About NEMA’s SF6 & Alternatives Coalition

• National Electrical Manufacturers Association – North American Manufacturers of Electrical Equipment (including MV and HV switchgear and breakers)

• SF6 & Alternative Coalition
  ▪ Formed in 2008
  ▪ GIE Manufacturers, Electric Utilities, Suppliers and Service Providers
  ▪ Mission: Education

https://www.sf6andalternativescoalition.org/
Agenda

• US EPA: Greenhouse Gas Reporting Rule
• California Air Resources Board: Regulation for Reducing Sulfur Hexafluoride Emissions from Gas Insulated Switchgear
US EPA Greenhouse Gas Reporting Rule

• Published in 2010
  ▪ Subpart DD:
    o Owners and operators of electric power transmission and distribution equipment with a total nameplate capacity exceeding 17,820 lbs of sulfur hexafluoride (SF6)
    o Track and report SF6 emissions
  ▪ Subpart SS: applies to GIE manufacturers

• Major Revisions to Subpart DD proposed in June 2022
  ▪ expected to take effect January 1, 2023
  ▪ Impact reports submitted in April 2024
Revisions to Subpart DD
§ 98.308 Definitions

• Electric Power System: …all electric transmission and distribution equipment insulated with or containing fluorinated GHGs that is linked through electric power transmission or distribution lines and functions as an integrated unit...

• Energized Equipment: …connected through busbars or cables to an electrical power system or fully-charged, ready for service, and being prepared for connection to the electrical power system...

• Insulating Gas: …any fluorinated GHG or fluorinated GHG mixture, including but not limited to SF6 and PFCs, that is used as an insulating and/or arc-quenching gas in electrical equipment.

• New Equipment: …any gas insulated equipment, including hermetically-sealed pressure switchgear, that is not energized at the beginning of the reporting year, but is energized at the end of the reporting year

• Retired Equipment: …any gas insulated equipment, including hermetically-sealed pressure switchgear, that is energized at the beginning of the reporting year, but is not energized at the end of the reporting year.
Revisions to Subpart DD
§ 98.301 Reporting Threshold

1. Electric power systems must estimate total annual emissions for all insulating gases using the following formula:

\[ E = \sum_j \sum_i N C_{EPS,j} \times GHG_{i,w} \times GWP_i \times EF \times 0.000453592 \]

2. Sum the results of each insulating gas

3. If total > 25,000 MTCO2e, then the electric power system must calculate actual emissions and report them.
Subpart DD
 § 98.303 Calculating GHG emissions

User Emissions$_i = GHG_{i,w} \times [(\text{Decrease in Insulating gas } j \text{ Inventory}) + (\text{Acquisitions of Insulating gas } j) - (\text{Disbursements of Insulating gas } j) - (\text{Net Increase in Total Nameplate Capacity of Equipment Operated Containing Insulating gas } j)]$
Subpart DD
§ 98.303(b) Nameplate Capacity Adjustments

• Can only adjust nameplate capacity on GIE > 38kV
  ▪ If one, then all
• **Must** use new value if > 2% delta above or below
• **May** adopt new value if <= 2%
  ▪ If one, then all
• Nameplate may only be adjusted more than once if the physical capacity of the device has changed
• Must document the process and report it
Subpart DD
§ 98.303(b) Nameplate Capacity Adjustments

Process for New Equipment
• Record amount of gas at acquisition
• If gas needs to be added to the GIE to prepare it for energization (first time), bring to proper pressure
  • Transfer gas from cylinder to gas cart, record amount added by weighing cylinder before and after
  • Use a mass flow meter to connect gas cart to GIE and record amount of gas transferred
• New nameplate = gas at acquisition + any gas added to it
Subpart DD
§ 98.303(b) Nameplate Capacity Adjustments

