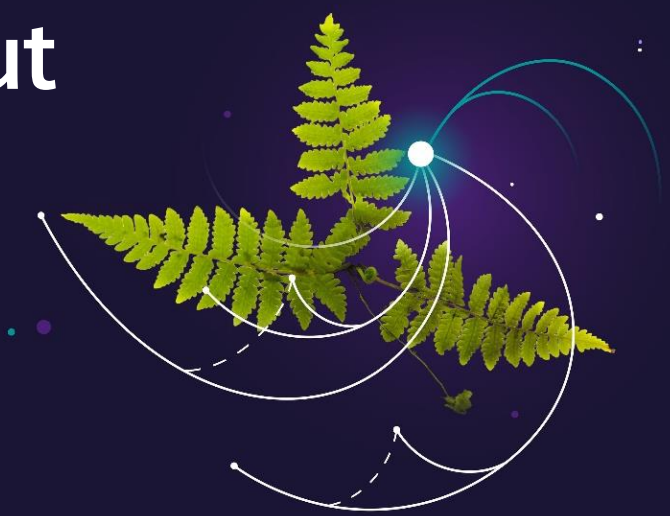
What would our power grids be without PFAS F-gases?

Clean and safe!



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Five reasons to avoid PFAS F-gases in high-voltage electrical equipment

1. Global trends on PFAS: timely action needed now

There is a worldwide trend to trace poly- and perfluoroalkyl substances, so-called PFAS (also known as 'forever chemicals'), in the environment, prevent their use and find alternatives. When released into the atmosphere, water or soil, these chemicals can accumulate in organisms and the environment. In accordance with the National Academies of Sciences, Engineering and Medicine, PFAS exposure is linked to increased risk of decreased antibody response, dyslipidemia (abnormal high cholesterol), decreased infant and fetal growth, and increased risk of kidney cancer [1].

In 2021, U.S. state Maine banned these compounds in all products by 2030, except in instances deemed "currently unavoidable" [2][3]. Plans to fight against PFAS pollution have also already been launched by the Australian and US authorities in 2020 and 2021, [4][5][6]. In Europe, the European Chemicals Agency (ECHA) submitted in February 2023 its restriction proposal for a comprehensive list of PFAS [7]. For PFAS F-gases used in switchgear, a ban is foreseen for voltage levels ≤ 145 kV in 2026/27 and for > 145 kV in 2033.

In 2022, a well known PFAS manufacturer also announced the following actions:

- exit all PFAS manufacturing by the end of 2025 including PFAS F-gases used in switchgear
- work to discontinue use of PFAS across their product portfolio by the end of 2025.

This announcement was made after careful considerations and a thorough evaluation of the evolving external landscape, including multiple factors such as accelerating regulatory trends focused on reducing or eliminating the presence of PFAS in the environment.

Meanwhile, another piece of legislation, the EU F-Gas Regulation, regulates fluorinated gases (F-gases) based on their global warming potential (GWP). Some F-gases also fall under the category of PFAS, yet their negative effects on health and the environment are **not** covered by the F-Gas Regulation [8].

2. Phasing out of PFAS F-gases in switchgear is feasible

In 2014, the high greenhouse gas potential of SF_6 led the EU to ban the use of this gas for most applications – except for the electricity sector due to a lack of alternatives. Since then, new F-gas-free (and PFAS-free) technologies have been developed for the high voltage (HV) sector.

These natural-origin gases technologies are available for all voltage levels and are gradually being introduced in the HV sector. With more than ten years of operational experience, they are in development, production and operational use for up to voltages of 420 kV with zero direct emissions [11].

Although these clean alternatives already exist, some operators still use fluoronitrile/C4F7N, an insulating F-gas for HV and medium voltage (MV) equipment which also falls under the category of PFAS.

3. Environment, health and safety in transmission & distribution equipment ensured

In order to handle PFAS F-(insulation) gases in gas production and subsequent handling, clear information is needed on the carcinogenic, mutagenic and reprotoxic (bio-accumulative/CMR) effects of the new insulation gas C4F7N, but these are currently not fully known [12].

Several tests have been performed to investigate the impact of C4F7N on health [13] [14][15]. For example, recent toxicological tests indicate that highly concentrated exposure to C4F7N provokes neurological issues like memory alterations and brain toxicity on mice, weeks after exposure [16].

Inhalation and skin contact are also categorized as harmful (CLP criteria, acute tox. cat. 4, [17]), leaving grounds for concern.

In addition to the health effects of using C4F7N, there are environmental concerns. During long-term testing with gas-insulated HV switchgear, decomposition products which are classified as hazardous, and toxic were formed They were formed by C4F7N in combination with gas moisture and are classified as hazardous and toxic [18].

Additionally, 100% C4F7N is also known to be a hazard when dissolved into water (WGK 2, AwSV, [19]).

The unwanted release of PFAS F-gases (e.g., intentional destruction or internal arcing) can lead to an accumulation in soil, when bound with water. If the release of these gases is caused by or linked to hot temperatures, the gas component C4F7N may be dissociated and even more toxic components like HF and TFA (hydrofluoric acid, equivalency factor for trifluoroacetic acid [13]) may occur.

Therefore, precautions and handling procedures, similar to those for used SF_6 gas and decomposition products should be recommended for C4F7N.

'Clean Air technology' using natural-origin gases is the best way to provide and guarantee safe equipment handling for researchers, equipment operators or maintenance personnel.

4. Clean air and natural-origin gases will be the future of global electricity grids

Siemens Energy and other original equipment manufacturers (OEM) have developed sustainable non-toxic alternatives to SF_6 and PFAS F-gases which are based on natural-origin gases (O_2, N_2, CO_2) [20]. These alternatives are simple to manage and are reliable and safe. They lead to no emissions, no additional upstream production of F-gases, PFAS F-gases and CO_2, low handling costs and no health risks to workers and to the public through contamination of air, water, or soil.
Innovations like these will allow us to achieve Europe's promised carbon neutrality target by 2050.

5. Consequences of our actions

In order to meet global climate goals, next steps must be carefully considered. Decisions taken today should take a long-term approach. Technologies intended to be used for the next 40-60 years, should not pose any risk to health and the environment. It is not sustainable to continue to rely on PFAS F-gases like C4F7N that will never lead to CO_2 neutrality. This would run contrary to EU climate law and would be counterproductive as these technologies will inevitably need to be replaced in the foreseeable future due to increasingly stringent environmental regulations. Therefore, we should move ahead with a clean and climate-neutral solution for switchgear, which is only possible with natural-origin gases.

NEMP – National Environmental Management Plan 2.0 (2020)
EHS – Environment Health & Safety
AwSV – German Federal Government Ordinance on Installations for the Handling of Substances Hazardous to Water 1, 2;

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