Draft revision to approved baseline and monitoring methodology AM0035

“SF₆ Emission Reductions in Electrical Grids”

I. SOURCE AND APPLICABILITY

Source

This methodology is based on the project activity “Reducing SF₆ Emissions in High-Voltage Transmission/Distribution Systems in Nigeria”, whose baseline and monitoring methodology and project design document were prepared by Quality Tonnes and World Bank Carbon Finance Unit.

For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0135: “SF₆ Emission Reductions for Electrical Grids” on http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

This methodology also refers to the latest version of the “Tool for the demonstration and assessment of additionality”.

Selected approach from paragraph 48 of the CDM modalities and procedures

“Actual or historical emissions, as applicable”.

Applicability

The methodology is applicable to project activities:
- To recycle SF₆ and/or reduce SF₆ leaks implemented at an electric utility;
- Implemented either in the entire electrical grid or a verifiable distinct geographic portion of an electrical grid of the electric utility;
- Where documented proof is available to confirm that reduction in emissions of SF₆ from replaced or repaired equipment is not claimed by any other CDM project. The DOE shall verify the documentation at validation as well as at verification.

II. BASELINE METHODOLOGY

Project boundary

The physical boundary is the electrical grid or subset of electrical grid where the project activity of recycling and leak reduction program is implemented. The greenhouse gas included is SF₆, which is commonly used as an insulator in electrical transmission and distribution grids. Any part of the grid where SF₆ leak reduction and recycling was being implemented prior to the start of project activity shall be excluded from the project boundary. If further emission reductions are achievable through improvement of efficiency in certain part of the grid even if SF₆ leak reduction and recycling was being implemented prior to the start of project activity, it can be included in the project boundary.
NOTE: In defining the project boundary it shall be ensured that all quantity of SF₆ gas moving in and out of the project boundary shall be well documented and these documents made available for audit by the DOE. The DOE shall check that these documents are consistent with the financial accounts of the project participants.

Table 1: Summary of gases and sources included/excluded in the project boundary.

<table>
<thead>
<tr>
<th>Source</th>
<th>Gas</th>
<th>Included?</th>
<th>Justification / Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>SF₆ emissions from utility equipment (trans-formers, circuit breakers, etc.)</td>
<td>SF₆</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>CO₂</td>
<td>No</td>
<td>No CO₂ emissions occur</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>No</td>
<td>No CH₄ emissions occur</td>
</tr>
<tr>
<td>Project Activity</td>
<td>SF₆ emissions from utility equipment (trans-formers, circuit breakers, etc.)</td>
<td>SF₆</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>No</td>
<td>No CO₂ emissions occur</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>No</td>
<td>No CH₄ emissions occur</td>
</tr>
</tbody>
</table>

Procedure for the selection of the most plausible baseline scenario

The methodology covers the following categories of SF₆ emissions reductions from the equipment within the project boundary:
- Recycling SF₆ encapsulated in existing equipment during repairs;
- Recycling SF₆ encapsulated in existing equipment during decommissioning; and
- Reduction in leaks by repairing the equipment;
- Recycling SF₆ encapsulated in existing equipment during routine inspection (Appendixes II and III of this methodology).

The baseline scenario shall be determined by analyzing the following potential alternatives
- Implementing the project activity without CDM; and
- Continuation of the current practice, which shall be described in the CDM-PDD.

Step 1: Assessment of National Policy/regulations on SF₆
- List national or regional policies/regulation that either require reduction of SF₆ emissions from the power sector or prescribe maintenance standards that affects SF₆ release to atmosphere.
  - If such policies exist, assess the enforcement of the policies;  
  - If above-mentioned policies/regulations exist and are enforced, then the project activity implemented without CDM is the baseline scenario.

Step 2: Assess if implementation of SF₆ recycling by any utility or by the utility in any part of its electrical grid is being undertaken.
- Identify and list the level and extent of SF₆ recycling being undertaken within the region or country where the project activity is implemented;
- If some utilities do undertake SF₆ recycling, are there factors that prevent the implementation of the same activity within the project boundary of the project activity. If not then the project activity implemented without CDM is the baseline scenario. If factors do prevent implementation of the same
activity then documented evidence for these factors preventing implementation shall be reported in the CDM-PDD and validated by the DOE.

Note: If the baseline is continuation of the present practice, then any existing efforts to recycle SF₆ shall not be included in the project boundary.

This methodology is applicable only if the baseline scenario is continuation of the current present practice.

