Draft revision to the approved baseline and monitoring 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 elements from the following proposed new methodology:

- NM0124-rev "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 proposed new methodology and its consideration by the CDM Executive Board please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

Selected approach from paragraph 48 of the CDM modalities and procedures

"Existing actual or historical emissions, as applicable".

Definitions

For the purpose of this methodology, the following definitions apply:

A cell is the electrolytic cell where aluminium is produced from primary materials by the electrolytic reduction of aluminium oxide (alumina). It comprises a carbon cathode, insulated by refractory bricks inside a rectangular steel shell, and a carbon anode suspended from an electrically conductive anode beam.

Potline refers to a number of cells which are connected to form an electrical reduction line.

Centre work pre-bake cell technology with a bar brake (CWPB) is an aluminium smelting technology, which belongs to the prebake type of cells. This type of cells uses anodes that are manufactured in a separate anode plant. With CWPB technology aluminium is produced by feeding alumina into the cell after the crust is broken along the centreline.

Centre work pre-bake cell technology with point feeder system (PFPB) is an aluminium smelting technology, which belongs to the prebake type of cells. This type of cells uses anodes that are manufactured in a separate anode plant. With PFPB technology aluminium is produced by feeding alumina into the cell after the crust is broken at selected points on the centreline of the cell. These feeding methods can be carried out without opening the gas collection hoods.

Anode effect refers to special conditions during aluminium production which occur when the concentration of aluminium oxide (the raw material for primary aluminium) dissolved in the cell drops too low and the electrolytic bath itself begins to undergo electrolysis. An anode effect in a cell is considered to begin when the cell voltage exceeds a defined voltage threshold (A). An anode effect is considered to end when the cell voltage drops below a second voltage threshold (B) and remains below this voltage level for a define time (T). Often, a value of 8.0 volts is used for the threshold A, a value of 6.0 volts is used for the threshold B, and 15 minutes are used for the time T. However, different values may be applied by the project participants if they were consistently used by the plant in the most recent three years prior to the implementation of the project activity. After the anode effect is extinguished, a series of anode raises are made until the cell reaches the lower resistance target range. At this time, a counter is started. If the voltage raises within the time T above the threshold B, it is considered as a repeat anode effect, and is not counted as a new anode effect. After the time period T has elapsed, any anode effects are counted as new.

Anode effect duration refers to the minutes per cell and day during which the voltage in the cell is above the threshold A defined for the anode effect above.

The current efficiency of aluminium production describes the efficiency of electrolytic reactions occurring in the process of aluminium production. It is defined as the ratio of the actual amount of aluminium produced with a given amount of electricity to the hypothetical maximum amount of aluminium that can be produced with the given amount of electricity. The value of 0.008058 metric tons of aluminium per kA and cell and day is based on Faraday's Law and corresponds to a current efficiency of 100%. The current efficiency is dimensionless.

Monitoring period *m*. The period, for which a monitoring report is submitted, the verification is performed and for which issuance of CERs is requested by the Project Developer through the Designated Operational Entity (DOE). A monitoring period can be of shorter duration than one year, but the last monitoring report in a calendar year *y* shall end on 31 December and the first monitoring report for a calendar year *y* shall start 1 January. Under this methodology, emission reductions are calculated for each monitoring period *m*.

Applicability

This methodology is applicable to project activities that conduct an investment to reduce the PFC emissions in existing aluminium smelting facilities that use centre work pre-bake cell technology with bar brake (CWPB) or point feeder systems (PFPB).

The methodology is applicable under the following conditions:

- The aluminium smelting facility(ies) and potlines where the project activity is implemented started commercial operation before 1 January 2009;
- Historical data on the current efficiency, the anode effects and aluminium production is available for the project potlines for the most recent three calendar years prior to the implementation of the project activity;
- Data from the International Aluminium Institute (IAI) on PFC emissions of individual aluminium smelting plants are available for a calendar year which does not start earlier than three years prior to the end of the monitoring period *m* and the data includes at least 33% of the global aluminium production;
- It can be 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 cells. This can be demonstrated for example by providing results of pilot tests carried out by the project participants.

II. BASELINE METHODOLOGY

Project boundary

The geographical delineation of the project boundary encompasses the physical site of the potlines where the project activity is implemented. The project boundary may include one, several or all potlines located at the aluminium smelting facility. The project participants shall transparently document in the CDM-PDD which potlines are included within the project boundary and, where applicable, which existing potlines are not included in the project boundary. 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.

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

	Source	Gas	Included?	Justification / Explanation
Baseline	Anode effects in cells	CF_4	Yes	Main emission source
		C_2F_6	Yes	
	Carbon anode reaction	CO_2	No	These GHG emission sources are not included for simplification
	Use of Na_2CO_3	CO_2	No	
	Use of cover gas	SF_6	No	
	Electricity consumption	CO_2	No	Electricity consumption is typically reduced to some extent due to the project activity. It is conservative to exclude this emission source
		CH_4	No	
		N_2O	No	
Project Activity	Anode effects in cells	CF_4	Yes	Main emission source
		C_2F_6	Yes	
	Carbon anode reaction	CO_2	No	These GHG emission sources are not included for simplification
	Use of Na_2CO_3	CO_2	No	
	Use of cover gas	SF_6	No	
	Electricity consumption	CO_2	No	Electricity consumption is typically reduced to some extent due to the project activity
		CH_4	No	
		N_2O	No	

Baseline identification and additionality demonstration

The methodology assumes that the baseline scenario is the continuation of the aluminium production by the same technology without investing to reduce the PFC emissions.

