aluminium Production). These three methods correspond to tiers, but are not identified as such. To be consistent with other sections of the *IPCC Guidelines* and the *Good Practice Guidance*, the methods presented in the *IPCC Guidelines* are referred to as tiers in this section. The most accurate method is either to monitor smelter emissions continuously (Tier 3a) or to develop a smelter-specific long-term relationship between measured emissions and operating parameters and to apply this relationship using activity data (Tier 3b). The Tier 3b method requires comprehensive measurements to develop the smelter-specific relationship and on-going collection of operating parameter data (e.g., frequency and duration of anode effects and the anode effect over-voltage) and production data. The Tier 2 approach uses default values for the technology-specific slope and over-voltage coefficients, whereas the Tier 1 approach provides default emission factors by technology type. The level of uncertainty in the Tier 1 method is much larger than for estimations using Tier 3 or Tier 2 methods. In this methodology only the Tier 3b and Tier 2 methods are to be considered in the calculation of baseline emissions.~~

~~The method to be used is therefore dependent on the whether anode effects are terminated manually prior to the implementation of the project activity or not, consistent with the EPA-IAI protocol.[6] Tier 2~~

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[6] This Protocol is recommended in the corresponding monitoring methodology.

~~is applicable if it can be proven and documented that 95% of the anode effects are manually terminated (cell hood must be opened during termination of the anode effect), while in all other cases, Tier 3b is applicable.~~

~~*Tier 3b Method – Smelter-specific relationship between emissions and operating parameters based on field measurements*~~

~~This method uses measurements to establish a smelter-specific relationship between operating parameters (i.e. frequency and duration of anode effects or Anode Effect Over-voltage) and emissions of~~ ~~CF_4~~ ~~and~~ ~~C_2F_6~~~~. These emission factors are multiplied by smelter-specific production (tonnes of aluminium) to estimate smelter emissions.~~

~~The following estimation relationships can be used:~~

- ~~Slope method;~~
- ~~Over-voltage method.~~

~~The optimum calculation method, (slope vs. over-voltage) depends largely on the type of anode effect kill practices used in plants.~~

1. ~~The slope method should be used with aggressive fast kill anode effect practices.~~
2. ~~The over-voltage method should be used with slow, repetitive anode effect kill practices.~~

~~*Slope Method:* This method uses a linear least squares relationship between anode effect (*AE*) and emissions, expressed as an emission factor (*EF*):~~

~~$EF\ (kg\ CF_4\ or\ C_2F_6\ per\ tonne\ of\ Al) = Slope \cdot AE\ \mathrm{min}/cell.day$ (2)~~

~~Where:~~

~~EF = Emission factor of~~ ~~CF_4 (kg CF_4/t Al) or C_2F_6 (kg C_2F_6/t Al)~~

~~Slope = Slope coefficient~~

~~AE = Anode Effect (min/cell.day[7])~~

~~To develop an accurate estimate of the slope, simultaneous measurements of emissions and collection of anode effect data over an appropriate period of time are required. The Slope Method is a variant of the **Tabereaux approach** described in the *IPCC Guidelines.* It is recommended that specific~~ ~~CF_4~~ ~~emissions for anode effects longer than 2 minutes be calculated as follows:~~

~~Tabereaux Approach~~

~~$EF\ (kg\ CF_4\ or\ C_2F_6\ per\ tonne\ of\ Al) = Slope \cdot AE\ \mathrm{min}/cell.day$ (3)~~

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[7] The ‘cell.day’ term really means ‘the number of cells operating multiplied by the number of days of operation.’ At a smelter this would more usually be calculated (for a certain period of time, e.g. a month or a year) using ‘the average number of cells operating across the smelter over a certain period of days multiplied by the number of days in the period.’