**Additionality**

Additionality shall be demonstrated using the latest version of the latest version of the “Tool for the demonstration and assessment of additionality”. In addition, it must be shown that no sectoral or regional/national-level policies exist that require the recycling or leak management of SF₆ in electric utility infrastructure.

The barriers listed below should be evaluated as part of the application of the latest version of the “Tool for the demonstration and assessment of additionality” “Guidelines for objective demonstration and assessment of barriers”:

- Investment barriers, other than the economic/financial barriers, e.g.:
  - Real and/or perceived risks associated with the technology or process are too high to attract investment;
  - Funding is not available for innovative projects.
- Technological barriers, e.g.:
  - Skilled and/or properly trained labour to operate and maintain the technology is not available, leading to equipment disrepair and malfunctioning;
- Barriers due to prevailing practice, e.g.:
  - Developers lack familiarity with state-of-the-art technologies and are reluctant to use them;
  - The project is the “first of a kind”;
  - Management lacks experience using state-of-the-art technologies, so that the project receives low priority by management;
  - Perceived technical and financial risks to enterprises (fears that a new technology may not work, could interrupt production, take time to perfect, or will not actually result in financial savings);
  - Real and perceived insignificance of many investments – for example, if energy efficiency (or SF₆) projects are relatively small and the value of the savings achieved typically is only a small percentage of enterprise operating costs.

These identified barriers are to be considered only if they would prevent potential project proponents from carrying out the proposed project activity were it not registered as a CDM activity.

**Baseline emissions**

The baseline emissions are the total SF₆ emitted from both leaks and non-recycling of SF₆ during repair and maintenance of the equipment in the baseline. The methodology provides two options to determine baseline emissions depending on the availability of historical information.
Option 1: Historical data is available

The calculations of SF₆ emitted shall be made in accordance with the 2006 IPCC SF₆ electric utility methodology guidelines, using the Tier 3 method.¹

Data for at least three years prior to the start of the project shall be used to establish the baseline. The data shall be based on inventory and all the purchase records and use data according to the steps described below.² In order to be conservative, the year with the lowest SF₆ emissions of the three or more years will be taken for the baseline.

The yearly emissions of SF₆ of year y are estimated using the following equation:

\[
AE_x = DI_x + AI_x - SI_x + REC_x - NEC_x
\]  

(1)

Where:

- \( AE_x \) = Annual SF₆ emissions in year x prior the implementation of the project activity (Kg SF₆)
- \( DI_x \) = Decrease in inventory during the year (kg SF₆)
- \( AI_x \) = Additions to inventory during the year (kg SF₆)
- \( SI_x \) = Subtractions from inventory during the year (kg SF₆)
- \( REC_x \) = Retired Equipment Capacity expressed as nameplate capacity of retired equipment (kg SF₆)
- \( NEC_x \) = New Equipment Capacity expressed as nameplate capacity of new equipment (kg SF₆)

The baseline emissions of SF₆ are estimated using the following equation:

\[
BE_y = \left( DI_x + AI_x - SI_x + REC_x - NEC_x \right) \times \frac{GWP_{SF₆}}{1000}
\]  

(1)

\[
BE_y = \min(AE_{x-1}; AE_{x-2}; AE_{x-3}) \times \frac{GWP_{SF₆}}{1000}
\]  

(2)

Where:

- \( BE_y \) = Baseline emissions during the year y (tCO₂/yr)
- \( AE_{x-1} \) = Annual SF₆ emissions in in the three years prior the implementation of the project
- \( AE_{x-2} \) = activity(KgSF₆)
- \( AE_{x-3} \)

¹ The 2006 IPCC Guidelines for National Greenhouse Gas Inventories, in its Volume 3 (Industrial Processes and Product Use), chapter 8, outlines a methodology to determine SF₆ emissions from individual utilities as part of a methodology to calculate the national level emissions of SF₆. Generally, emissions estimates developed using the Tier 3 method, which is implemented at the facility level, will be the most accurate, and as such should be used or otherwise well justified. Simply put, if a utility purchased 2000 kg of SF₆ in the baseline year to recharge leaking circuit breakers, but is able to reduce those purchases to 1000 kg the following year by recycling SF₆ before maintenance and repairing leaks, the utility can claim 1000 kg of emissions reductions.