The project activity is assumed to be additional if the emission performance of the potlines involved in the project activity is better than a benchmark emission factor. A separate assessment of additionality is therefore not required.

The benchmark emission factor is calculated based on the performance of other aluminium smelting facilities, using data from the annual survey of anode effects and PFC emissions, published by the International Aluminium Institute (IAI). The benchmark emission factor shall be calculated following the approach set out in the section “Baseline emissions” below, using the most recent calendar year for which data is available from the IAI.

Baseline emissions

Baseline emissions are determined based on:

(a) The total eligible aluminium production from potline(s) included in the project boundary during the monitoring period *m*;

(b) The average historical emission factor of the relevant potline in the project aluminium smelting facility prior to the implementation of the project activity ($EF_{p,hist}$); and

(c) a benchmark emission factor, determined based on the performance of other aluminium smelting facilities that use CWPB or PFPB aluminium smelting technology ($EF_{BM,Al,y}$).

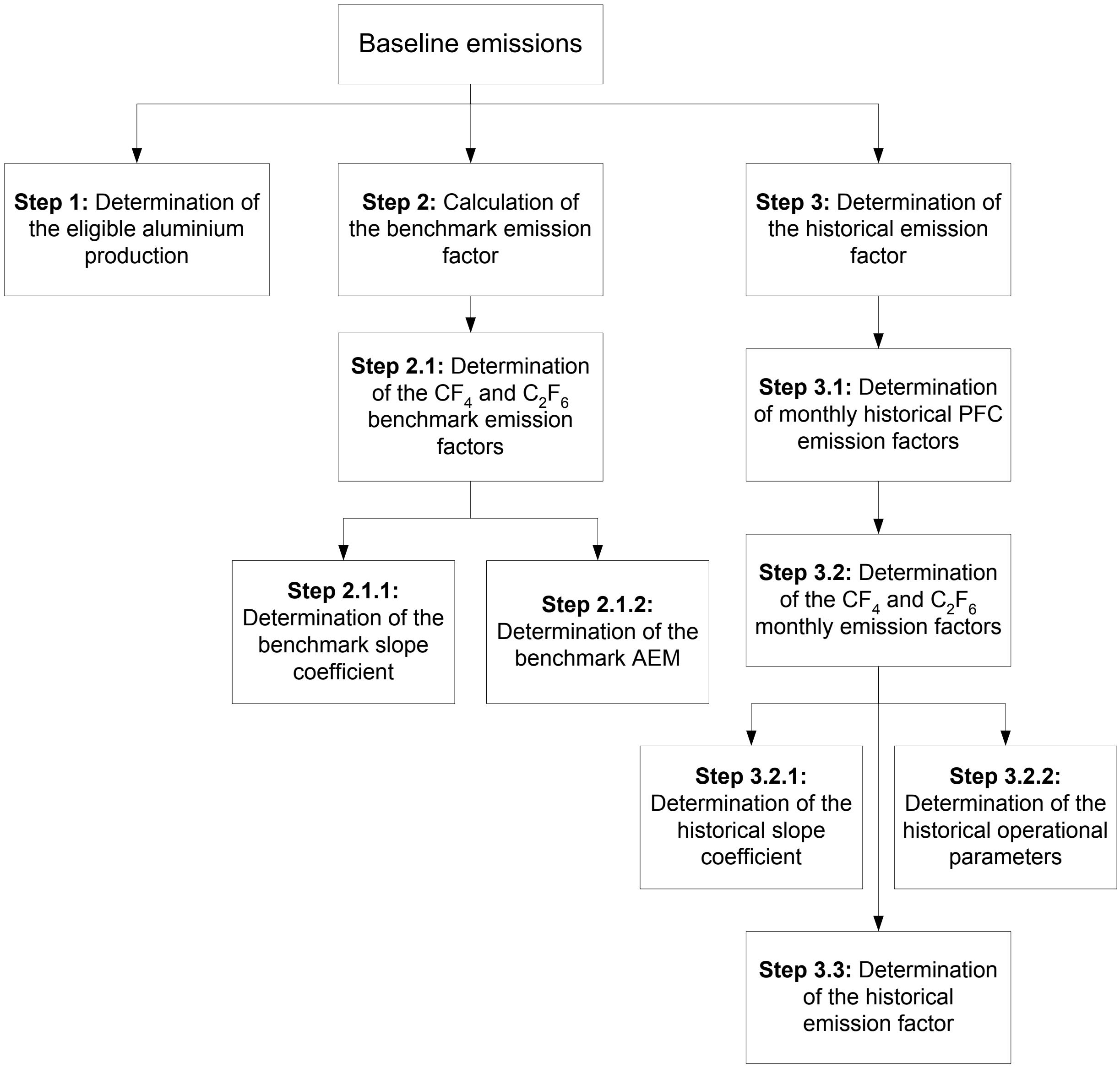
As a conservative approach, the lower value between the historical emission factor of the project potline prior to the implementation of the project activity ($EF_{p,hist}$) and the benchmark emission factor ($EF_{BM,Al,y}$) is used to calculate baseline emissions. Baseline emissions are determined separately for each potline *p* included in the project boundary. Baseline emissions for the monitoring period *m* shall be calculated as follows:

$$BE_m = \sum_p \min\{EF_{p,hist}; EF_{BM,Al,y}\} \times P_{AL,p,m} \quad \textbf{(1)}$$