~~$Slope = 1.698\,(p/CE)$ and $AE\ \text{min/cell.day} = AEF \cdot AED$~~

~~Where:~~

~~EF = Emission factor of CF_4 (kg CF_4/t Al) or C_2F_6 (kg C_2F_6/t Al)~~

~~Slope = Slope coefficient (kg PFC/t Al)/(AE-minute/cell.day)~~

~~AE = Anode Effect (min/cell.day[8])~~

~~*p* = Average fraction of CF_4 in the cell gas during anode effects for the CF_4 slope or Average fraction of C_2F_6 in the cell gas during anode effects for the C_2F_6 slope~~

~~- Prebake: p = 0.08 (8%)~~

~~- Søderberg: p = 0.04 (4%)~~

~~*CE* = Current Efficiency for the aluminium production process (fraction)~~

~~*AEF* = Number of anode effects per cell.day~~

~~*AED* = Anode effect duration in minutes (min)~~

~~Consistent with the 1996 Revised IPCC Guidelines the default rate for C_2F_6 emissions should be 1/10 that of CF_4.~~

~~*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/day). The correlation formula was derived from measurements of PFC generation at smelters with Pechiney technology, expressed as an emission factor (*EF*):~~

~~$EF\ (kg\ CF_4\ or\ C_2F_6\ per\ tonne\ of\ Al) = OVC \cdot AEO / CE \qquad (4)$~~

~~Where:~~

~~EF = Emission factor of CF_4 (kg CF_4/t Al) or C_2F_6 (kg C_2F_6/t Al)~~

~~*OVC* = Over-Voltage Coefficient (kg PFC/t Al)/(mV/cell.day)~~

~~*AEO* = Anode effect over-voltage (mV/cell.day)~~

~~*CE* = Aluminium production process current efficiency (%)~~

~~By using historical data of the plant (*AEO* or *AEF* and *AED* and *CE*) and the coefficient measured, CF_4 and C_2F_6 emission factors are determined and will remain constant throughout the crediting period. The emission factors and the results of the measurements should be documented transparently in the CDM-PDD.~~

~~Ex ante baseline emissions will be estimated from Eq. (1) using the ex ante aluminium production data estimated by the plant for the crediting period. Following the project, P_{Al} will be monitored and then ex post baseline emissions will be obtained from Eq. (1).~~

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[8] The 'cell.day' term really means 'the number of cells operating multiplied by the number of days of operation.' At a smelter this would more usually be calculated (for a certain period of time, e.g. a month or a year) using 'the average number of cells operating across the smelter over a certain period of days multiplied by the number of days in the period.'

~~*Tier 2 Method – Smelter-specific relationship between emissions & operating parameters based on default technology-based slope and over-voltage coefficients*~~

~~If measurement data are not available to determine smelter-specific Slope or Over-voltage coefficients, default coefficients may be used together with smelter-specific operating parameters. *Good practice* default coefficients are listed in Table 1, Default Coefficients for the Calculation of PFC Emissions from Aluminium Production (Tier 2 Methods).~~

~~Default Coefficients for the Calculation of PFC Emissions form Aluminium Production~~

~~(TIER 2 Methods)~~

~~**Technology**~~[a]	~~**Slope**~~[b, c] ~~**(kg PFC/t Al)/(AE-Minutes/cell.day)**~~				~~**Over-voltage coefficient**~~[b] ~~**(kg PFC/t Al)/(mV/cell.day)**~~	
	~~**CF_4**~~	~~**Uncertainty**~~	~~**C_2F_6**~~	~~**Uncertainty**~~	~~**CF_4**~~	~~**C_2F_6**~~
~~CWPB~~	~~0.14~~	~~±0.009~~	~~0.018~~	~~±0.004~~	~~1.9~~	~~NA~~

~~a Centre Worked Prebaked (CWPB) – PFPB is a Centre Worked Prebake cell technology with a Point Alumina Feed System.~~

~~b Source: IPAI, EPA field measurements, and other company measurement data.~~

~~c Embedded in each Slope coefficient is an assumed emissions collection efficiency as follows: CWPB 95%. These collection efficiencies have been assumed based on expert opinion.~~

~~NA = not available.~~

~~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 the IPCC default value for CWPB is proposed to be used.~~

~~By using historical data of the plant (*AEO* or *AEF* and *AED* and *CE*), ex ante CF_4 and C_2F_6 emission factors are set and will remain constant through the crediting period. Ex ante baseline emissions will be estimated from Eq. (1) using the ex ante aluminium production data estimated by the plant for the crediting period.~~

~~Following the project P_{Al} will be monitored and then ex post baseline emissions will be obtained from Eq. (1).~~