² In cases where three years of data do not exist, the project developer will need to demonstrate that the data does not exist and explain the steps being taken to ensure that the baseline year data is not being manipulated. This would likely include a detailed description of normal operating practices over the past three year period and a detailed description of activities using the order of magnitude test described in the “Linkage Between Project Activities and Emission Reduction Results” section.
DI = Decrease in inventory in the baseline year (only cylinders; from beginning of baseline year until end; number can be negative. This is expressed as “cylinders at the beginning of the year less that at the end of the year in the inventory.”) (kg SF₆)

AI = Additions to Inventory in baseline year (cylinder purchases, recycled SF₆ returned to inventory (captured from retiring equipment) and any SF₆ included in new equipment fully charged by manufacturer) (kg SF₆)

SI = Subtractions from inventory in baseline year (only cylinders; sold back to supplier, or sent for recycling) (kg SF₆)

REC = Retired Equipment Capacity expressed as nameplate capacity of retired equipment (kg SF₆)

NEC = New Equipment Capacity expressed as nameplate capacity of new equipment (kg SF₆)

GWPSF₆ = Global warming potential of SF₆ (tCO₂e/tSF₆)

Note: Any Force Majeure events that affect the measurement of inventory will be factored out of the baseline. This will be done in a conservative manner as follows: if a piece of SF₆ containing equipment is destroyed by a force majeure event, releasing all of its SF₆, the project developer will calculate the inventory change as an emissions-neutral event. This means that the nameplate capacity of the old equipment will be calculated as equal to the new equipment. This is conservative, since it assumes that all the SF₆ in the nameplate capacity of the equipment destroyed was actually present at the time of destruction (i.e. no leaks).

The data inventory should be maintained in a the same or similar format to that provided in the Annex Appendix I to this methodology.

The inventory estimates shall be cross-checked with estimation of emissions based on the: (i) inventory of all SF₆ containing equipment within the project boundary; and (ii) all actions used to reduce SF₆ emissions. This is called the order of magnitude test and is described in the monitoring methodology section.

**Option 2: No historical data is available**

In case that there is no historical information available, project proponents shall identify all the devices that use SF₆ in the project activity and estimate a conservative baseline emissions using default factor for SF₆ emissions in the absence of the project activity.

The baseline emissions of SF₆ are estimated using the following equation:

\[
BE_y = E_{rate} \times \frac{GWPSF_6}{1000} \sum C_i
\]

Where:

- \(BE_y\) = Baseline emissions during the year \(y\) (tCO₂/yr)
- \(E_{rate}\) = Default baseline emission rate
- \(C_i\) = Nameplate capacity for the gas insulated equipment (kg SF₆)
- \(GWPSF_6\) = Global warming potential of SF₆ (tCO₂e/tSF₆)

Project Emissions

\[
PE_y = (DI_y + AI_y - SI_y + REC_y - NEC_y) \times \frac{GWPSF_6}{1000}
\]
Where:

\[ PE_y = \text{Project emissions during the year } y \ (tCO_2/yr) \]

\[ DI_y = \text{Decrease in inventory in year } y \ (\text{only cylinders; from beginning of year until end; number can be negative}) \ (kg \ SF_6) \]

\[ AI_y = \text{Additions to Inventory in year } y \ (\text{cylinder purchases, recycled } SF_6 \text{ returned to inventory and any } SF_6 \text{ included in new equipment fully charged by manufacturer}) \ (kg \ SF_6) \]

\[ SI_y = \text{Subtractions from inventory in year } y \ (\text{only cylinders; sold back to supplier, or sent for recycling}) \ (kg \ SF_6) \]

\[ RECy = \text{Retired Equipment Capacity, expressed as nameplate capacity of retired equipment, in year } y \ (kg \ SF_6) \]

\[ NECy = \text{New Equipment Capacity, expressed as nameplate capacity of new equipment, in year } y \ (kg \ SF_6) \]

\[ GWPSF6 = \text{Global warming potential of } SF_6 \ (tCO_2e/tSF6) \]

The inventory estimates shall be cross-checked with estimation of emissions based on the: (i) inventory of all SF6 containing equipment within the project boundary; and (ii) all actions used to reduce SF6 emissions. This is called the order of magnitude test and is described in the monitoring methodology section.

**Leakage**

There is no consideration of leakage as leakage is not likely to occur.

**Emission reductions**

Emission reductions are calculated as follows:

\[ ER_y = BE_y - PE_y \]

Where:

\[ ER_y = \text{Emission reductions during the year } y \ (tCO_2/yr) \]

\[ BE_y = \text{Baseline emissions during the year } y \ (tCO_2/yr) \]

\[ PE_y = \text{Project emissions during the year } y' \ (tCO_2/yr) \]

**Changes required for methodology implementation in 2\textsuperscript{nd} and 3\textsuperscript{rd} crediting periods**

Project proponents shall use the latest version of the tool “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period” when considering the necessary changes in the 2\textsuperscript{nd} and 3\textsuperscript{rd} crediting period.

