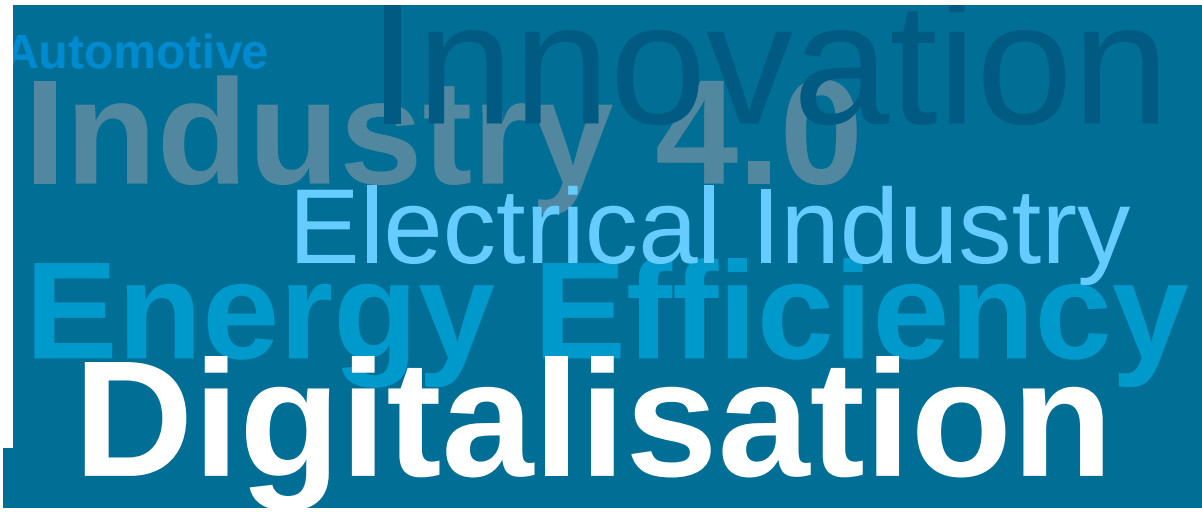
ZVEI:
Die Elektroindustrie

Position Paper

Potential for Optimising the Use of SF_6 in Switchgear



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ZVEI – German Electrical and Electronic Manufacturers‘ Association

Contents

1. Introduction 1
2. Potential for optimisation through modern SF_6 technology 2
3. Possibilities for optimising existing systems 3
4. Current state and outlook on alternative gases and gas mixtures 4
5. Conclusion and recommendations by ZVEI 5

1. Introduction

SF_6 is a reliable gas and ensures the reliability of supply in electrical systems. It is neither toxic nor flammable and does not have any carcinogenic, mutagenic or reprotoxic (CMR) characteristics. This provides the highest level of safety for the operator, and the gas remains in a closed circuit, even after the end of the system's life. On the other hand there is a high global warming potential or GWP of SF_6 of 22.800[1], which contributes to global warming.

In modern switchgear, it has been possible to continuously reduce the amount of SF_6 while maintaining the same functionality. The results in the reports on SF_6 emissions issued every year by the Federal Ministry for the Environment, Nature Conservation, Building & Nuclear Safety (BMUB) confirm this statement.

An amended version of the EU F-Gas Regulation of 2006 – Regulation (EU) No. 517/2014 of the European Parliament and of the Council of 16 April 2014– on fluorinated greenhouse gases was published on 20 May 2014 at the European level and will be reviewed at regular intervals. The next review will be in 2022.

Against this background, not only manufacturers of SF_6 equipment but also operators, testing laboratories, standardisation bodies, research institutions, associations and universities are tackling the reduction of the amount of SF_6 in new switchgear and investigate in further reduction of emissions through modern SF_6 technology, but also in alternative gases and gas mixtures which should be suitable for replacing SF_6.

[1] cf.: https://www.umweltbundesamt.de/sites/default/files/medien/376/dokumente/treibhauspotentiale_ausgewaehlter_verbindungen_und_deren_gemische_2015_05.pdf

2. Potential for optimisation through modern SF_6 technology

The use of SF_6 in switchgear offers specific advantages. For instance, SF_6 gas-insulated enclosed equipment (gas-insulated switchgear GIS, gas-insulated lines GIL) can be designed much smaller and more compact than air-insulated switchgear (AIS) because SF_6 has a dielectric strength exceeding that of air by a factor of 3 and a significantly better heat transmission capacity.

Compactness plays a crucial role wherever physical footprints for switchgear are expensive or limited (e.g. in urban areas, indoor installations or wind power stations). Due to their gas-tight encapsulated design, the use of the systems does not depend on external conditions, which is, for example, a requirement for switchgear close to the coast or in wind power plants, distribution substations in areas prone to flooding, in challenging climatic conditions or polluted areas, but also for installations at high altitudes.

Furthermore, SF_6 shows outstanding arc-extinguishing characteristics in the interruption of currents, which are not achieved by any other gas or gas mixture. The use of SF_6 in electrical equipment leads to high availability and low maintenance requirements.

In the course of the past decades, it has been possible to build increasingly compact gas-insulated switchgear through the consistent use of electric field optimised geometry, which has continuously reduced the specific filling mass and thus the use of SF_6 for various functions. Technical innovations such as the choice of better materials for sealants and flanges as well as better O-ring slots have led to a constant reduction of gas emission during operation. In addition, SF_6 is handled in a closed system in the manufacturing plants, no SF_6 filling is used in destructive testing and sophisticated apparatus is used for measuring gas quality.

