Power Transmission and Distribution

Cradle-to-Grave

$\text{SF}_6$ Inventory Methodology

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CAPIEL    EURELECTRIC
What is CAPIEL?

CAPIEL: Coordinating Committee for the Associations of Manufacturers of Industrial Electrical Switchgear and Controlgear in the European Union

Member countries: Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Finland, Sweden, United Kingdom.

Total turnover: 18.25 billion € (export 25 %)

Employees: around 118,000 in Europe
What is EURELECTRIC?

eurelectric: The "Union of the Electricity Industry-EURELECTRIC" is the association which represents the common interests of the electricity industry at pan-European level plus its worldwide affiliates and associates. The association was formed as a result of a merger in December 1999 of the twin sector bodies UNIPEDE and EURELECTRIC.

Members: Currently there are 32 Full Members of EURELECTRIC, including all 15 EU Member States and all current candidate countries negotiating to join the Community.

Installed total power: 700,000. MegaWatt (Source: www.eurelectric.org)
Kyoto Summit 1997: Greenhouse Gases

Kyoto summit on climate change:

1st group of greenhouse gases:
- Carbon dioxide (CO₂) from burning of fossil fuels
- Methane (CH₄) from intensive cattle farming
- Dinitrogen monoxide (N₂O) from nitrogen fertilization

2nd group of greenhouse gases:
- Hydrofluor carbons (HFC)
- Perfluor carbons (PFC)
- Sulfur hexafluoride (SF₆)

Contribution of various gases to the greenhouse effect

(Source: BMU, Kyoto summit on climate change 1997)

Reduction of the emission in Europe: 8 % (basis 1990/95) until 2010

International Conference on SF₆, San Diego, 2002
• The contribution of SF$_6$ - emission from Electricity Sector to man made global warming is less than 0.1%. European Electricity Sector contributes only 0.008%.
• However, European switchgear manufacturers and users are aware that SF$_6$ is a persistent gas.
• Therefore, use and emission of SF$_6$ in electrical switchgear shall be controlled.
• Voluntary agreements are signed by CAPIEL and EURELECTRIC in 2001 to contribute to the European Climate Change Program (ECCP).
Objective:
identify and develop elements for an EU climate change strategy necessary for implementation of Kyoto Protocol

Concentrate on:
- improvement of inventories and emission data
- developing measures for emission reductions
- developing policies to ensure reductions will be achieved

Parties involved:
- European Commission
- Member States
- industries
- (E)NGO’s

Time scale:
- start summer 2000
- agreed policies and measures ready spring 2001
Final Report on Fluorinated Gases, June 2001

Sector specific aspects:

Production & Use of SF$_6$ switchgear:
- Emissions slightly decrease, despite projected increase of 50% in population
- Monitoring and verification put in place
- Reduction options by voluntary actions initiated by the sector

Policies and Measures discussed for E-sector:
- Consolidation of monitoring system
- Formal recognition of voluntary European action to provide framework for flexible national targets

EU Legislation now in preparation, comprising:
- Containment and monitoring
- Marketing and use restrictions for certain application as SF$_6$ in tyres, sound insulating glazing and sport shoes.
SF₆ and switchgear technology: Situation in the EU 15 (1995 and 2000)

1995: SF₆ emission world total = 6200 t p.a. - including 2800 t p.a. from the Electricity Sector

- SF₆ emission world total = 6200 t p.a.
- Including 2800 t p.a. from the Electricity Sector

- Total installed in 1995: 4,000 t

- Leakage, handling losses (total from switchgear installed in Europe) 3% p.a.

- Total installed in 2010 estimated: 6,000 t

- Emissions from the European Switchgear Industry (manufacturers and users)

- Estimated constant 120 t p.a.

- Consumption for new SF₆ switchgear: 1,000 t p.a. (incl. export)

- 90 t p.a. (1995) development, manufacturing, installation (2/3 of installation outside Europe)

- Export Europe

Annual Assessment of SF₆-quantities at OEMs

\[ \text{SF}_6 \text{ Input} - \text{SF}_6 \text{ Output} +/\text{- Delta Stock} = \text{SF}_6 \text{ Emission} \]
CAPIEL Inventory Methodology (2)

Annual Assessment of SF₆- Quantities for all Partners

SF₆-Producer/Supplier → Component-Manufacturer → OEM-Manufacturer

Substation Contractor → Utility → Re-Cycling Provider

\[ n \times (\text{SF}_6 \text{ Input} - \text{SF}_6 \text{ Output} \pm \text{Delta Stock}) = \text{total SF}_6 \text{ Emission} \]
Inventory Methodology: Example Switzerland

Year 2000

SF₆ Flow

Export

Stock

53.9t

1.4t

4.5t

other uses

???

Switchgear 50.5t

Recycled SF₆ 3.5t

Emissions 1.8t

22.4t

-7.8t

Switchgear 8.1t

Switchgear 0.5t

Emissions ~1.1t

213.3t

Utilities/User CH

CH

48.8t

Gear 6.8t

2.4t

Switchgear

1.4t

0.6t

Gear 0t

Inventory Methodology: Example Switzerland

International Conference on SF₆, San Diego, 2002
Switchgear Equipment Leakage (1)

CAPIEL commitment: Indication of SF₆ content on nameplate to support inventory-methodology and instruction for proper re-cycling and disposal.