Retiring Equipment / Serviced Equipment

- Record initial system pressure; if not accurate then two options
  - Complete Recovery
    - Bring equipment to proper pressure by add/removing gas as needed
    - Recover all gas from GIE
      - Mass flow meter five minutes after the pressure in the electrical equipment reaches the blank-off pressure
      - Record amount of gas added or removed by either
        - Reading mass flow meter, or
        - Weigh cylinder before and after
    - Recovered gas = new nameplate value
  - Partial Recovery (If system pressure >= 90% of design pressure)

\[
NC_C = \frac{P_{NC}}{(P_i - P_f)} \times M_R
\]
CARB Regulation

• Legislative mandate in 2006 (AB 32) to reduce GHG emissions
• First regulation proposed in 2010 by CARB; took effect in January 2011.
• All owners of non-hermetically sealed SF6-insulated equipment must reduce annual emissions rate to 10%, with subsequently 1% annual reductions
• Updated in 2022
Revisions to Carb Regulation Definitions

- Active GIE: …non-hermetically sealed GIE that is connected through cables or busbars to the electrical power system, or that is fully charged, ready for service, and being prepared for connection...
- Covered Insulating Gas: …an insulating gas with a GWP > 1
- Many others…
## Revisions to CARB Regulation
### SF6 Phase-out Dates for SF6 GIE with Voltage Capacity $\leq 38$kV

### §95352

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Rated System Voltage, kV</th>
<th>Rated Short Circuit Current, kA</th>
<th>Phase-out Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Ground</td>
<td>$U_r &lt; 38$</td>
<td>All</td>
<td>January 1, 2025</td>
</tr>
<tr>
<td></td>
<td>$U_r = 38$</td>
<td>All</td>
<td>January 1, 2028</td>
</tr>
<tr>
<td>Below Ground</td>
<td>$U_r \leq 38$</td>
<td>$&lt; 25$</td>
<td>January 1, 2025</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\geq 25$</td>
<td>January 1, 2031</td>
</tr>
</tbody>
</table>

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SF₆ & ALTERNATIVES COALITION

National Electrical Manufacturers Association
Revisions to CARB Regulation
SF6 Phase-out Dates for SF6 GIE with Voltage Capacity > 38kV

§ 95352

<table>
<thead>
<tr>
<th>Rated System Voltage, kV</th>
<th>Rated Short Circuit Current, kA</th>
<th>Phase-out Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>38 &lt; Ur ≤ 145</td>
<td>&lt;63</td>
<td>January 1, 2025</td>
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<tr>
<td></td>
<td>≥63</td>
<td>January 1, 2028</td>
</tr>
<tr>
<td>145 &lt; Ur ≤ 245</td>
<td>&lt;63</td>
<td>January 1, 2027</td>
</tr>
<tr>
<td></td>
<td>≥63</td>
<td>January 1, 2031</td>
</tr>
<tr>
<td>Ur &gt; 245</td>
<td>All</td>
<td>January 1, 2033</td>
</tr>
</tbody>
</table>
Revisions to CARB Regulation
§ 95352a Special Conditions

• Equipment failure
• Equipment purchase prior to phase-out date
• GIE replacement under terms of warranty
• Replacement parts
• Exemption: limited availability
Revisions to CARB Regulation § 95353 Annual Emissions Limit

Avg. Systems Nameplate Capacity

Avg. CO₂e Capacity

Baseline CO₂e Capacity 2024

Baseline CO₂e Capacity 2025+

Baseline CO₂e Capacity 2025+ EAC

Emission Limit

Early Action Credit

Emission Factor
Revisions to CARB Regulation
Average System Nameplate Capacity

\[ C_{avg,j,i} = \frac{\sum_{k}^{n} (d_{k,j} \times C_{k,j})}{D_i} \]

- **Active Days**
- **Mass Gas Mixture**
- **Days per Year**
Revisions to CARB Regulation
Average CO$_2$e Capacity

$$\text{Average CO}_2\text{e capacity}_i = \sum_{j}^{m} \frac{\text{GWP}_j \times \text{C}_{\text{avg},j,i}}{2204.62}$$

GWP Gas Mixture

Metric tonnes per lb
Revisions to CARB Regulation
Baseline CO$_2$e Capacity 2024

$$BL\ CO_2e\ capacity_{12/31/2024} = \sum_{j}^{m} \frac{GWP_j \times C_{k,j}}{2204.62}$$