~~**Note 1**: In order to determine the average anode effect over-voltage (AEO), duration (AED) and frequency (AEF) it is necessary to have data from historical records. This information results from taking the average of a quantity of values (corresponding to weekly or monthly data of the cells working all days in average and with, commonly, three shifts per day). From the mean value and its standard deviation a 95% confidence interval (applying a Student's t-distribution for α degrees of freedom) can be set. The uncertainty associated with *AEF* and *AED* or *AEO*, when measured, is expected to be low but will depend on computer scan rates (e.g., long scan rates will yield higher uncertainties) and data collection systems at each site. However, statistical error estimates for *AEF* and *AED* or *AEO* should be reported in the CDM-PDD.~~

~~**Note 3:** The over-voltage method does not provide any recommendation for the over-voltage coefficient corresponding to C_2F_6. This methodology requires that the rate for C_2F_6 emissions be 1/10 that of CF_4, as pointed out by the Revised 1996 IPCC Guidelines. The default rate for C_2F_6 emissions should always be defined according to the most recent published IPCC Guidelines.~~

~~**Note 4**: When properly established, Tier 3 coefficients will have an uncertainty of +/-15% at the time the coefficients are measured. Working with the lower limit for the baseline emissions and the upper limit for the project emissions will guarantee conservatism. If a Tier 2 method is used, in order to ensure conservativeness, the corresponding lower value within the uncertainty interval for each coefficient (Slope or Over-voltage) should be used, as recommended by the USEPA/IAI protocol for measurement of PFC emissions from primary aluminium production (see references).~~

Data source & key parameters

The data necessary and parameters required to determine PFC baseline emissions are listed below:

Symbol	Definition	Data source (in order or preference) and justification
EF_{CF_4}	Emission factor of CF_4 (kg CF_4/t Al)	Anode effect Over-voltage (AEO), Anode Effect Frequency (AEF) and Anode Effect Duration (AED) on-site measurements in order to introduce in the corresponding equations of IPCC Methods.
$EF_{C_2F_6}$	Emission factor of C_2F_6 (kg C_2F_6/t Al)	AEO, AEF and AED on-site measurements in order to introduce in the corresponding equations of IPCC Methods~~. IPCC suggests using 1/10 of EF_{CF_4}~~.
OVC	Over-voltage coefficient [(kg PFC/t Al)/(mV/cell.day)]	1. OVC (PFC) on-site measurements 2. IPCC default tier 2 emissions factors only for baseline emissions. Tier 2 is applicable if it can be proven and documented that 95% of the anode effects are manually killed (cell hood must be opened during termination of the anode effect)
Slope	Slope [(kg PFC/t Al)/(AE-Minutes/cell.day)]	1. Slope (PFC) on-site measurements 2. IPCC default tier 2 emissions factors only for baseline emissions. Tier 2 is applicable if it can be proven and documented that 95% of the anode effects are manually killed (cell hood must be opened during termination of the anode effect)
P	Average fraction of CF_4 in the cell gas during anode effects for the CF_4 slope or Average fraction of C_2F_6 in the cell gas during anode effects for the C_2F_6 slope	1. PFC on-site measurements 2. IPCC default emissions factors only for baseline emissions. Applicable if it can be proven and documented that 95% of the anode effects are manually killed (cell hood must be opened during termination of the anode effect)

Thus, the following list of references is provided:

- IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (http://www.ipccnggip.iges.or.jp/public/gp/english/3_Industry.pdf). The baseline methodology should always consider the most recent recommendations from IPCC.
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Reference Manual Volume 3 (http://www.ipccggip.iges.or.jp/public/gl/invs6b.htm). The methodology should always consider the most recent recommendations from IPCC.
- Draft 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

- USEPA and IAI (2003), Protocol for Measurement of Tetrafluoromethane and Hexafluoroethane from Primary Aluminium Production. U.S. EPA Climate Protection Partnerships Division, Washington, DC (called “Protocol” in this methodology).
- The International Aluminium Institute’s report on the aluminium industry’s global perfluorocarbon gas emissions reduction programme – results of the 2003 anode effect survey.

Leakage

No leakage is expected to occur in this type of projects.