No changes are required for consideration of the methodology in future crediting periods. It should be noted that the project developer will need to check on national and regional policies at the renewal of each crediting period, in case these have changed. In case the project, or part of the project activity, has become part of the baseline due to changes in policies, the project developer will have to redefine the baseline as appropriate or potentially withdraw the project from consideration for a new CDM project period.
At the renewal of crediting period, the guidance provided in Annex 7 of the report of the Board’s twentieth meeting or any revisions of it shall be taken into account while assessing the continued validity of the baseline and updating the baseline.
Data and parameters not monitored

Use the following table for each data/parameter

<table>
<thead>
<tr>
<th>Data / parameter:</th>
<th>GWP&lt;sub&gt;SF₆&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td>tCO₂e/tSF₆</td>
</tr>
<tr>
<td>Description:</td>
<td>Global warming potential for SF₆</td>
</tr>
<tr>
<td>Source of data:</td>
<td>IPCC</td>
</tr>
<tr>
<td>Measurement</td>
<td>23,900 for the first commitment period. Shall be updated according to any future COP/MOP decisions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / parameter:</th>
<th>E&lt;sub&gt;rate&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data unit:</td>
<td></td>
</tr>
<tr>
<td>Description:</td>
<td>Default baseline emission rate</td>
</tr>
<tr>
<td>Source of data:</td>
<td>The default baseline emission rate will vary every year. In year 2012 the rate will be 10% and then it will decrease every year until it reaches a final value of 1% in year 2021. The value of 1% will remain constant after 2020, as provided in the following table:</td>
</tr>
<tr>
<td>Measurement</td>
<td>None</td>
</tr>
<tr>
<td>Any comment:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>E&lt;sub&gt;rate&lt;/sub&gt; value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>10%</td>
</tr>
<tr>
<td>2013</td>
<td>9%</td>
</tr>
<tr>
<td>2014</td>
<td>8%</td>
</tr>
<tr>
<td>2015</td>
<td>7%</td>
</tr>
<tr>
<td>2016</td>
<td>6%</td>
</tr>
<tr>
<td>2017</td>
<td>5%</td>
</tr>
<tr>
<td>2018</td>
<td>4%</td>
</tr>
<tr>
<td>2019</td>
<td>3%</td>
</tr>
<tr>
<td>2020</td>
<td>2%</td>
</tr>
<tr>
<td>2021</td>
<td>1%</td>
</tr>
</tbody>
</table>

III. MONITORING METHODOLOGY

Monitoring procedures

The methodology is based on a mass-balance approach following 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Chapter 8, using Tier 3 Method. The project developer must document changes in SF₆ inventories in a baseline year (at least three years of data required with the lowest of the three years being the baseline) that would point to its use to recharge equipment due to leaks and emissions during maintenance. The reduced demand of SF₆, as identified from the data provided in the inventory during project crediting period, will be used to calculate the reduction of emissions resulting from repaired leaks and recycling.
The following steps are followed in estimating the SF₆ needed every year and, hence, the emissions:
1. Estimate the net decrease in the amount of SF₆ inventory over the baseline year;
2. Add the amount purchased including SF₆ contained in purchased equipment;
3. Subtract any SF₆ returned to supplier;
4. Add any recycled SF₆ returned to inventory;
5. Subtract any SF₆ sent to recycling firms, sold to other entities, destroyed by the utility; or installation, or returned to the supplier;
6. Add the nameplate capacity of the retired equipment;
7. Subtract nameplate capacity of new equipment.

**Good records required for the effective management of SF₆ inventories.**

The following should be recorded:
- The location and identification reference of the equipment;
- The make and type of the equipment;
- The quantity of SF₆ installed in each item when first commissioned;
- The quantity of SF₆ added;
- Any quantity of SF₆ recovered during servicing, maintenance and final disposal;
- Establish and maintain a current and complete GIS equipment inventory, which includes the following information for each piece of equipment:
  - Manufacturer serial number;
  - Equipment type (e.g., circuit breaker, transformer, etc.);
  - Seal type (hermetic or non-hermetic);
  - Equipment manufacturer name;
  - Date equipment was manufactured;
  - Equipment voltage capacity;
  - Equipment SF₆ nameplate capacity;
  - A chronological record of the dates on which SF₆ was transferred into or out of active GIS equipment;
  - The amount of SF₆ transferred into or out of the active GIS equipment;
  - Equipment status (active or inactive);
  - Equipment location;
- Establish and maintain a current and complete inventory of gas containers;
- Retain SF₆ gas and equipment purchase documentation (such as contracts, material invoices, receipts, etc.).

