2006 IPCC Guidelines for Estimating SF$_6$ Emissions from Electrical Equipment and Other Products

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Purpose of IPCC Guidelines

• United Nations Framework Convention on Climate Change (UNFCCC) requires countries to provide national inventories of greenhouse gas (GHG) emissions.
• IPCC Guidelines are used to estimate emissions
• The national significance of the source determines the choice of estimation accuracy and precision (Tiers).
• Earlier this year, the IPCC finished its two-year effort to update the Guidelines on estimating GHG emissions from all sources.
Previous IPCC Guidance for “Industrial Sources,” Including EE

- 1996 IPCC Guidelines
  - Tier 1: Consumption = Emissions
  - Tier 2: Two emission-factor approaches
  - Tier 3: Three mass-balance approaches
2006 Guidelines: Five Volumes

1. General Guidance
2. Energy
3. Industrial Processes and Product Use
   ➢ All SF$_6$ sources are here
4. Agriculture and Forestry
5. Waste
SF$_6$ Sources in Vol. 3 of Guidelines

- Magnesium production: Chapter 4, Metal Industry Emissions
- Semiconductor and flat panel display production: Chapter 6, Electronics Industry Emissions
- Manufacture and use of electrical equipment: Chapter 8, Other Product Use
- Other sources (accelerators, military, etc.): Chapter 8, Other Product Use
Revised Guidelines for Electrical Equipment
Reflect Experience Since 2000

• 2006 GL both simpler and more flexible than their predecessor, the 2000 Good Practice Guidance
  – 3 methods rather than 6
  – GL’s most advanced (Tier 3) approach allows combination of mass-balance and emission-factor methods to maximize accuracy and adaptability to national circumstances
Two Types of Estimation Methods for Electrical Equipment

- **Emission Factor (EF)**
  \[ \text{Emissions} = \text{EF} \times \text{Bank (total charge) of SF}_6 \text{ in equipment} \]

- **Mass-Balance (MB)**
  \[ \text{Emissions} = \text{Annual SF}_6 \text{ consumption} - \text{SF}_6 \text{ charge of new equipment} + \text{SF}_6 \text{ charge of retiring equipment} \]
EF vs. MB

- Both methods can be used at different levels of aggregation (lifecycle stage, facility, country) and accuracy
- Choice between methods depends on
  - Data availability
  - Country-specific circumstances
  - For most accurate approach, circumstances considered by life-cycle stage and equipment type (e.g., closed- vs. sealed-pressure)
EF vs. MB

Mass-Balance more accurate where:
- Emission rates vary across facilities and/or equipment, and to some extent, over time
- Process emission rates above 3%
- Equipment is refilled frequently
- Equipment stock is growing slowly
- Equipment containing SF$_6$ has been in use in the country for at least as long as the typical time between refills for that equipment.
  - 10-20 years for electrical equipment

Emission-Factor more accurate where:
- Emission rates are fairly constant within defined types of equipment and/or facilities
- Process emission rates below 3%
- Equipment is rarely or never refilled
- Equipment stock is growing quickly
- Equipment containing SF$_6$ has been in use in the country for less than the typical time between refills for that equipment.
  - 10-20 years for electrical equipment
2006 GL: Three Tiers

- Tier 1 (least complex, accurate): Default emission factors x SF$_6$ bank
- Tier 2 (middle): Country-specific emission factors x SF$_6$ bank.
- Tier 3 (most complex, accurate): Emissions estimated at each lifecycle stage at each facility using either EF or MB, as appropriate
  - U.S. EPS Partnership and German manufacturers and utilities use variants of Tier 3 approach.
START

Can an annual survey of facilities that use SF₆ be completed, gathering data by lifecycle stage?

Yes

Estimate emissions using Tier 3 Hybrid Life-Cycle approach.

No

Are country-specific emission factors available?

Yes


No

Collect data for Tier 2 or 3 approaches

Is the Other Product Manufacture and Use a key category, and is this subcategory significant?

Yes

Estimate emissions using the Tier 1 Default Emission Factor Approach.

No

2006 GL Decision Tree
SF₆ Emissions Reduction Partnership for Electric Power Systems

**Annual Reporting Form**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Company Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title:</td>
<td>Report Year:</td>
</tr>
<tr>
<td>Phone:</td>
<td>Date Completed:</td>
</tr>
</tbody>
</table>

### CHANGE IN SF₆ INVENTORY (IN CYLINDERS)

<table>
<thead>
<tr>
<th>Inventory (in cylinders, not equipment)</th>
<th>AMOUNT</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>SF₆ purchased from producers or distributors in cylinders</th>
<th>AMOUNT</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF₆ provided by equipment manufacturers with/inside equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SF₆ returned to the site after off-site recycling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Total Purchases/Acquisitions (3+4+5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SALES/DISBURSEMENTS OF SF₆

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

### CHANGE IN NAMEPLATE CAPACITY OF EQUIPMENT

<table>
<thead>
<tr>
<th>AMOUNT</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>AMOUNT (lbs.)</th>
<th>Tonnes CO₂ equiv. (lbs.SF₆x23,900/2205)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Total Emissions (A+B-C-D)</td>
<td>-</td>
</tr>
<tr>
<td>Emission Rate (optional)</td>
<td>-</td>
</tr>
</tbody>
</table>

### Emission Rate (Emissions/Capacity)

<table>
<thead>
<tr>
<th>AMOUNT (lbs.)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nameplate Capacity at End of Year</td>
<td>PERCENT (%)</td>
</tr>
<tr>
<td>F. Emission Rate</td>
<td>-</td>
</tr>
</tbody>
</table>
German Approach (cont.)

Medium Voltage (up to 52 kV)
SF₆ Emission Estimation by Manufacturers and Operators

- Import
- Export

units x nameplate capacity

SF₆ Bank
- Domestic site erection
- Banked this year
- from previous years

Decommissioning

Manufacturer's Consumption
- Change in stocks
- Purchase new SF₆
- Return to gas supplier

Development

Emission
Consumption
Return

MB 1

Manufacturers' Consumption

Operator

Nameplate Capacities
Tier 2 and 3 Methods Require Long-Term Cooperation Among

- Inventory compilers
- Equipment manufacturers
- Equipment users
- Gas suppliers
PFCs Also Included

- PFCs used in some transformers as dielectrics and heat transfer fluids
- $\text{C}_6\text{F}_{14}$ – Liquid
- Sometimes substitute for CFC-113
- Guidance for SF$_6$ applies
Other Products

- Military applications
  - AWACs
  - heat transfer fluids (PFCs)
- Research and medical particle accelerators
- Adiabatic applications (tires, sport shoes)
- Sound-proof windows
- Tracer gases
Other Products (cont.)

• Guidance tailored to variety of emission profiles
  – Quick release of 100% (leak detection)
  – Brief storage (adiabatic—3 years)
  – Long storage (windows—25 years)
2006 Guidelines: Future Use

- IPCC adopted 2006 Guidelines in April
- Countries free, but not required, to use 2006 GL now
- 2006 GL are already having an influence beyond national inventories (CDM projects, corporate inventories)
- SBSTA will consider requirements and timing of full adoption next year.
- http://www.ipcc-nggip.iges.or.jp/