Emission Reductions

The project emissions (PE) are given by Eq. (5):

$$PE \ \ (tCO_{2e} / year) = \left(\frac{EF_{CF_4} \cdot GWP_{CF_4} + EF_{C_2F_6} \cdot GWP_{C_2F_6}}{1000} \right) \cdot P_{Al} \qquad \textbf{(5)}$$

Where:

PE = Project emissions (t CO_2e/year)

EF_{CF_4} = Emission factor of CF_4 (kg CF_4/t Al)

$EF_{C_2F_6}$ = Emission factor of C_2F_6 (kg C_2F_6/t Al) ~~= 1/10 of EF_{CF_4}~~

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

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

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

For ex ante calculation of project emissions, the PDD will have to provide a justified estimation of the future values of *AEO* (or *AEF* and *AED*) and *CE* (ex ante CF_4 and C_2F_6 emission factors). The future production of aluminium will be estimated for the crediting period by the plant.

Ex post emissions of the project are calculated based on monitored values of *AEO* (or *AEF* and *AED*) and *CE* in Eqs. (2), (3) or (4), as applicable.

Following project implementation, P_{Al} will be monitored and ex post project emissions will be obtained from Eq. (5).

Project emissions will be obtained by the application of Tier 3 method only: To obtain the slope coefficient or the over-voltage coefficient a measurement shall be performed once following project implementation and every three years or less according to the IAI/USEPA protocol.

The emission reductions, *ER*, by the project activity is given by:

$$\mathrm{ER} = \mathrm{BE} - \mathrm{PE} \qquad \textbf{(6)}$$

Where:

ER = Emission Reductions (tCO_2e/year)

BE = Baseline Emissions (tCO_2e/year)

PE = Project Emissions (tCO_2e/year)

Total emission reductions should be calculated ex ante, using an estimated value for *BE* corresponding to emissions prior to project implementation. The estimation of total emission reductions shall be reported in the PDD submitted for validation.

III. MONITORING METHODOLOGY

Monitoring procedures

~~Approved monitoring methodology AM0030~~

~~"PFC emission reductions from anode effect mitigation at primary aluminium smelting facilities"~~

~~Source~~

~~This monitoring methodology is based on the "Monitoring methodology for PFC emission reductions from anode effect mitigation at a primary aluminium smelting facility" submitted by MGM International on behalf of Aluar Aluminio Argentino.~~

~~For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0124rev: "PFC emission reductions from anode effect mitigation at a primary Aluminium smelting facility" on http://cdm.unfccc.int/methodologies/approved~~

~~Applicability~~

~~This methodology is applicable to project activities:~~
~~Primarily aiming at the avoidance of PFC emissions~~[9] ~~in aluminium smelting facilities that use center work prebake cell technology with bar brake (CWPB) or point feeder systems (PFPB) and that have started operation before 31 December 2002;~~
~~Where at least three years of historical data is available regarding current efficiency, anode effect and aluminium production of the industrial facility from 31 December 2002 onwards or, in case of project activities with a starting date before 31 December 2005, from 3 years prior to the implementation of the project activity onwards, until the starting date of the project activity.~~
~~At facilities where the existing number of potlines and pots within the system boundary is not increased during the crediting period. The methodology is only applicable up to the end of the lifetime of existing potlines if this is shorter than the crediting period.~~
~~Where it is demonstrated that, due to historical improvements carried out, the facility achieved an "operational stability associated to a PFC emissions level" that allows increasing the aluminium production by simply increasing the electric current in the pots". This can be demonstrated providing results of, e.g., pilot tests carried out by the company.~~

~~This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0030.~~

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[9] ~~In contrast to activities primarily aiming at increasing aluminium production, with emission avoidance as a side-effect.~~

All monitoring procedures must be in accordance with the USEPA and IAI "Protocol for Measurement of Tetrafluoromethane and Hexafluoroethane from Primary Aluminium Production".

Project emissions are determined by multiplying aluminium production with the post-project implementation emission factors for PFCs. Post project emission factors are determined by measuring Current Efficiency (CE) and Anode Effect Frequency and Duration (AEF and AED) or Anode Effect Over-voltage (AEO) and using slope coefficients or over-voltage coefficients based on PFC on-site measurements.

To obtain the project activity slope coefficient [(kg PFC/t Al)/(AE-minute/cell.day)] or over-voltage coefficient [(kg PFC/t Al)/(mV/cell.day)] a measurement shall be performed each three years (tier 3 method). By using historical data of the plant (AEO —or AEF and AED— and CE) and the coefficient measured, ex ante CF_4 and C_2F_6 emission factors are set and will remain constant until a new measurement is conducted (every three years or less).

Ex ante baseline emissions will be estimated from Eq. (1) using the ex ante aluminium production data estimated by the plant for the crediting period.