**SF₆ Inventory Measurement Procedures**

- Establish and adhere to written procedures to track all gas containers as they are leaving and entering storage;
- Weigh all gas containers on a scale that is certified by the manufacturer to be accurate to within one percent of the true weight;
- Establish and maintain a log of all measurements required;
- Record the scale calibration methods used;
- Retain all documents and records required for a minimum of three years;
- Improved filling procedures on site;
- Use of sealed pressure systems, where available;
- Better monitoring in service (for closed pressure systems).
- Target older existing equipment with known leakage problem for repair/replacement;
- Improved maintenance procedures, including RCM (Reliability Centered Maintenance);
- Improved end-of-life recovery and recycling (in co-operation with specialised disposal/recycling entities);
- Human resources:
  - Ensure that only certified personnel are used for any activity involving the recovery of SF₆;
  - Make sure all personnel (both in-house and contractors) working on switchgear containing SF₆ understand the environmental impacts of emitting SF₆ to the atmosphere. Initial filling of equipment is an area where significant emissions can occur. Ensure all personnel are properly trained to minimize emissions, especially on initial filling of equipment.

Linkage Between Project Activities and Emission Reduction Results

An Order of Magnitude check³ shall be performed each year.

To implement this order of magnitude check a continuous and detailed record of all repairs, rehabilitations, and recycling included in the project activity shall be recorded. For each activity, the documentation should cover the equipment involved, the type of action, and the estimated amount of SF₆ involved. An example below presents the data to be stored for an order of magnitude test.

³ Described in Chapter 8, Volume 3, of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
<table>
<thead>
<tr>
<th>Description of Project Activities</th>
<th>Description of Equipment Involved in the activity (including nameplate capacity of SF₆)</th>
<th>Force Majeure event</th>
<th>Best Estimate of SF₆ Inventory Increase (+) or Decrease (-): Please include reasons for estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycled SF₆ from decommissioned Circuit breaker</td>
<td>GE High Voltage Circuit Breaker 250 kV 250kg SF₆ Capacity</td>
<td></td>
<td>+250kg Based on number of tanks filled</td>
</tr>
<tr>
<td>Repair SF₆ leak in High Voltage Circuit Breaker</td>
<td>ABB High Voltage Circuit Breaker 500kV 500kg SF₆ capacity</td>
<td></td>
<td>-25kg Based on estimate of gas injected into circuit breaker following the repair</td>
</tr>
<tr>
<td>Performed Basic Maintenance on Circuit Breaker requiring removal of SF₆</td>
<td>Pars Switch High Voltage Circuit Breaker 145kV 250kg SF₆ capacity</td>
<td>+250g - 250g = 0 SF₆ was recycled from unit and returned after the maintenance was complete. In the baseline scenario this would have likely resulted in a -250kg, since the SF₆ would have been vented before the repair and replaced with new SF₆.</td>
<td></td>
</tr>
<tr>
<td>Replaced High Voltage Circuit breaker</td>
<td>Previous: ABB High voltage 250kV SF₆ 100kg New: ABB High Voltage 250kV SF₆ 25kg</td>
<td>Yes-Lightening and fire destroyed old unit</td>
<td>+100kg leaked +25kg new entering inventory This action would be conservatively factored out of the emission reduction results for the year</td>
</tr>
</tbody>
</table>

The order of magnitude estimate results in a range for SF₆ emissions. This range shall be compared with the results from the mass balance approach described in the baseline methodology (equation 1 and 2). If the mass balance estimate lies outside the range, the reason for differences should be identified and explained. If the difference cannot be explained, CERs for that period cannot be claimed. The data required for order of magnitude test and explanation of any differences with mass balance approach should be documented as part of the monitoring plan and annual monitoring reports submitted for verification.
Box 1. Example of order of magnitude check

Based on the mass balance formulas, the emission reductions are estimated to be 1,500 kg of SF₆ (35,850 tCO₂e) in a given year during the crediting period. Typically, an order of magnitude test as described in this methodology provides a range of emissions reductions rather than a precise number. In this example, if the order of magnitude test yielded a range of 1,050 kg to 1,950 kg of savings (i.e. 1,500 kg ±30%), then this check would confirm the mass balance estimate, since the mass balance estimate was within the range. In other words, if the mass balance estimate falls within the range of the order of magnitude check, then this validates the mass balance estimate and CERs can be issued accordingly. If the order of magnitude check leads to an estimate of 100 to 300 kg emissions reductions, then clearly something is wrong. Because the mass balance estimate is higher than the range from the order of magnitude check, no CERs would be awarded to the project. If the order of magnitude check range is higher than the mass balance estimate of 1,500 kg (e.g. in the range of 2,000-3,000 kg), then the lower 1,500 kg figure would be used in order to be conservative.