Where:

BE_m	=	Baseline emissions for monitoring period *m* (t CO_2e)
$EF_{p,hist}$	=	Historical emission factor per tonne of aluminium produced for potline *p* (t CO_2e / t Al)
$EF_{BM,Al,y}$	=	Benchmark emission factor for year *y* (t CO_2e / t Al)
p	=	Potlines included in the project boundary
$P_{AL,p,m}$	=	Total eligible aluminium production from potline *p* in monitoring period *m* (t Al)

A step wise approach shall be followed in order to determine the relevant parameters in equation (1) above, as presented at flow-chart:



Step 1: Determination of the total eligible aluminium production ($P_{AL,p,m}$)

The total eligible aluminium production from each potline *p* shall be determined as the lowest value between the actual aluminium production during the monitoring period *m* and the maximum annual historical production, adjusted to the duration of the monitoring period *m*, in the last three calendar years prior to the implementation of the project activity, as follows:

$$P_{AL,p,m} = \min\left\{P_{AL,PJ,p,m}; \frac{M}{Y} \times P_{p,hist}\right\} \quad \textbf{(2)}$$

Where:

$P_{AL,p,m}$	=	Total eligible aluminium production from potline *p* in monitoring period *m* (t Al)
$P_{AL,PJ,p,m}$	=	Total amount of aluminium produced in potline *p* in monitoring period *m* (t Al)
M	=	Duration of the monitoring period *m* (days)
Y	=	Number of days of the calendar year *y* of monitoring period *m* (days)

$P_{p,hist}$	=	Maximum annual amount of aluminium production from the potline *p* in the most recent three calendar years prior to the implementation of the project activity (t Al)
p	=	Potlines included in the project boundary

Step 2: Calculation of the benchmark emission factor ($EF_{BM,Al,y}$)

The benchmark emission factor shall be determined using the IPCC Tier 2 approach and shall be based on the minimum of the average values of the anode effect minutes per cell-day (AEM) for the top 20% performers that use the same aluminium smelting technology as the project activity.

To determine the average values of the anode effect minutes per cell-day (AEM), the published IAI surveys of anode effects and PFC emissions from the aluminium industry shall be used. The set of surveys to determine the benchmark for year *y* shall include the five most recent surveys prior to the implementation of the project activity and the surveys that have been published since the implementation of the project activities until the end of the monitoring period *m*, if any.
The benchmark emission factor for year *y* shall be determined as follows:

$$EF_{BM,Al,y} = \left(EF_{CF_4,BM,Al,y} \times GWP_{CF_4} + EF_{C_2F_6,BM,Al,y} \times GWP_{C_2F_6}\right) \times 10^{-3} \quad (3)$$

Where:

$EF_{BM,Al,y}$	=	Benchmark emission factor for year *y* (t CO_2e / t Al)
$EF_{CF_4,BM,Al,y}$	=	Benchmark emission factor of CF_4 for year *y* (kg CF_4/t Al)
$EF_{C_2F_6,BM,Al,y}$	=	Benchmark emission factor of C_2F_6 for year *y* (kg C_2F_6/t Al)
GWP_{CF_4}	=	Global warming potential of CF_4 (kg CO_2e/kg CF_4)
$GWP_{C_2F_6}$	=	Global warming potential of C_2F_6 (kg CO_2e/kg C_2F_6)

Step 2.1: Determination of the CF_4 and C_2F_6 benchmark emission factors

The benchmark emission factors of the CF_4 and C_2F_6 shall be determined according to the IPCC Tier 2 approach, as follows:

$$EF_{CF_4,BM,Al,y} = S_{CF4} \times AEM_{BM,Al,y} \quad (4)$$

$$EF_{C_2F_6,BM,Al,y} = EF_{CF_4,BM,Al,y} \times F_{C_2F_6/CF4} \quad (5)$$

Where:

$EF_{CF_4,BM,AL,y}$	=	Benchmark emission factor of CF_4 for year *y* (kg CF_4/t Al)
$EF_{C_2F_6,BM,Al,y}$	=	Benchmark emission factor of C_2F_6 for year *y* (kg C_2F_6/t Al)
S_{CF4}	=	Slope coefficient for CF_4 [(kg CF_4/t Al)/(AE-min/cell-day)]
$AEM_{BM,Al,y}$	=	Benchmark for the anode effect minutes per cell and per day for year *y* (AE-min/cell-day)
$F_{C2F6/CF4}$	=	Weight fraction of C_2F_6/CF_4

Step 2.1.1: Determination of the slope coefficient

The project participants shall use the default values for the slope coefficient and the weight fraction of C_2F_6/CF_4 provided for the IPCC Tier 2 approach in the 2006 IPCC Guidelines (Vol. 3, Section 4.4.2.4, Tier 2: PFC emission factor based on a technology specific relationship between anode effect performance and PFC emissions).

