



May 26, 2021

California Air Resources Board  
1001 I Street  
Sacramento, California 95814

Electronic Submittal, <https://ww2.arb.ca.gov/rulemaking/2020/sf6>

GE Grid Solutions applauds California Air Resources Board's (CARB) ongoing efforts to reduce usage of greenhouse gases and appreciate CARB staff solicitation of industry input through the process.

We respectfully submit that the current "PROPOSED AMENDMENTS TO THE REGULATION FOR REDUCING SULFUR HEXAFLUORIDE EMISSIONS FROM GAS INSULATED SWITCHGEAR" do not effectively support implementation of viable SF<sub>6</sub>-free solutions and place an undue burden on users to report emissions from gas insulated equipment (GIE) having substantial global warming potential (GWP) improvement.

GE strongly recommends to CARB to reconsider the reporting requirement of alternative gas solutions with a maximum GWP reporting threshold of at least 500. Please consider the following:

- Our position is supported by multiple California end users
- End users stated that reporting burden will impede decision to use gas blends:
  - Slowing early adopters and integration into the California grid, especially special applications and ratings  $\geq 145\text{kV}$  and  $\geq 50\text{kA}$
  - Slow adoption could impede product development, challenging the phase-out schedule
  - When solutions don't exist to meet the phase-out schedule, users will apply for SF<sub>6</sub> exemptions resulting in further increases in California's SF<sub>6</sub> inventory
- Multiple OEMs are working on alternative gases. GE Renewable Energy's Grid Solutions and Hitachi ABB Power Grids Ltd. recently announced a non-exclusive, cross-licensing agreement related to the use of an alternative gas to sulfur hexafluoride (SF<sub>6</sub>) used in high voltage equipment.  
<https://www.ge.com/news/press-releases/ge-and-hitachi-abb-power-grids-sign-landmark-agreement-to-reduce-environmental-impact-electrical-transmission-industry>
- Proposed amendment does not consider the minimal usage of NOVEC™ fluids in alternative gas blends nor the very low risk of emissions due to the fact that the permeation of NOVEC™ 4710 molecule through GIE gaskets is much lower than CO<sub>2</sub> and O<sub>2</sub> leading to very low risk of emissions of GHG with GWP >1. Under normal operating conditions emissions will consist mostly of CO<sub>2</sub> with equivalent GWP emissions lower than methane.

- Methane does not appear to be a fair comparison to gas blends
  - Methane is the second most important GHG in California, accounting for 9% of 2017 GHG emissions in CO<sub>2</sub> equivalent unit Source:  
<https://ww3.arb.ca.gov/cc/inventory/background/ch4.htm>
  - For example, NOVEC™ 4710 gas blend in a high voltage circuit breaker with a partial pressure mixture ratio of 83.5/13/3.5% (CO<sub>2</sub>/O<sub>2</sub>/C<sub>4</sub>F<sub>7</sub>N) approximately represents only 0.0036% of methane emissions.
- Proposed amendment influences other regulations in the US and North America and could affect development cycles of alternative gas solutions which may be the best technology especially for higher ratings and special applications.
- Inconsistent with EU progress where gas blends are easily usable and accepted as a critical viable technology for replacing SF<sub>6</sub>.
  - European Commission “REPORT FROM THE COMMISSION assessing the availability of alternatives to fluorinated greenhouse gases in switchgear and related equipment, including medium-voltage secondary switchgear recognizes the benefit of fluoronitrile gas blends.
  - [https://ec.europa.eu/clima/sites/clima/files/news/docs/c\\_2020\\_6635\\_en.pdf](https://ec.europa.eu/clima/sites/clima/files/news/docs/c_2020_6635_en.pdf)
- Proposed amendment does not consider Life Cycle Assessment of the replacement solution and the environmental impact of SF<sub>6</sub>-free technology through consumption of raw materials, transportation, manufacturing, land usage, operation, and end of life. We believe it favors technology such as vacuum and CO<sub>2</sub> that can have a higher overall environmental impact using Life Cycle Assessment methodology (reference CIGRE 2020 A3-102, CIGRE 2018 C3-302).

Thank you for your consideration. Please do not hesitate to contact GE experts if there should be questions.

Best Regards,



Bertrand Portal  
Director of SF<sub>6</sub>-Free Products

## **Supporting Information**

From “Initial Statement of Reasons”

“Absent the proposed amendments, staff estimates that SF<sub>6</sub> emissions in 2036 would be 364,000 MTCO<sub>2</sub>e, a significant increase relative to estimated emissions of 286,000 MTCO<sub>2</sub>e in 2024,”

“If all SF<sub>6</sub> in active, non-hermetically sealed GIE in California at present were converted to CO<sub>2</sub>, the amount of CO<sub>2</sub> in GIE statewide would only be about 1,000 MTCO<sub>2</sub>e. Annual CO<sub>2</sub> emissions in this case would be roughly ten metric tons (assuming a one-percent leak rate as required by the Regulation),”