Data and parameters monitored

<table>
<thead>
<tr>
<th>Data / parameter</th>
<th>Cᵢ</th>
<th>Kg SF₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Nameplate capacity for the gas insulated equipment</td>
<td></td>
</tr>
<tr>
<td>Source of data</td>
<td>Nameplate or purchase orders</td>
<td></td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>At the time of purchase</td>
<td></td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data / parameter</th>
<th>DIₓ, DIᵧ</th>
<th>kg SF₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Decrease in inventory during the year</td>
<td></td>
</tr>
<tr>
<td>Source of data</td>
<td>Project inventory records</td>
<td></td>
</tr>
<tr>
<td>Measurement procedures (if any):</td>
<td>Based on number of cylinders in inventory at start and end of year.</td>
<td></td>
</tr>
<tr>
<td>Monitoring frequency:</td>
<td>DIₓ: at start and end of year for at least three years prior to project start; DIᵧ: at start and end of each year during project operation</td>
<td></td>
</tr>
<tr>
<td>QA/QC procedures:</td>
<td>Metering will rely on the simple counting of cylinders. The cylinders are filled using meters with 99% accuracy, and are double checked by weighing cylinders on scales with 99% accuracy. QA/QC will also include checking purchase records by trained staff. There will be little or no chance for human error given the simple nature of the measuring process and the double checks undertaken. All meters and scales will be calibrated as per manufacturers’ recommendations</td>
<td></td>
</tr>
<tr>
<td>Any comment:</td>
<td>Number can be negative</td>
<td></td>
</tr>
</tbody>
</table>
### Data / parameter: \( A_1, A_1 \)
- **Data unit:** kg SF\(_6\)
- **Description:** Additions to inventory during the year
- **Source of data:** Project inventory, purchase records, and supplier and recycler receipts
- **Measurement procedures (if any):** This includes purchased cylinders, SF\(_6\) included in new equipment, and SF\(_6\) returned from recyclers (where the equipment are sent out of the project boundary for recycling).
- **Monitoring frequency:** Continuous, as and when purchases or receipt of equipment/recycled SF\(_6\) is realized;
- **QA/QC procedures:** Metering will rely on the simple counting of cylinders. The cylinders are filled using meters with 99% accuracy, and are double checked by weighing cylinders on scales with 99% accuracy. QA/QC will also include checking purchase records by trained staff. There will be little or no chance for human error given the simple nature of the measuring process and the double checks undertaken. All meters and scales will be calibrated as per manufacturers’ recommendations.
- **Any comment:**

### Data / parameter: \( S_1, S_1 \)
- **Data unit:** kg SF\(_6\)
- **Description:** Subtractions from inventory during the year
- **Source of data:** Supplier receipts and purchase records
- **Measurement procedures (if any):** This includes cylinders sold back to supplier or equipment sent for recycling contained SF\(_6\)
- **Monitoring frequency:** Continuous, as purchases or changes in equipment happen;
- **QA/QC procedures:** Metering will rely on the simple counting of cylinders. The cylinders are filled using meters with 99% accuracy, and are double checked by weighing cylinders on scales with 99% accuracy. QA/QC will also include checking purchase records by trained staff. There will be little or no chance for human error given the simple nature of the measuring process and the double checks undertaken. All meters and scales will be calibrated as per manufacturers’ recommendations.
- **Any comment:**