Step 2.1.2: Determination of the benchmark for the anode effect minutes per cell and day ($AEM_{BM,Al}$)

The benchmark for the anode effect minutes per cell and day ($AEM_{BM,Al,y}$) is based on the minimum of the average values of the top 20% performing plants using the respective aluminium smelting technology.

To determine $AEM_{BM,Al,y}$, the following approach shall be used:

(1) Using the latest IAI "Anode Effect Surveys", including the five most recent surveys published prior to the implementation of the project activity and all surveys published since the implementation of the project activity until the end of the monitoring period *m*, determine the number of plants (N_x) for each applicable year *x* by multiplying the total number of plants included in the survey for that year (Z_x) by 20%. In the case that the resulting value is fractional it should be arithmetically rounded to the integer value.

Example. For the year 2009 (IAI survey published by 2009), the number of aluminium smelting facilities using PFPB technology and reported PFC emissions to the IAI is Z_{2009}=99. Therefore number of plants that shall be used to calculate the benchmark is N_{2009}=99*20% = 19.8≈20.

(2) Determine the benchmark for the anode effect minutes per cell and day ($AEM_{BM,Al,y}$) as the minimum of values among all years, calculated for each year as the average anode effect minutes per cell and day of the aluminium smelting facilities N_x identified in the previous step, as follows:

$$AEM_{\mathrm{BM,Al,y}} = \min\left\{\frac{1}{N_x}\sum_{\mathrm{n}}\mathrm{AEM}_{\mathrm{Al,n,x}}, \frac{1}{N_{x-1}}\sum_{\mathrm{n}}\mathrm{AEM}_{\mathrm{Al,n,x\text{-}1}}, \ldots, \frac{1}{N_{(x-g)}}\sum_{\mathrm{n}}\mathrm{AEM}_{\mathrm{Al,n,(x\text{-}g)}}\right\} \quad \textbf{(6)}$$

With

$$N_x = \mathrm{Z_x} \times 0.2 \quad \textbf{(7)}$$

Where:

$AEM_{BM,Al,y}$	=	Benchmark for the anode effect minutes per cell and day for year *y* (AE-min/cell-day)
N_x	=	Number of plants that are used to calculate the benchmark AEM
Z_x	=	Number of aluminium smelting facilities included in the IAI survey in year *x* for the respective aluminium smelting technology
$AEM_{Al,n,x}$	=	Anode effect minutes per cell-day reported for plant *n* in the IAI survey for year x (AE-min/cell-day)
x	=	The latest year for which the data was collected in the latest available IAI survey by the end of the monitoring period *m*
g	=	The amount of years between year *x* and the earliest year for which published IAI survey is used to determine the benchmark

n = Aluminium production plants from the IAI survey for the relevant aluminium smelting technology that are used to calculate the benchmark for the anode effect minutes per cell and day in year x

Step 3: Determination of the historical emission factor ($EF_{p,hist}$)

The historical emission factor shall be determined using the continuous period of six months within the most recent three calendar years prior to the implementation of the project activity which had the lowest average emission factor per tonne of aluminium produced, as follows:

$$\mathrm{EF_{p,hist}} = \frac{\min\left\{\sum_{i=1}^{6} EF_{p,hist,i}, \sum_{i=2}^{7} EF_{p,hist,i}, \ldots, \sum_{i=31}^{36} EF_{p,hist,i}\right\}}{6} \quad \textbf{(8)}$$

Where:

$EF_{p,hist}$	=	Historical emission factor per tonne of aluminium produced for potline *p* ($t\ CO_2e\ /\ t\ Al$)
$EF_{p,hist,i}$	=	Emission factor per tonne of aluminium produced for potline *p* in month *i* ($t\ CO_2e\ /\ t\ Al$)
i	=	Months within the most recent three calendar years prior to the implementation of the project activity

Step 3.1: Determination of monthly historical PFC emission factors

Determine the monthly historical PFC emission factor for each potline *p* included in the project boundary for each calendar month *i* within the most three recent calendar years prior to the implementation of the project activity, as follows:

$$\mathrm{EF_{p,hist,i}} = \left(\mathrm{EF_{CF_4,p,i}} \times \mathrm{GWP_{CF_4}} \times (1 - \mathrm{U_{CF4,p,i}}) + \mathrm{EF_{C_2F_6,p,i}} \times \mathrm{GWP_{C_2F_6}} \times \left(1 - \mathrm{U_{C2F6,p,i}}\right)\right) \times 10^{-3} \quad \textbf{(9)}$$

Where:

$EF_{p,hist,\ i}$	=	Emission factor per tonne of aluminium produced for potline *p* in month *i* ($t\ CO_2e\ /\ t\ Al$)
$EF_{CF_4,p,i}$	=	Emission factor of CF_4 in month *i* ($kg\ CF_4/t\ Al$)
$U_{CF4,p,i}$	=	Uncertainty range for all measurements applied to the monthly emission factor of CF_4 determination in month *i*
$U_{C2F6,p,i}$	=	Uncertainty range for all measurements applied to the monthly emission factor of CF_6 determination in month *i*
$EF_{C_2F_6,p,i}$	=	Emission factor of C_2F_6 in month *i* ($kg\ C_2F_6/t\ Al$)
GWP_{CF_4}	=	Global warming potential of CF_4 ($kg\ CO_2e/kg\ CF_4$)
$GWP_{C_2F_6}$	=	Global warming potential of C_2F_6 ($kg\ CO_2e/kg\ C_2F_6$)

The approach to determine the monthly historical emission factors is based on the IPCC method for estimating PFC emission factors from aluminium production.