MV-sealed for life switchgear: leakage rate 0.1%...0.01% p.a.

MV switchgear: typical leakage rate < 0.1 % p.a.

Dead-Tank Circuit-Breaker 145 kV

HV switchgear: typical leakage < 0.5 % p.a.

Live-Tank Circuit-Breaker 300 kV
Switchgear Equipment Leakage (2)

Gas-Insulated Switchgear (GIS) 550 kV

Gas-Insulated Line 420/550 kV

Highly-Integrated Switchgear 145 kV/40 kA (Outdoor GIS)

SF₆ content on nameplate

HV switchgear: typical leakage rate < 0.5 % p.a.
Switchgear standards referring to SF₆ - issues

Development
- IEC 60376 (new SF₆)
- IEC 60480 (used SF₆)

Manufacturing
- Manufacturers internal instructions, design- and routine-test principles
- IEC 62271 Series for High Voltage and Medium Voltage Switchgear Apparatus/Devices
- IEC 61634 (handling SF₆)
- IEC 60376 (new SF₆)
- IEC 60480 (used SF₆)

Installation, erection, commissioning
- IEC 61634 (handling SF₆)
- IEC 60376 (new SF₆)
- IEC 60480 (used SF₆)

Leakage
- IEC 60376
- IEC 60480
- CIGRE 2002 (Electric Industry)

Handling losses during repair work and maintenance
- IEC 16634 (handling SF₆)
- CIGRE 1991 (handling SF₆)
- CIGRE 2000 (gas mixtures)

End of life, recycling
- CIGRE 1997 (Recycling Guide)

International Conference on SF₆, San Diego, 2002
Reduction of SF$_6$ quantities for switchgear was efficient
Equipment for using SF₆ in the Development (2)

1. Fill the test equipment
2. Evacuate with a suction unit...
3. Mobile re-cycling equipment...
4. In a transport container for used SF₆
5. Remove by-products
6. Check SF₆ quality
7. Remove air if necessary
8. Recycled SF₆ is re-filled to stock

A large part of the decomposition products is immediately removed with a molecular sieve after the test. Compensation of SF₆ loss...

Separating equipment for SF₆/air...Gas-recycling equipment with a molecular sieve...
Equipment for using SF$_6$ at substation

- Evacuate with a suction unit...
- Re-fill switchgear...
- Use a mobile re-cycling equipment...
- Check SF$_6$ quality...
- Or fill in a transport container for used SF$_6$ for re-cycling...
Routine test for all pressurized assemblies is mandatory

Helium test equipment for integral leakage detection
Responsibility Flowchart for SF₆ Monitoring

Development → Manufacturing → Installation, erection, commission

- closed pressure system: Manufacturers
- sealed for life system: Manufacturers

Leakage → Handling losses (repair work, maintenance) → End of life, recycling

- closed pressure system: Utility/Users
- sealed for life system: Utility/Users

0.1 % p.a. for Medium Voltage Switchgear
0.5 % p.a. as agreed in IEC for High Voltage Switchgear

Recycling and disposal:
Companies

International Conference on SF₆, San Diego, 2002
SF₆ Emission Reduction in the Switchgear Industry

- Avoid unnecessary transport of SF₆
- Promote concept of re-use of SF₆
- Ensure re-use in relevant standards:
  - IEC 60480 presently under revision
  - IEC 62271 series
- Promote use of appropriate handling equipment, ensuring low emissions and re-use of the SF₆
- Promote setting up SF₆ handling/storage ventures, country organization wise
Improvement for total Electricity Industry

Manufacturers are requested to lead development of a sustained End of Life Concept:

– Utilities participate in existing voluntary agreements

– Non-utility users shall also be instructed by manufacturers on proper recycling/disposal.

– Extension of existing voluntary agreement to total Electricity Sector (manufacturers and users)

Possible solution:

• Partnership agreement between government and Electricity Sector (in accordance with voluntary inventory system for switchgear equipment); actual focus: improved process for SF₆ - recycling.
Conclusions (1)

- The CAPIEL Inventory Methodology was developed in cooperation with EURELECTRIC and is established for electrical switchgear equipment in Europe.

- National inventories run successfully (i.e. Germany, Switzerland).

- Emissions are reduced and industry’s voluntary action prove being effective.

- There is no need for governmental regulation - Industry acts responsibly.
Conclusions (2)

- If some users (utilities/non utilities) may not be covered reasonable estimates can be provided.

- Actual improvement efforts are addressed to de-commissioning and re-cycling.

- Extension to total Electricity Sector under discussion on national level.
### CAPIEL- Environmental Sustainability Dossier

<table>
<thead>
<tr>
<th>Part A</th>
<th>Part B</th>
<th>Part C</th>
<th>Part D</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPIEL, Facts</td>
<td>CAPIEL Environment Sustainability Approach</td>
<td>Environmental Impacts</td>
<td>Switchgear Industry and Environment Sustainability</td>
</tr>
<tr>
<td>and Data</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- contains state of the art information
- is open to be adopted
- supports the $\text{SF}_6$ - emission control and - reduction