### Data / parameter: \( R_{EC}, R_{EC} \)
- **Data unit:** kg SF\(_6\)
- **Description:** Retired equipment capacity in a given year
- **Source of data:** Nameplate of equipment or manufacturer’s specifications
- **Measurement procedures (if any):** Nameplate capacity of equipment retired will be recorded
- **Monitoring frequency:** Continuous, as equipment is retired;
- **QA/QC procedures:** Inventories will be maintained and regularly checked
- **Any comment:**
<table>
<thead>
<tr>
<th><strong>Data / parameter:</strong></th>
<th>NEC₂, NEC₃</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data unit:</strong></td>
<td>kg SF₆</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>New equipment capacity in a given year</td>
</tr>
<tr>
<td><strong>Source of data:</strong></td>
<td>Nameplate of equipment</td>
</tr>
<tr>
<td><strong>Measurement procedures (if any):</strong></td>
<td>Nameplate capacity of new equipment will be recorded</td>
</tr>
<tr>
<td><strong>Monitoring frequency:</strong></td>
<td>Continuous, as equipment is retired;</td>
</tr>
<tr>
<td><strong>QA/QC procedures:</strong></td>
<td>Inventories will be maintained and regularly checked</td>
</tr>
<tr>
<td><strong>Any comment:</strong></td>
<td></td>
</tr>
</tbody>
</table>
Appendix I: A Typical SF₆ Reporting Form

**Annual Reporting Form**

| Name: | Company Name: |
| Title: | Month or Year: |
| Phone: | Date Completed: |

**Change in Inventory (SF₆ contained in cylinders, not electrical equipment)**

<table>
<thead>
<tr>
<th>Inventory (in cylinders, not equipment)</th>
<th>AMOUNT (kg)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Beginning of Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. End of Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Change in Inventory (1 - 2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Purchases/Acquisitions of SF₆**

<table>
<thead>
<tr>
<th>AMOUNT (kg)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. SF₆ purchased from producers or distributors in cylinders</td>
<td></td>
</tr>
<tr>
<td>4. SF₆ provided by equipment manufacturers with/inside equipment</td>
<td></td>
</tr>
<tr>
<td>5. SF₆ returned to the site after off-site recycling</td>
<td></td>
</tr>
<tr>
<td>B. Total Purchases/Acquisitions (3+4+5)</td>
<td></td>
</tr>
</tbody>
</table>

**Sales/Disbursements of SF₆**

<table>
<thead>
<tr>
<th>AMOUNT (kg)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Sales of SF₆ to other entities, including gas left in equipment that is sold</td>
<td></td>
</tr>
<tr>
<td>7. Returns of SF₆ to supplier</td>
<td></td>
</tr>
<tr>
<td>8. SF₆ sent to other facilities</td>
<td></td>
</tr>
<tr>
<td>9. SF₆ sent off-site for recycling</td>
<td></td>
</tr>
<tr>
<td>C. Total Sales/Disbursements (6+7+8+9)</td>
<td></td>
</tr>
</tbody>
</table>

**Change in Nameplate Capacity**

<table>
<thead>
<tr>
<th>AMOUNT (kg)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Total nameplate capacity (proper full charge) of new equipment</td>
<td></td>
</tr>
<tr>
<td>11. Total nameplate capacity (proper full charge) of retired or sold equipment</td>
<td></td>
</tr>
<tr>
<td>D. Change in Capacity (10 - 11)</td>
<td></td>
</tr>
</tbody>
</table>

**Total Annual Emissions**

<table>
<thead>
<tr>
<th>kg SF₆</th>
<th>Tonnes CO₂ equiv. (kglbs. SF₆×1000×23,900/1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Total Emissions (A+B-C-D)</td>
<td>-</td>
</tr>
</tbody>
</table>
Appendix II: Best practices on routine inspections

The maintenance of circuit breakers deserves special consideration because of their importance for routine switching and for protection of other equipment. Electric transmission system breakups and equipment destruction can occur if a circuit breaker fails to operate because of a lack of preventive maintenance. Breakers that remain idle for 6 months or more should be made to open and close several times in succession to verify proper operation and remove any accumulation of dust or foreign material on moving parts and contacts.

a) Maintenance of molded circuit breakers

Frequency of maintenance: Molded case circuit breakers are designed to require little or no routine maintenance throughout their normal lifetime. As an accumulation of dust on the latch surfaces may affect the operation of the breaker, molded case circuit breakers should be exercised at least once per year. Routine trip testing should be performed every 3 to 5 years.

Routine Maintenance test:
• Insulation resistance test;
• Millivolt drop test;
• Connections test;
• Overload tripping test;
• Mechanical operation.

b) Maintenance of low-Voltage circuit breakers

Frequency of maintenance: Low-voltage circuit breakers operating at 600 volts alternating current and below should be inspected and maintained very 1 to 3 years, depending on their service and operating conditions. Conditions that make frequency maintenance and inspection necessary are:
• High humidity and high ambient temperature;
• Dusty or dirty atmosphere;
• Corrosive atmosphere;
• Frequent switching operations;
• Frequent fault operations;
• Older equipment.