Step 3.2l: Determination of the monthly emission factors of CF_4 and C_2F_6

The monthly emission factors of CF_4 and C_2F_6 shall be determined for each month *i* and each potline *p* within the most three recent calendar years prior to the implementation of the project activity. The emission factors shall be determined according to the IPCC Tier 2 or 3 approach, as follows:

$$EF_{CF_4,p,i} = S_{CF4,p,i} \times AEM_{p,i} \quad (10)$$

$$EF_{C_2F_6,p,i} = EF_{CF_4,p,i} \times F_{C_2F_6/CF4,p,i} \quad (11)$$

Where:

$EF_{CF_4,p,i}$	=	Emission factor of CF_4 in month *i* (kg CF_4/t Al)
$EF_{C_2F_6,p,i}$	=	Emission factor of C_2F_6 in month *i* (kg C_2F_6/t Al)
$S_{CF4,p,i}$	=	Slope coefficient for CF_4 for the potline *p* in month *i* [(kg CF_4/t Al)/(AE-min/cell-day)]
$AEM_{p,i}$	=	Anode effect minutes per cell-day for the potline *p* in month *i* (AE-min/cell-day)
$F_{C2F6/CF4,p,i}$	=	Weight fraction of C_2F_6/CF_4 for the potline *p* in month *i*
p	=	Potlines included in the project boundary
i	=	Months within the most recent three calendar years prior to the implementation of the project activity

Step 3.2.1: Determination of the historical slope coefficient

The project participants shall use the "slope method" to determine the slope coefficient and the weight fraction of C_2F_6/CF_4 . Two options are available to the project participants for the determination of these coefficients:

(1) The slope coefficient and the weight fraction of C_2F_6/CF_4 shall be determined in accordance with the "Protocol for Measurement of Tetrafluoromethane and hexafluoroethane Emissions from Primary Aluminium Production - April 2008"[1] (in the following referred to as "EPA-IAI protocol");

(2) The default values for the slope coefficient and the weight fraction of C_2F_6/CF_4 provided for the IPCC Tier 2 approach in the 2006 IPCC Guidelines shall be used (Vol. 3, Section 4.4.2.4, Tier 2: PFC emission factor based on a technology specific relationship between anode effect performance and PFC emissions). This option can only be used if it can be demonstrated that for the most recent three calendar years prior to the implementation of the project activity measurements of the slope coefficient were not performed.

Step 3.2.2: Determination of the historical operational parameters

In order to apply the IPCC Tier 2/3 approach, the average monthly value of the anode effect minutes per cell-day ($AEM_{p,i}$) shall be determined for each potline *p* based on the measurements performed for each cell in the potline. To account for errors of the measurements the 95% confidence interval with a precision of 10% shall be applied to the set of data. Consistency of the data shall be checked by the DOE during validation.

[1] <http://www.world-aluminium.org/?pg=/Downloads/Publications/Full%20Publication&path=381>.

Step 3.3: Determination of the uncertainty range of the determination of EF_{CF4} and EF_{C2F6}

Two options are available to project participants to determine the uncertainty:

Option A. The uncertainty is fixed and calculated based on Table 4.16 of the IPCC Tier 2 approach in the 2006 IPCC Guidelines (Vol. 3, Section 4.4.2.4, Tier 2: PFC emission factor based on a technology specific relationship between anode effect performance and PFC emissions). The uncertainty range applied to the monthly emission factor of CF_4 ($U_{CF4,p,i}$) is 6%, while uncertainty range applied to the monthly emission factor of C_2F_6 ($U_{C2F6,p,i}$) is 12.53%;

Option B. The uncertainty shall be determined in accordance with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Program, Volume 1, 2006), where the overall uncertainty in the Tier 3 emission factors can be calculated as the square root of the sum of all sources of variance (U^2) in the measurement process.

In case option 2 under the Step 3.2.1. is using, Option A shall be applied.

$$U_{CF4,p,i} = \sqrt{\sum_k U^2_{CF4,p,i,k}} \tag{12}$$

Where:

$U_{CF4,p,i}$	=	Uncertainty range for all measurements applied to the monthly emission factor of CF_4 determination in month *i*
$U_{CF4,p,i,k}$	=	Uncertainties associated with each of the quantities *k* applicable to the CF_4 emission factor (aluminium production, instrument measurement, duct flow rate, Slope coefficient for CF_4, etc.) in month *i*
p	=	Potlines included in the project boundary
i	=	Months within the most recent three calendar years prior to the implementation of the project activity
k	=	Source of variance in the CF_4 measurement

$$U_{C2F6,p,i} = \sqrt{\sum_q U^2_{C2F6,p,i,q}} \tag{13}$$

Where:

$U_{C2F6,p,i}$	=	Uncertainty range for all measurements applied to the monthly emission factor of C_2F_6 determination in month n
$U_{C2F6,p,i,q}$	=	Uncertainties associated with each of the quantities *q* applicable to the C_2F_6 emission factor (aluminium production, instrument measurement, duct flow rate, weight fraction of C_2F_6/CF_4, etc.) in month *i*
p	=	Potlines included in the project boundary
i	=	Months within the most recent three calendar years prior to the implementation of the project activity
q	=	Source of variance in the C_2F_6 measurement

Project emissions

Project emissions are determined for each potline *p* separately by multiplying the aluminium production during the monitoring period *m* with the project emission factors for CF_4 and C_2F_6. The project emission factors are determined ex post by measuring the slope coefficient, the weight fraction of C_2F_6/CF_4 and the anode effect minutes per cell and day during the crediting period.

