



## SF<sub>6</sub> - strongest greenhouse gas and its application in the electrical industry

A background paper by Deutsche Umwelthilfe

Sulphur hexafluoride (SF<sub>6</sub>) is a man-made gas, synthesized from elemental sulphur and fluorine. Due to its physical and chemical properties, SF<sub>6</sub> is widely used as an insulating gas in the electrical industry. In consequence of its enormous climate impact, the rapid switch to alternatives must be immediate. In particular, an increased use of SF<sub>6</sub> within the imminent expansion of renewable energies must be prevented now. In view of the existence of climate- and environmentally friendly alternatives, Deutsche Umwelthilfe calls for a shift towards these fully developed and tested technologies and a strict ban of SF<sub>6</sub>.

### Climate impact of SF<sub>6</sub>

The current Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has repeatedly emphasized the urgent need for action on climate protection. Of particular concern is SF<sub>6</sub>, the most potent greenhouse gas. The concentration of SF<sub>6</sub> in the atmosphere is continuously increasing (Fig. 1) and its global warming potential has been repeatedly upgraded by the IPCC to now 25,200 compared to the same amount of CO<sub>2</sub>. Moreover, with an atmospheric lifetime of about 1,000 years, SF<sub>6</sub> is extremely long-lived ([IPCC 2021](#)).

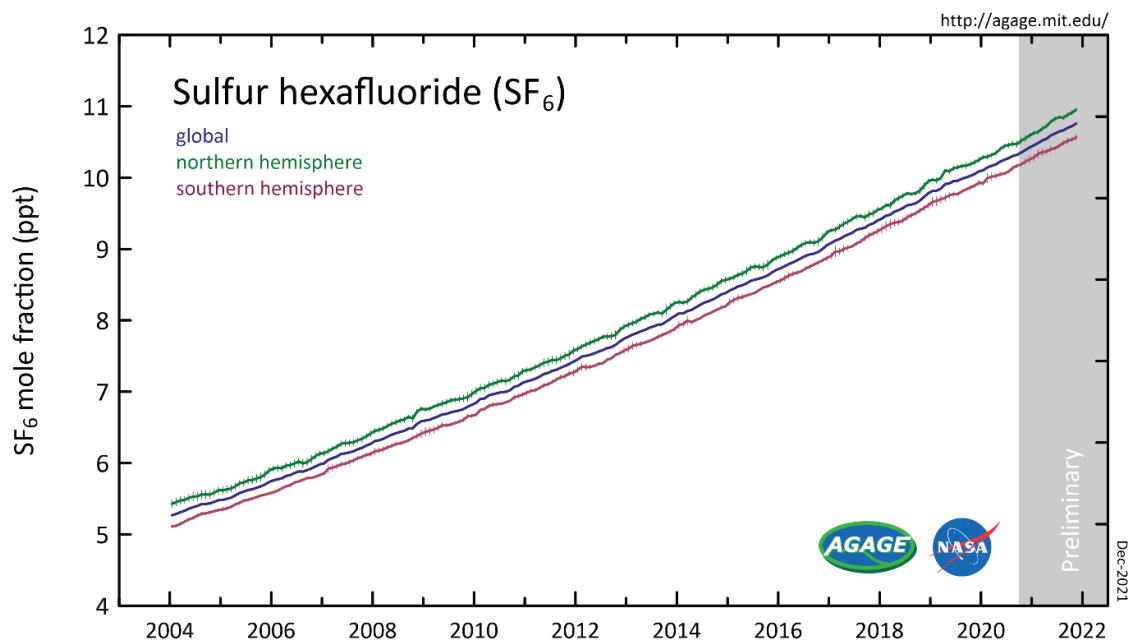


Fig. 1: Continuous global increase in atmospheric SF<sub>6</sub>. Source: [Prinn et al. 2022](#)

Despite [international regulations](#) to minimize SF<sub>6</sub> emissions, a significant increase in atmospheric concentrations is measurable. This shows the urgent need for action and redirection.