Maintenance procedures:
• Initial check;
• Cleaning of insulating parts;
• Checks and adjustments of movable and stationary contacts;
• Checks arc chutes;
• Inspect breaker operating mechanism;
• Clean and relubricate operating mechanism;
• Set breaker operating mechanism adjustments;
• Replaced contacts if in bad condition;
• Inspect wiring connections for tightness;
• Check after servicing circuit breaker.

c) Maintenance of Medium-Voltage Circuit Breakers
Frequency of maintenance: Medium-voltage circuit breakers which operate in the range of 600 to 15,000 volts should be inspected and maintained annually or after every 2,000 operations, whichever comes first.

Safety practices: Maintenance procedures include the safety practices indicated in the ROMSS (Reclamation Operation & Maintenance Safety Standards).

d) Maintenance of High-Voltage Circuit Breakers

Frequency of inspections: Most manufacturers recommend complete inspections, external and internal, at intervals of from 6 to 12 months.

Other

The adoptions of tools such as “Failure Modes and Effects Analysis or Reliability Analysis” minimize the need for monitoring and maintenance for modern electrical systems. For SF6 switchgear two classes are available today: sealed and closed pressure systems. For the first one no need for any refilling is required during the whole life cycle; consequently no monitoring or maintenance is needed. In the second case each compartment can be equipped with density monitoring devices alerting and ultimately preventing gas losses.
Appendix III: Standards to be considered

In case of repair, the maintenance operations including SF$_6$ handling and operational procedures shall be in accordance with IEC 61634 requirements.

<table>
<thead>
<tr>
<th>Standard Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 62271-1</td>
<td>Common specifications for SF6-insulated and air-insulated high-voltage switchgear and control gear.</td>
</tr>
<tr>
<td>IEC 62271-200</td>
<td>High-Voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV</td>
</tr>
<tr>
<td>IEC 62271-303</td>
<td>High-voltage switchgear and control gear – Part 303: Use and handling of sulphur hexafluoride (SF6) (Revision in progress: IEC 62271-4)</td>
</tr>
<tr>
<td>IEC 60376</td>
<td>Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment (Maintenance of the standard scheduled until 2014. Target: 1 standard only, SF6-Gas mixtures to be included, recommendation on monitoring).</td>
</tr>
<tr>
<td>IEC 60480</td>
<td>Guidelines for the checking and treatment of sulfur hexafluoride (SF6) taken from electrical equipment and specification for its re-use</td>
</tr>
<tr>
<td>IEEE C37.122</td>
<td>Gas Insulated Substations</td>
</tr>
<tr>
<td>ASTM D2472-00 SF6-gas</td>
<td>Engineering recommendation in reporting SF6 bank, emissions and recovery</td>
</tr>
<tr>
<td>ENA-ER S38</td>
<td>Engineering recommendation in reporting SF6 bank, emissions and recovery</td>
</tr>
<tr>
<td>PAS55</td>
<td>Asset management Standard</td>
</tr>
<tr>
<td>Cigré. SF6 tightness guide Nº 430</td>
<td>Guarantee of SF6 tightness due to state-of-the-art equipment and testing</td>
</tr>
<tr>
<td>Cigré. SF6 handling guide Nº 276</td>
<td>Avoid SF6 handling losses due to stat-of-the-art handling</td>
</tr>
<tr>
<td>Cigré. SF6 recycling guide. Nº 234</td>
<td>Assure long term use of SF6</td>
</tr>
</tbody>
</table>
## History of the document

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Nature of revision(s)</th>
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<tbody>
<tr>
<td>02.0.0</td>
<td>13 September 2012</td>
<td>EB 69, Annex&lt;br&gt;&lt;br&gt;<strong>Revision includes:</strong>&lt;br&gt;- Clarify that enhanced SF₆ recovery is allowed as baseline scenario;&lt;br&gt;- Incorporate procedures to determine baseline emissions in case of lack of historical information;&lt;br&gt;- Add a provision for the inclusion of recycling of SF₆ during routine inspection as a project activity.</td>
</tr>
<tr>
<td>01</td>
<td>EB 26, Annex 2&lt;br&gt;29 September 2006</td>
<td>Initial adoption.</td>
</tr>
</tbody>
</table>

**Decision Class:** Regulatory  
**Document Type:** Standard  
**Business Function:** Methodology