The project emissions for monitoring period *m* should be calculated as follows:

$$PE_m = \sum_p \left(\frac{EF_{CF_4,p,m} \times GWP_{CF_4} \times (1 + U_{CF4,p,m}) + EF_{C_2F_6,p,m} \times GWP_{C_2F_6} \times (1 + U_{C2F6,p,m})}{1000} \right) \times P_{Al,PJ,p,m} \quad \textbf{(14)}$$

Where:

PE_m	=	Project emissions during the monitoring period *m* (t CO_2e)
$EF_{CF_4,p,m}$	=	Emission factor of CF_4 for the monitoring period *m* (kg CF_4/t Al)
$EF_{C_2F_6,p,m}$	=	Emission factor of C_2F_6 for the monitoring period *m* (kg C_2F_6/t Al)
$U_{CF4,p,m}$	=	Uncertainty range for all measurements applied to the emission factor of CF_4 determination during the monitoring period *m*
$U_{C2F6,p,m}$	=	Uncertainty range for all measurements applied to the emission factor of C_2F_6 determination during the monitoring period *m*
GWP_{CF_4}	=	Global warming potential of CF_4 (kg CO_2e/kg CF_4)
$GWP_{C_2F_6}$	=	Global warming potential of C_2F_6 (kg CO_2e/kg C_2F_6)
$P_{Al,PJ,p,m}$	=	Total amount of aluminium produced in potline *p* in monitoring period *m* (t Al)
p	=	Potlines included in the project boundary

Step 1: Determination of the CF_4 and C_2F_6 emission factors

The CF_4 and C_2F_6 emission factors shall be determined according to the IPCC Tier 3 approach, using the "slope method", as follows:

$$EF_{CF_4,p,m} = S_{CF4,p,m} \times AEM_{p,m} \quad \textbf{(15)}$$

$$EF_{C_2F_6,p,m} = EF_{CF_4,p,m} \times F_{C_2F_6/CF4,p,m} \quad \textbf{(16)}$$

Where:

$EF_{CF_4,p,m}$	=	Emission factor of CF_4 for the potline *p* for the monitoring period *m* (kg CF_4/t Al)
$EF_{C_2F_6,p,m}$	=	Emission factor of C_2F_6 for the potline *p* for the monitoring period *m* (kg C_2F_6/t Al)
$S_{CF4,p,m}$	=	Slope coefficient for CF_4 for the potline *p* for the monitoring period *m*[(kg CF_4/t Al)/(AE-min/cell-day)]
$AEM_{p,m}$	=	Anode effect minutes per cell-day for the potline *p* for the monitoring period *m* (AE-min/cell-day)
$F_{C2F6/CF4,p,m}$	=	Weight fraction of C_2F_6/CF_4 for the potline *p* for the monitoring period *m*
p	=	Potlines included in the project boundary

Step 2: Determination of the uncertainty range of the determination of EF_{CF4} and EF_{C2F6}

Two options are available to project participants to determine the uncertainty range:

Option A. The uncertainty range is fixed and calculated based on Table 4.16 of the IPCC Tier 2 approach in the 2006 IPCC Guidelines (Vol. 3, Section 4.4.2.4, Tier 2: PFC emission factor based on a technology specific relationship between anode effect performance and PFC emissions). The uncertainty range applied to the monthly emission factor of CF_4 ($U_{CF4,p,i}$) is 6%, while uncertainty range applied to the monthly emission factor of C_2F_6 ($U_{C2F6,p,i}$) is 12.53%;

Option B. The uncertainty range shall be determined in accordance with 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Programme, Volume 1, 2006), where the overall uncertainty in the Tier 3 coefficients can be calculated as the square root of the sum of all sources of variance (U^2) in the measurement process:

$$U_{CF4,p,m} = \sqrt{\sum_{r} U^2_{CF4,p,m,r}} \quad \textbf{(17)}$$

Where:

$U_{CF4,p,m}$	=	Uncertainty range for all measurements applied to the emission factor of CF_4 determination during the monitoring period m
$U_{CF4,p,m,r}$	=	Uncertainties associated with each of the quantities *r* applicable to the CF_4 emission factor (aluminium production, instrument measurement, duct flow rate, Slope coefficient for CF_4, etc.) during the monitoring period m
p	=	Potlines included in the project boundary
m	=	Monitoring period
r	=	Source of variance in the CF_4 measurement

$$U_{C2F6,p,m} = \sqrt{\sum_{j} U^2_{C2F6,p,m,j}} \quad \textbf{(18)}$$

Where:

$U_{C2F6,p,m}$	=	Uncertainty range for all measurements applied to the emission factor of C_2F_6 determination during the monitoring period m
$U_{C2F6,p,m,j}$	=	Uncertainties associated with each of the quantities *j* applicable to the C_2F_6 emission factor (aluminium production, instrument measurement, duct flow rate, weight fraction of C_2F_6/CF_4, etc.) during the monitoring period m
p	=	Potlines included in the project boundary
m	=	Monitoring period
j	=	Source of variance in the C_2F_6 measurement

Leakage

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

Emissions reductions

The emission reductions shall be calculated as follows:

$$ER_m = BE_m - PE_m \quad \textbf{(19)}$$

Where:

ER_m	=	Emission reductions during the monitoring period *m* (t CO_2e)
BE_m	=	Baseline emissions during the monitoring period *m* (t CO_2e)
PE_m	=	Project emissions during the monitoring period *m* (t CO_2e)

Renewal of the crediting period

The methodology is only applicable for one single crediting period which cannot be renewed.

Data and parameters not monitored

Data/ Parameter:	p
Data unit:	-
Description:	Potlines included in the project boundary
Source of data:	Aluminium smelting facility
Value to be applied:	-
Any comment:	-

Data/ Parameter:	i
Data unit:	-
Description:	Months within the most recent three calendar years prior to the implementation of the project activity
Source of data:	Aluminium smelting facility
Value to be applied:	-
Any comment:	-

Data/ Parameter:	k
Data unit:	-
Description:	Source of variance in the CF_4 measurement
Source of data:	Aluminium smelting facility
Value to be applied:	-
Any comment:	-

Data/ Parameter:	q
Data unit:	-
Description:	Source of variance in the C_2F_6 measurement
Source of data:	Aluminium smelting facility
Value to be applied:	-
Any comment:	-

Data/ Parameter:	GWP_{CF4}
Data unit:	kg CO_2e/kg CF_4
Description:	Global warming potential of CF_4
Source of data:	Relevant CMP decisions
Value to be applied:	Project participants shall update GWPs according to any decisions by the CMP. For the first commitment period GWP_{CF4}=6,500
Any comment:	The value applied is valid for the first commitment period

Data/ Parameter:	GWP_{C2F6}
Data unit:	kg CO_2e/kg C_2F_6
Description:	Global Warming Potential of C_2F_6
Source of data:	Relevant CMP decisions
Value to be applied:	Project participants shall update GWPs according to any decisions by the CMP. For the first commitment period GWP_{C2F6}=9,200
Any comment:	The value applied is valid for the first commitment period

Data/ Parameter:	$AEM_{Al,n,x}$
Data unit:	AE-min/cell-day
Description:	Anode effect minutes per cell-day reported for plant *n* in the IAI survey for year x
Source of data:	The International aluminium Institutes' survey On The aluminium Industry's Global Perflurocarbon Gas Emissions Reduction Programme, available at <www.world-aluminium.org>
Value to be applied:	-
Any comment:	Most recent IAI survey should be referred

Data/ Parameter:	$U_{CF4,p,i,k}$
Data unit:	-
Description:	Uncertainties associated with each of the quantities *k* applicable to the CF_4 emission factor (aluminium production, instrument measurement, duct flow rate, etc.) in the month *i*
Source of data:	Aluminium smelting facility
Value to be applied:	6% in case option A under the step 3.3 is used
Any comment:	

Data/ Parameter:	$U_{C2F6,p,i,q}$
Data unit:	-
Description:	Uncertainties associated with each of the quantities *q* applicable to the C_2F_6 emission factor (aluminium production, instrument measurement, duct flow rate, etc.) in the month *i*
Source of data:	Aluminium smelting facility
Value to be applied:	12.53% in case option A under the step 3.3 is used
Any comment:	

Data/ Parameter:	$P_{p,hist}$
Data unit:	Tonne
Description:	Maximum annual amount of aluminium production from the potline *p* in the most recent three calendar years prior to the implementation of the project activity
Source of data:	Aluminium smelting facility
Value to be applied:	-
Any comment:	-

Data/ Parameter:	$S_{CF4,p,i}$
Data unit:	$(kgCF_4/tAl)/(AE\text{-}min/cell\text{-}day)$
Description:	Slope coefficient for CF_4 for the potline *p* in month *i*
Source of data:	Aluminium smelting facility
Value to be applied:	-
Any comment:	-

Data/ Parameter:	$AEM_{p,i}$
Data unit:	AE-min/cell-day
Description:	Anode effect minutes per cell-day for the potline *p* in month *i*
Source of data:	Aluminium smelting facility
Value to be applied:	-
Any comment:	-

Data/ Parameter:	$F_{C2F6/CF4,p,i}$
Data unit:	-
Description:	Weight fraction of C_2F_6/CF_4 for the potline *p* in month *i*
Source of data:	Aluminium smelting facility
Value to be applied:	-
Any comment:	-

Data/ Parameter:	S_{CF4}
Data unit:	($kgCF_4$/tAl)/(AE-min/cell-day)
Description:	Slope coefficient for CF_4
Source of data:	2006 IPCC Guidelines (Vol. 3, Section 4.4.2.4, Tier 2: PFC emission factor based on a technology specific relationship between anode effect performance and PFC emissions)
Value to be applied:	0.143
Any comment:	