Following the project, P_{Al} will be monitored and then ex post baseline emissions will be obtained from Eq. (1).

To obtain the baseline scenario slope coefficient [(kg PFC/t Al)/(AE-minute/cell.day)] or over-voltage coefficient [(kg PFC/t Al)/(mV/cell.day)] a measurement shall be performed once prior to project implementation (tier 3 method). By using historical data of the plant (AEO - or AEF and AED - and CE) and the coefficient measured, ex ante CF_4 and C_2F_6 emission factors are set and will remain constant throughout the crediting period.

To determine baseline emissions, if measurement data are not available to determine smelter-specific Slope or Over-voltage coefficients, default coefficients may be used together with smelter-specific operating parameters. *Good practice* default coefficients are listed in Table 1, Default Coefficients for the Calculation of PFC Emissions from Aluminium Production (tier 2 method).

Data and parameters monitored
~~*Parameters to be monitored*~~

Data/Parameter:	P.1/ CE
Data unit:	%
Description:	Current efficiency of Aluminium production process
Source of data:	Aluminium plant
Measurement procedures (if any):	
Monitoring frequency:	Monthly
QA/QC procedures:	The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process
Any comment:	

Data/Parameter:	P.2/AEO
Data unit:	mV/cell.day
Description:	Anode effect over voltage

Source of data:	Aluminium plant
Measurement procedures (if any):	
Monitoring frequency:	Daily
QA/QC procedures:	The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process
Any comment:	

Data/Parameter:	P.3/ P_{Al}
Data unit:	Tonne
Description:	Aluminium production
Source of data:	Aluminium plant
Measurement procedures (if any):	
Monitoring frequency:	Monthly
QA/QC procedures:	The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process
Any comment:	

Data/Parameter:	P.4/ AEF
Data unit:	Number of anode effects per cell.day
Description:	Anode effect frequency
Source of data:	Aluminium plant
Measurement procedures (if any):	
Monitoring frequency:	Daily
QA/QC procedures:	The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process
Any comment:	

Data/Parameter:	P.5/ AED
Data unit:	Minutes
Description:	Anode effect duration
Source of data:	Aluminium plant
Measurement procedures (if any):	
Monitoring frequency:	Daily
QA/QC procedures:	The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process
Any comment:	

Data/Parameter:	P.6 /Slope
Data unit:	[(kg PFC/t Al)/(AE-minute/cell.day)]
Description:	Slope coefficient
Source of data:	Aluminium plant
Measurement	

procedures (if any):	
Monitoring frequency:	Every 3 year, or less according to the "protocol"
QA/QC procedures:	The aluminium plant should follow QA/QC procedures described in page 32, section 8 of the Protocol
Any comment:	

Data/Parameter:	P.7/ OVC
Data unit:	(kg PFC/t Al)/(mV/ cell.day)
Description:	Over-voltage coefficient
Source of data:	Aluminium plant
Measurement procedures (if any):	
Monitoring frequency:	Every 3 year, or less according to the "protocol"
QA/QC procedures:	The aluminium plant should follow QA/QC procedures described in page 32, section 8 of the Protocol
Any comment:	

Data / Parameter:	EF_{CF4}
Data unit:	Kg CF_4/t Al
Description:	Emission factor of CF_4
Source of data:	Anode effect over voltage (AEO), Anode Effect Frequency (AEF) and Anode Effect Duration (AED) onsite measurements in order to introduce in the corresponding equations of IPCC Methods.
Measurement procedures (if any):	In accordance with Protocol for measurement of Tetrafluoromethane (CF4) Emissions from Primary Aluminium Production, USEPA and IAI, May 2003
Monitoring frequency:	Every 3 year, or as per "protocol Monthly
QA/QC procedures:	Uncertainty level of data is Low. The aluminium smelting plant should of series of internal check procedures including scheduled calibration to ensure low uncertainties of the data produced during monitoring.
Any comment:	

Data / Parameter:	EF_{C2F6}
Data unit:	Kg C_2F_6/t Al
Description:	Emission factor of C_2F_6
Source of data:	AEO, AEF and AED on-site measurements in order to introduce in the corresponding equations of IPCC Methods.
Measurement procedures (if any):	In accordance with Protocol for measurement of Hexafluoroethane (C_2F_6) Emissions from Primary Aluminium Production, USEPA and IAI, May 2003
Monitoring frequency:	Every 3 year, or as per "protocol"
QA/QC procedures:	Uncertainty level of data is Low. The aluminium smelting plant should of series of internal check procedures including scheduled calibration to ensure low uncertainties of the data produced during monitoring.
Any comment:	

