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Carbon Footprint of SF_6 Alternatives for HV GIS

SC B3 – PS2 – Question PS2.2

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HITACHI Inspire the Next

Question and our contribution

Question PS2.2

- Much development has taken place to reduce SF_6 impact on the environment from utility application for electrical insulating and interrupting equipment. What are likely to be the enduring initiatives to prevent SF_6 gas leaks and find a possible alternative to SF_6 for GIS applications?

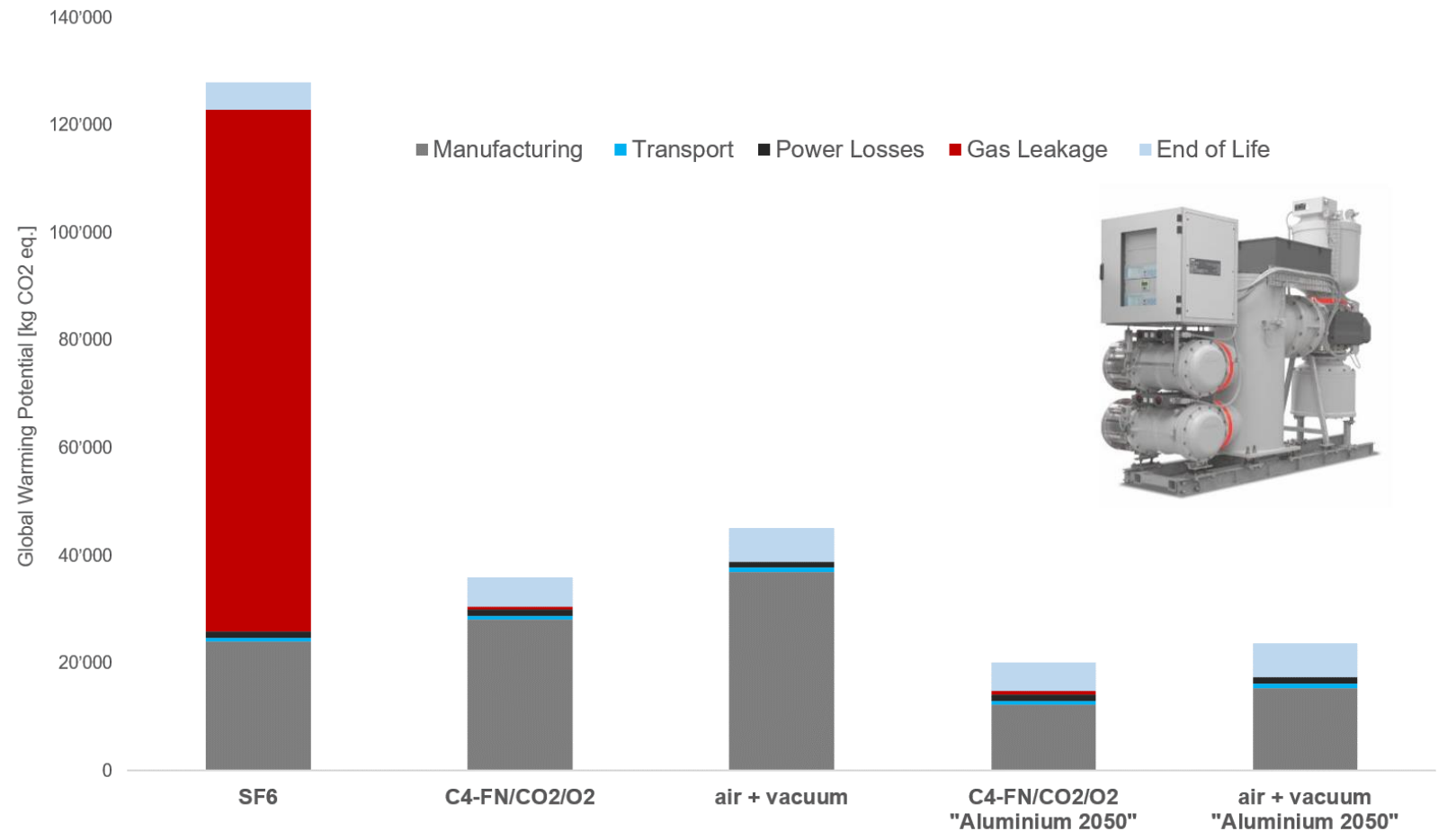
Answer

- Hitachi Energy's and other equipment manufacturers' alternative to SF_6 for GIS and further switchgear applications is C4-FN/CO_2/O_2 gas mixture for insulation and interruption. In the contribution, we use a Life Cycle Assessment of a 145 kV GIS to detail how the equipment's impact on global warming is reduced compared to SF_6. We show that by virtue of the equipment's compactness, C4-FN/CO_2/O_2 technology enables and will for the next decades continue to enable lower overall carbon footprint than other SF_6 alternatives do. We also address the 2022 F-gas regulation proposal by the European Commission and its impact on technology choice.

Possible Alternative to SF_6 for GIS Applications

- **SF_6** has enabled **reliable, compact and performant** HV gas-insulated switchgear (GIS).
- With improved sealing systems, handling procedures, and adequate service, SF_6 emissions are significantly reduced, but they stay dominant in overall carbon footprint of HV GIS.
- Regulators are pushing to reduce carbon footprint of the equipment. The **2022 F-gas regulation proposal** by the European Commission can pave the way to a phase-out of SF_6 by the end of the decade. The proposal in its current form is focused on the GWP (global warming potential) of the gas only, giving preference to solutions with GWP < 10.
- Today, eco-efficient SF_6 alternatives have been developed and first equipment is commissioned and operated by the users. For **high-voltage GIS** two SF_6 alternative technologies are dominant:
  - **C4-FN/CO_2/O_2** gas mixture for insulation and interruption, GWP = 300…600
  - **Synthetic air** in combination with **vacuum circuit breakers**, GWP = 0
- GWP of the gas is not the only criteria, it does not consider the **overall environmental footprint** of the entire **switchgear** and the **substation**.