Data/ Parameter:	$F_{C2F6/CF4}$
Data unit:	-
Description:	Weight fraction of C_2F_6/CF_4
Source of data:	2006 IPCC Guidelines (Vol. 3, Section 4.4.2.4, Tier 2: PFC emission factor based on a technology specific relationship between anode effect performance and PFC emissions)
Value to be applied:	0.121
Any comment:	

Data/ Parameter:	Z_x
Data unit:	-
Description:	Number of aluminium smelting facilities included in the IAI survey in year *x* for the respective aluminium smelting technology
Source of data:	The International aluminium Institutes' Report On The aluminium Industry's Global Perflurocarbon Gas Emissions Reduction Programme, available at <www.world-aluminium.org>
Value to be applied:	-
Any comment:	-

III. MONITORING METHODOLOGY

Monitoring procedures

All monitoring procedures must be in accordance with the EPA-IAI protocol.

Data and parameters monitored

Data/Parameter:	$P_{Al,PJ,p,m}$
Data unit:	Tonne
Description:	Total amount of aluminium produced in potline *p* in monitoring period *m*
Source of data:	Aluminium smelting facility
Measurement procedures (if any):	-
Monitoring frequency:	Monthly
QA/QC procedures:	The aluminium smelting facility should have a series of internal procedures that ensures data have low uncertainties during monitoring process
Any comment:	For *ex ante* calculation of project emissions a justified estimation of the future values of $P_{Al,PJ,p,m}$ shall be provided

Data/Parameter:	$U_{CF4,p,m,r}$
Data unit:	-
Description:	Uncertainties associated with each of the quantities *r* applicable to the CF_4 emission factor (aluminium production, instrument measurement, duct flow rate, etc.) during the monitoring period *m*
Source of data:	Aluminium smelting facility
Measurement procedures (if any):	-
Monitoring frequency:	Monthly
QA/QC procedures:	According to the EPA-IAI protocol
Any comment:	Value of 6% shall be applied in case Option A under step 2 of project emissions section is used

Data/Parameter:	$U_{C2F6,p,m,j}$
Data unit:	-
Description:	Uncertainties associated with each of the quantities *j* applicable to the C_2F_6 emission factor (aluminium production, instrument measurement, duct flow rate, etc.) during the monitoring period m
Source of data:	Aluminium smelting facility
Measurement procedures (if any):	-
Monitoring frequency:	Monthly
QA/QC procedures:	According to the EPA-IAI protocol
Any comment:	Value of 6% shall be applied in case Option A under step 2 of project emissions section is used

Data/Parameter:	$S_{CF4,p,m}$
Data unit:	$(kgCF_4/tAl)/(AE\text{-}min/cell\text{-}day)$
Description:	Slope coefficient for CF_4 for the potline *p* for the monitoring period *m*
Source of data:	Aluminium smelting facility
Measurement procedures (if any):	-
Monitoring frequency:	Once per three years or more frequent
QA/QC procedures:	According to the EPA-IAI protocol
Any comment:	-

Data/Parameter:	$AEM_{p,m}$
Data unit:	AE-min/cell-day
Description:	Anode effect minutes per cell-day for the potline *p* for the monitoring period *m*
Source of data:	Aluminium smelting facility
Measurement procedures (if any):	-
Monitoring frequency:	Continuously
QA/QC procedures:	According to the EPA-IAI protocol
Any comment:	For *ex ante* calculation of project emissions a justified estimation of the future values of $AEM_{p,m}$ shall be provided.

Data/Parameter:	$F_{C2F6/CF4,p,m}$
Data unit:	-
Description:	Weight fraction of C_2F_6/CF_4 for the potline *p* for the monitoring period *m*
Source of data:	Aluminium smelting facility
Measurement procedures (if any):	-
Monitoring frequency:	Once per three years or more frequent
QA/QC procedures:	According to the EPA-IAI protocol
Any comment:	-

Data/Parameter:	*r*
Data unit:	-
Description:	Source of variance in the CF_4 measurement
Source of data:	Aluminium smelting facility
Measurement procedures (if any):	-
Monitoring frequency:	Continuously
QA/QC procedures:	According to the manual of measurement instrument
Any comment:	-

Data/Parameter:	*j*
Data unit:	-
Description:	Source of variance in the C_2F_6 measurement
Source of data:	Aluminium smelting facility
Measurement procedures (if any):	-
Monitoring frequency:	Continuously
QA/QC procedures:	According to the manual of measurement instrument
Any comment:	-

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History of the document

Version	Date	Nature of revision(s)
04.0.0	EB 67, Annex # 11 May 2012	Revision to: • Incorporate a benchmark approach for the baseline emissions calculation; • Improve the clarity of the language; and • Ensure internal consistency. Due to the overall modification of the documents, no highlights of the changes are provided.
03	EB 44, Annex 8 28 November 2008	Changes in baseline section to redefine the emission factor (BE_{IAI}) to make it applicable for current technology, based on latest IAI survey.
02	EB 36, Annex 9 30 November 2007	Update of IPCC guidelines from 1996 to 2006
01	EB 24, Annex 12 19 May 2006	Initial adoption.
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