### SF<sub>6</sub> applications

Exemplarily for Germany, the [Federal Statistical Office states that 733 tonnes of SF<sub>6</sub> were distributed to various economic sectors in 2020](#). The majority, approx. 70 %, is used in the electrical industry and in apparatus engineering. SF<sub>6</sub> is used there as an insulating and switching medium and has the functions of cooling, extinguishing electric arcs and insulating electric field strengths ([Ecofys 2018](#)). SF<sub>6</sub> emissions are mainly generated during the production of electrical equipment such as high and medium voltage switchgear as well as measuring transformers and capacitors. In addition, emissions occur during the use of this equipment due to leakage, which depends on various factors such as the age of the equipment or the quality of the seals ([Warncke und Gschrey 2021](#)). In the future, emissions

will increasingly play a role in the disposal of equipment in the course of dismantling equipment, as many older systems will gradually have reached their end of life at 40 years (Ecofys 2018).



#### The issue of SF<sub>6</sub> regarding the expansion of renewable energies

The expansion of renewable energies in form of offshore and onshore wind turbines and solar panels is desperately needed to reach EU climate targets. This decentralized way of power generation entails an immense uptake of switchgear. Exemplarily for Germany, the growth rate of switchgear is expected to be 2 % every year until 2050. So far, the issue of SF<sub>6</sub> is unrecognised in the debate about the expansion of the renewables. It is key, that wind and solar park investors and operators combine their sustainable energy source with a likewise sustainable power distribution without SF<sub>6</sub>. Otherwise, in regards to the significant uptake of switchgear, SF<sub>6</sub> emissions will soar and be locked in for millennia, jeopardizing the EU Green Deal's ambition and undermining efforts to decarbonize the energy and transport sectors through renewable electrification.

#### Efforts for a SF<sub>6</sub> phase out

A restriction of SF<sub>6</sub> in, among other things, gas-insulated medium and high-voltage switchgear is imminent in the course of the revision of the European F-Gas Regulation (EU) No. 517/2014. In Germany, the electrical industry associations support this and the SF<sub>6</sub> phase-out is considered a consensus. However, there are major uncertainties and disagreements about transition periods and suitable alternatives. In particular, the desired transition periods suggested by the industry are clearly too conservative in view of the availability of SF<sub>6</sub>-free alternatives and the high need for action in climate protection and the realization of the EU Green Deal. International and national efforts for strong SF<sub>6</sub>-phase-out plans need to be strengthened, particularly in regards to the expansion of renewable energies.

#### SF<sub>6</sub> alternatives and their availability



Regarding SF<sub>6</sub>-free alternatives, it is important to differentiate: There are new substitutes, [perfluorinated ketone](#) and [perfluorinated nitrile](#), which reduce the global warming potential in a certain gas mixture significantly. However, both substitutes belong to the problematic group of per- and polyfluoroalkyl substances (PFAS). PFAS are also known as *forever chemicals* since their lifetime is around 1,000 years before they degrade. Accordingly, they are accumulating increasingly in our ecosystems. [Experts worldwide, including the European Chemicals Agency, are expressing their concerns](#), identifying PFAS as a global threat to human and environmental health. PFAS have been linked to many adverse health and environmental effects, such as kidney cancer and groundwater contamination, and research on them is just in the beginning ([Kwiatkowski et al. 2020](#)). Following the precautionary principle, SF<sub>6</sub>-free substitutes that are PFAS are no alternatives for SF<sub>6</sub> applications.

The only sustainable solution are PFAS-free alternatives. For example, vacuum or "dry air" (nitrogen/oxygen mixture), which are both climate and environmentally friendly and market-ready for a multitude of medium and high voltage switchgear technologies. The exact availability of SF<sub>6</sub>-free alternatives is complex due to the variety of applications and ongoing research and development. A 2020 [EU Commission report assessing the availability of alternatives to fluorinated greenhouse gases in switchgear](#) provides a first overview, which has already been overtaken by new developments. According to various manufacturers, PFAS-free SF<sub>6</sub> alternatives are available up to a voltage level of 145 kilovolts. In addition, manufacturers are working at full speed to quickly close the gaps in product portfolios in order to offer PFAS-free solutions for special cases and higher voltage levels. In November 2021, ten market-leading switchgear manufacturers committed in a [joint statement](#) to develop exclusively PFAS-free SF<sub>6</sub> alternatives and thus enable the transition towards a climate-neutral power grid as quickly as possible.