- SF<sub>6</sub> GWP = 22,800
  - Proposed GWP limit = 500
  - CO<sub>2</sub>/O<sub>2</sub>/FN GWP = 300 (example for HVCB)
  - Methane GWP = 25 (Source: <https://ww3.arb.ca.gov/cc/inventory/background/ch4.htm>)
- 
- CO<sub>2</sub>e all SF<sub>6</sub> circuit breakers
  - CO<sub>2</sub>e replacing all SF<sub>6</sub> with CO<sub>2</sub>
  - CO<sub>2</sub>e replacing all SF<sub>6</sub> with CO<sub>2</sub>/O<sub>2</sub>/FN
- 
- CO<sub>2</sub>e CO<sub>2</sub> cb emissions = 10 MTCO<sub>2</sub>e (Source STAFF REPORT: INITIAL STATEMENT OF REASONS, DATE OF RELEASE: July 21, 2020)
  - CO<sub>2</sub>e SF<sub>6</sub> emissions = 228,000 MTCO<sub>2</sub>E (10 x 22,800)
  - CO<sub>2</sub>e CO<sub>2</sub>/O<sub>2</sub>/FN cb emissions = 1,500 MTCO<sub>2</sub>e [ (10\*300)/2, assuming CO<sub>2</sub>/O<sub>2</sub>/FN is ½ weight of SF<sub>6</sub>]

Methane (CH<sub>4</sub>)

Source: <https://ww3.arb.ca.gov/cc/inventory/background/ch4.htm>

CO<sub>2</sub>e 2017 Methane emissions = 39,900,000 MTCO<sub>2</sub>e

Assuming 100% adoption, CO<sub>2</sub>/O<sub>2</sub>/FN emissions represent 0.0036% of methane emissions

## **Proposed Revisions**

The following actions and revisions are requested to further incentivize users and OEMs of alternative gas blend GIE to pursue new product with higher ratings performance for the 60 Hz market (vs 50 Hz in Europe) and without the reporting burden associated with SF<sub>6</sub> and other very high GWP GHGs:

1. Change the definition of “Covered Insulating Gas” to include gas blends and Raise GWP exclusion for gas blends to 500.
  2. Consider GWP of the gas blend, rather than the individual components. Alternative gas GIE using NOVEC™ 4710 will only use gas blends. The individual molecule will never be used independently.
- Page 3
    - § 95351 (a)
      - “Covered Insulating Gas” means an insulating gas with a GWP greater than one **or gas blend with NET GWP greater than five hundred (500)**. When the ~~amount~~ **net GWP** of covered insulating gas must be calculated for gas blends, it must be calculated pursuant to section 95354(l).
  - Page 5
    - § 95351 (a)
      - “Global Warming Potential” or “GWP” means the ratio of the time-integrated radiative forcing from the instantaneous release of one unit of a trace substance relative to that of one unit of a reference gas, in this case, carbon dioxide. The GWP values for this subarticle are as specified in Table A-1 to Subpart A of Title 40 CFR Part 98 as published to the Federal Register on December 11, 2014, which is hereby incorporated by reference. The GWP of NOVEC™ -4710 shall be the default GWP for “other fluorinated GHGs” (2,000) as listed in Table A-1 of Subpart A of Title 40 CFR Part 98 as published to the Federal Register on December 11, 2014. Reporting of NOVEC™ 5110 is not required because the default GWP in Table A-1 (Subpart A of Title 40 CFR Part 98 as published to the Federal Register on December 11, 2014) for a compound of its type is 1. **Reporting of NOVEC™ -4710 is not required when used in a gas blend with net GWP less than 500 calculated pursuant to section 95354(l).**
  - Page 23
    - § 95354 (l)
      - Gas Blends. Whenever **GWP of a** covered insulating gas ~~that is a constituent of a gas blend~~ must be quantified, use the following equation to calculate the **gas blend GWP amount of covered insulating gas to be reported (pounds)** and record the values of ~~the inputs used:~~ (Reference “*Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006*” <https://www.eea.europa.eu/policy-documents/regulation-eu-no-517-2014> )

#### ANNEX IV

##### METHOD OF CALCULATING THE TOTAL GWP OF A MIXTURE

The GWP of a mixture is calculated as a weighted average, derived from the sum of the weight fractions of the individual substances multiplied by their GWP, unless otherwise specified, including substances that are not fluorinated greenhouse gases.

$$\Sigma (\text{Substance X \%} \times \text{GWP}) + (\text{Substance Y \%} \times \text{GWP}) + \dots (\text{Substance N \%} \times \text{GWP}),$$

where % is the contribution by weight with a weight tolerance of +/- 1 %.

For example: applying the formula to a blend of gases consisting of 60 % dimethyl ether, 10 % HFC-152a and 30 % isobutane:

$$\Sigma (60 \% \times 1) + (10 \% \times 124) + (30 \% \times 3)$$

→ Total GWP = 13,9

The GWP of the following non-fluorinated substances are used to calculate the GWP of mixtures. For other substances not listed in this annex a default value of 0 applies.