- Product **Life Cycle Assessments (LCA)** can help chose the solution with minimal environmental impact.
- Equipment size is an important factor for application of GIS.

LCA 145 kV GIS – Carbon Footprint for 40 Years



One double-busbar-bay including CB, CT, DES, MPES, VT, cable connection, LCC and steel support

SF_6: current equipment, 0.1 %/year leakage

SF_6 alternatives: detailed design study:

- C4-FN/CO_2/O_2: 0.2 %/year leakage (irrelevant for air)
- Air + VCB: one size up (equivalent to 170 kV SF_6), smaller drive for VCB

Production incl. aluminum in Europe (global carbon footprint of aluminum would be higher)

800 A permanently, operation in grid with renewable energy

Aluminum assumption today: 0 % recycled aluminum is used for production, 95 % is recycled at end of life

“Aluminum 2050” scenario: 100 % recycled aluminum is used for production, 100 % is recycled at end of life – circular economy

LCA 3rd party verified according ISO 14040/14044

Outcome of Comparison of Different LCA Scenarios

- **Two technology options for 145 kV** essentially eliminate carbon footprint of insulation gas losses over the lifetime of HV GIS:
- C4-FN/CO_2/O_2 for insulation and interruption
  - Lowest overall CO_2 eq. emissions
  - Equipment has similar size as today's SF_6 equipment, low material (aluminum) and space consumption
  - Proven gas circuit breaker technology
  - Scalability to higher voltages: 245 kV, 420 kV, 550 kV and beyond
- Technical air and vacuum CB
  - No CO_2 eq. emissions from insulating gas (GWP = 0)
  - Larger equipment as today's SF_6 technology and associated carbon footprint for materials production (mainly aluminum, will remain relevant factor for the foreseeable future, even in a fully circular economy)
- **GWP < 10 as in current F-gas regulation proposal would limit technology choice** and disadvantage C4-FN/CO_2/O_2 technology with lowest overall carbon footprint and more compact spatial footprint (smaller switchgear buildings and associated emissions)
- SF_6 phase out could actually be delayed by limiting technology choice
- Insulating gas based on C4-FN is versatile and additionally enables Retrofill of existing passive equipment, preventing future SF_6 gas leaks in the large installed fleet with without exchanging primary equipment: **10103, 10656**