#### Legal framework for SF<sub>6</sub>

SF<sub>6</sub> is already extensively regulated due to its harmfulness to the climate. At international level, it has been on the list of greenhouse gases to be minimized in the [Kyoto Protocol](#) since 1997. In the European

Union, SF<sub>6</sub> is regulated in the [EU F-Gas Regulation 517/2014](#). This is currently under revision and a proposal from the EU Commission is expected in April 2022.

SF<sub>6</sub> can be further regulated at national levels and several governments have signed voluntary agreements to minimize SF<sub>6</sub> emissions ([Ecofys 2018](#)). In Germany, the gas is restricted in the [General Administrative Regulation of the Federal Government on the Procurement of Climate-friendly Services \(AVV Klima\)](#). The AVV Klima was published on 15 September 2021 and contains a procurement ban on medium-voltage switchgear containing SF<sub>6</sub> since its entry into force on 1 January 2022. In other EU countries, SF<sub>6</sub> is subject to taxation: Denmark implemented a tax for the import of SF<sub>6</sub> and Spain taxes refills of SF<sub>6</sub> in switchgear ([Ecofys 2018](#)). In the Netherlands, a subsidy scheme for the reduction of SF<sub>6</sub> is in place ([RVO 2022](#)).

### Position and demands

In the course of EU Green Deal, the urgently needed expansion of renewable energies and the therewith associated further expansion of electricity grids at all voltage levels constitute a threat of an increase in SF<sub>6</sub>-containing switchgear! The increased installation of SF<sub>6</sub> is in strong contrast to Europe's climate goals.

The extremely long atmospheric lifetime of SF<sub>6</sub> and the long lifetime of switchgear underline the generational conflict. It is irresponsible and unfair to future generations to tolerate a global increase in SF<sub>6</sub> - especially because SF<sub>6</sub>-free alternatives are already available for many applications. The landmark ruling of the German Federal Constitutional Court in March 2021 underlines the obligation to protect the climate consistently and the responsibility towards future generations.

Deutsche Umwelthilfe demands that this responsibility is met:

- Ban of SF<sub>6</sub> applications for which PFAS-free alternatives are available
- Ambitious transition periods for the SF<sub>6</sub> phase-out of applications without marketable PFAS-free alternatives
- Immediate switch to 100 % PFAS-free alternatives (e.g. dry air, vacuum)  
According to the precautionary principle of the European Green Deal, no uncertain potentially negative consequences of PFAS substitutes can be tolerated.
- Public procurement to be SF<sub>6</sub>-free with immediate effect
- Further development of SF<sub>6</sub> monitoring and the introduction of an SF<sub>6</sub> register  
Emission monitoring and clarification of existing uncertainties about emission quantities and origins are indispensable. For the proper recovery and recycling of SF<sub>6</sub> at the end of life of equipment, a monitoring body is needed, e.g. based at emission control authorities.
- For the sake of precaution, it is useful to ensure the financing of proper SF<sub>6</sub> disposal at the end of life of switchgear already when new plants containing SF<sub>6</sub> are built.

### Further reading and prime examples

The study "[Concept for SF<sub>6</sub>-free transmission and distribution of electrical energy \(final report\)](#)" (Ecofys 2018) offers further detailed recommendations for action in addition to fundamental analyses.

The realization of SF<sub>6</sub>-free switchgear is not a future utopia. Exemplarily, there are successful implementations of [SF<sub>6</sub> and PFAS-free offshore wind farms](#) already. Moreover, many promising pilot projects are underway and there are [grid operators that switch towards SF<sub>6</sub> and PFAS-free already](#).

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