Mass Gas Mixture
Metric tonnes per lb

SF$_6$ & ALTERNATIVES
COALITION
Revisions to CARB Regulation
Baseline CO2e Capacity 2025+

\[
BL \text{CO}_2 \text{e capacity}_{12/31/2024,i} = BL \text{CO}_2 \text{e capacity}_{12/31/2024,i-1} - \sum_{j}^{m} \frac{GWP_{j} \cdot C_{kn, j}}{2204.62} + \sum_{j}^{m} \frac{GWP_{j} \cdot C_{knca, j}}{2204.62} - \sum_{j}^{m} \frac{GWP_{j} \cdot C_{kr, j}}{2204.62} + \sum_{j}^{m} \frac{GWP_{j} \cdot C_{kn, j}}{2204.62}
\]
Revisions to CARB Regulation
Early Action Credit

\[ EAC_i = \sum_{k}^{n} C_{e,k} - \sum_{l}^{o} C_{e,r,l} + EAC_{i-1} \]

<table>
<thead>
<tr>
<th>Voltage Capacity (kV)</th>
<th>MTCO$_2$e</th>
</tr>
</thead>
<tbody>
<tr>
<td>72.5</td>
<td>300</td>
</tr>
<tr>
<td>$72.5 &lt; x \leq 145$</td>
<td>700</td>
</tr>
<tr>
<td>$145 &lt; x \leq 245$</td>
<td>1900</td>
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<tr>
<td>$\geq 245$</td>
<td>2400</td>
</tr>
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</table>
Revisions to CARB Regulation
Baseline CO2e Capacity 2025+ EAC

\[ BL \text{ CO}_2\text{e capacity}_i = EAC_{<10} + BL \text{ CO}_2\text{e capacity}_{12/31/2024,i} + \text{Average CO}_2\text{e capacity}_i \]
# Revisions to CARB Regulation

## Emissions Factors

### Average CO₂e Capacity ≥ 10,000 MTCO₂e

<table>
<thead>
<tr>
<th>Year</th>
<th>AEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021 - 2034</td>
<td>1.0</td>
</tr>
<tr>
<td>2035+</td>
<td>0.95</td>
</tr>
</tbody>
</table>

###Average CO₂e Capacity < 10,000 MTCO₂e

<table>
<thead>
<tr>
<th>Year</th>
<th>AEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021 - 2034</td>
<td>2.0</td>
</tr>
<tr>
<td>2035+</td>
<td>1.9</td>
</tr>
</tbody>
</table>
Revisions to CARB Regulation
Annual Emissions Limit

**2021 - 2024**

\[
Emissions\ Limit_i = \frac{AEF_i}{100} \times (Average\ CO_2e\ capacity_i + EAC_{\leq 10})
\]

**2025+**

\[
Emissions\ Limit_i = \frac{AEF_i}{100} \times BL\ CO_2e\ capacity_i
\]
Revisions to CARB Regulation
§ 95357.2 Nameplate Capacity Adjustment

• Optional, if one then all
• Only once, unless change in physical capacity
• During maintenance that requires opening gas compartment or removed from service
• Allowed
  ▪ Non-hermetically sealed
  ▪ >38kV
  ▪ Acquired prior to 12/31/2021
Revisions to CARB Regulation
§ 95357.2 Nameplate Capacity Adjustment

• Record initial system pressure and GIE temperature
• Convert system pressure to temp-compensate pressure provided by OEM
• If actual pressure doesn’t match intended system pressure, add or remove gas as needed
• Remove all gas from GIE
• Record amount of insulating gas removed
  ▪ Flow meter
  ▪ Weigh cylinders
<table>
<thead>
<tr>
<th></th>
<th>US EPA (Pending)</th>
<th>CARB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who Reports?</td>
<td>25,000 MTCO\textsubscript{2}e</td>
<td>All</td>
</tr>
<tr>
<td>Emissions Calculation</td>
<td>Simple</td>
<td>Complicated</td>
</tr>
<tr>
<td>Gas</td>
<td>All fluorinated GHG</td>
<td>GWP &gt; 1</td>
</tr>
<tr>
<td>Nameplate Adjustment</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Phase-out</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>