~~*Parameters to be monitored*~~

~~B.2.1. Data to be collected or used 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 B.7)***~~	~~**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**~~
~~P.1~~	~~Current efficiency of aluminium production process (CE)~~	~~Aluminium plant~~	~~%~~	~~M~~	~~Monthly~~	~~100%~~	~~Paper (field record)~~ ~~Electronic (spreadsheet)~~	
~~P.2~~	~~Anode Effect Over-voltage (AEO)~~	~~Aluminium plant~~	~~mV/cell.day~~	~~M~~	~~Daily~~	~~100%~~	~~Paper (field record)~~ ~~Electronic (spreadsheet)~~	
~~P.3~~	~~Aluminium production (P_{Al})~~	~~Aluminium plant~~	~~Tonne~~	~~M~~	~~Monthly~~	~~100%~~	~~Paper (field record)~~ ~~Electronic (spreadsheet)~~	
~~P.4~~	~~Anode effect frequency(AEF)~~	~~Aluminium plant~~	~~Number of anode effects per cell.day~~	~~M~~	~~Daily~~	~~100%~~	~~Paper (field record)~~ ~~Electronic (spreadsheet)~~	
~~P.5~~	~~Anode effect duration (AED)~~	~~Aluminium plant~~	~~Minutes~~	~~M~~	~~Daily~~	~~100%~~	~~Paper (field record)~~ ~~Electronic (spreadsheet)~~	
~~P.6~~	~~Slope coefficient~~	~~Aluminium plant~~	~~[(kg PFC/t Al)/(AE-minute/cell.day)]~~	~~M~~	~~Every 3 year, or less according to~~	~~At least 15 anode effects~~	~~Paper (field record)~~ ~~Electronic~~	~~Refer to instructions in page 34, section~~

~~ID number~~ *~~(Please use numbers to ease cross-referencing to table B.7)~~*	~~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~~
					~~the "protocol"~~		~~(spreadsheet)~~	~~10 of the Protocol.~~
~~P.7~~	~~Over-voltage coefficient~~	~~Aluminium plant~~	~~[(kg PFC/t Al)/(mV/cell.day)]~~	~~M~~	~~Every 3 year, or less according to the "protocol"~~	~~At least 15 anode effects~~	~~Paper (field record)~~ ~~Electronic (spreadsheet)~~	~~Refer to instructions in page 34, section 10 of the Protocol.~~

~~B.2.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of greenhouse gases (GHG) within the project boundary and how such data will be collected and archived:~~

~~ID number (Please use numbers to ease cross-referencing to table B.7)~~	~~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~~
~~B.1~~	~~Current efficiency of aluminium production process (CE)~~	~~Aluminium plant~~	~~%~~	~~m~~	~~Monthly~~	~~100%~~	~~Paper (field record)~~ ~~Electronic (spreadsheet)~~	
~~B.2~~	~~Aluminium production~~ ~~(P$_{Al}$)~~	~~Aluminium plant~~	~~Tonne~~	~~m~~	~~Monthly~~	~~100%~~	~~Paper (field record)~~ ~~Electronic (spreadsheet)~~	

~~Quality Control (QC) and Quality Assurance (QA) Procedures~~

~~B.7. Please indicate whether quality control (QC) and quality assurance (QA) procedures are being undertaken for the items 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.**~~
~~P.1~~	~~*Low*~~	~~*The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process*~~
~~P.2~~	~~*Low*~~	~~*The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process*~~
~~P.3~~	~~*Low*~~	~~*The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process*~~

~~**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.**~~
~~P.4~~	~~*Low*~~	~~*The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process*~~
~~P.5~~	~~*Low*~~	~~*The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process*~~
~~P.6 – P.7~~	~~*Medium*~~	~~*The aluminium plant should follow QA/QC procedures described in page 32, section 8 of the Protocol.*~~
~~B.1~~	~~*Low*~~	~~*The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process*~~
~~B.2~~	~~*Low*~~	~~*The aluminium plant should have a series of internal procedures that ensures data have low uncertainties during monitoring process*~~

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