From today's perspective, the high technology standard achieved with SF_6 regarding its use as an insulating, switching and quenching gas in switchgear has been technically and economically optimised. Leakage rates of new switchgear are below 0.5% p.a. for high-voltage GIS and below 0.1% p.a. for medium-voltage GIS as stated in the currently applicable IEC standard. Practical experiences and measured values for modern switchgear show significantly lower values. This standard was achieved by European switchgear manufacturers together with operators and research institutions over a period of more than four decades.

3. Possibilities for optimising existing systems

It is possible to reduce both the amount of SF_6 banked in and emitted[2] from installed switchgear within a short time. Major emission sources could be identified through the introduction of compulsory documentation for high-voltage switchgear, particularly of the first and second generations.

The replacement of this equipment with new, modern switchgear would lead to a significant reduction of the amount of banked SF_6 and of SF_6 emissions of all assets. We therefore propose the following:

1. Compulsory documentation of the SF_6 emissions for high-voltage switchgear of the first and second generations.
2. Laws/regulatory rules for the revision or replacement of installed switchgear with higher leakage rates within a defined period, beginning with the switchgear that has the highest leakage rate.
3. Pursuant to the German Electricity Grid Charge Ordinance (Stromnetzentgeltverordnung – StromNEV), compensation for lost depreciation should be granted up to the end of the imputed useful life if users/operators suffer a financial loss because affected systems are not yet fully depreciated.

Ultimately, an efficient and expedient measure emerges to reduce the amount of SF_6 banked in and emitted from switchgear.

[2] Demonstrated in Germany with the emissions statistics by FNN

4. Current state and outlook on alternative gases and gas mixtures

Introducing alternative gases and gas mixtures that have a much lower GWP than SF_6 will make it possible to reduce SF_6 in the long term.

Against this background, the manufacturers of switchgear, operators, standardisation bodies, research institutions, associations and universities have been intensively tackling the subject of alternative gases and gas mixtures suitable as substitutes for SF_6.

An alternative gas or gas mixture that is comparable with SF_6 in all its relevant characteristics has not yet been found despite intensive research, based on the premise that the current demands placed on electrical equipment (e.g. long useful life, high degree of reliability and availability, comparable size, cost effectiveness) are to remain unchanged.

With regard to the use of alternative gases and gas mixtures in switching devices and switchgear, the current state is as follows:

- Pilot experiences are currently being gained with switching devices and switchgear in distribution and transmission networks (up to 170 kV at the moment); long-term experiences are not yet available.
- International bodies (IEC; IEEE, CIGRÉ) are dealing with the subject of alternative gases and gas mixtures and their use in electrical equipment because relevant standards either do not exist or need to be revised.
- T&D Europe has issued an initial guide, “Technical guide to validate alternative gas for SF_6 in electrical equipment[3]”, for the qualification of alternative gases and gas mixtures, which is based on the complex validation of SF_6 that has developed over the course of years.
- The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) / Federal Environment Agency (UBA) has commissioned Ecofys and ETH Zürich to perform a national study regarding a concept for the SF_6-free transmission and distribution of electrical energy. Completion is planned for February 2018.

[3] cf. for more detailed information: http://www.tdeurope.eu/data/T&D%20Europe%20Technical%20guide%20%20to%20validate%20alternative%20gas%20for%20SF6%20in%20electrical%20equipment.pdf

Data is currently being collected on pilot experiences made with switching devices and switchgear. A detailed evaluation of the various gases and gas mixtures being tested is not possible yet. Furthermore, the environmental compatibility of alternative gases or gas mixtures must be examined throughout the entire useful life of GIS technology (e.g. carbon footprint, end-of-life treatment).

International standards needed for use of alternative gases or gas mixtures in electrical equipment and their handling are currently only available for SF_6. According to experience, the time frame for standardisation can be far more than 5 years, which means that, unfortunately, standardisation cannot make a quick contribution to the use of alternative gases and mixtures throughout the industry.

5. Conclusion and recommendations by ZVEI

From today's perspective, the technology standard of switchgear achieved with SF_6 gas regarding its use as an insulating, switching and quenching gas is at the highest technical and economical level. It is not possible to replace SF_6 in the short and medium term in all significant areas of energy transmission and distribution nor in the medium-voltage switchgear secondary distribution segment.

The industry is currently evaluating all possibilities to find the best alternative gases or gas mixtures for significant network and industrial applications in order to provide users with an equivalent switchgear technology that is space-saving, environmentally compatible and independent on environmental conditions. However, there are no international standards and – due to partly contradictory advantages and disadvantages – no standardisation on a single gas or gas mixture.

Switchgear containing alternative gases or gas mixtures will only be successful if it can compete on the global market with existing switchgear containing SF_6 (regarding the fulfilment of technical requirements, total cost balance and also a positive life cycle assessment).

Therefore, the ZVEI clearly recommends that no restrictions should be placed on the use of SF_6 for switching devices and switchgear, but that further developments with alternative gases and gas mixtures should be followed up and supported.

In the light of the above, the ZVEI currently regards a replacement programme for old equipment to be the best option in the short and medium terms for reducing SF_6 emissions from switchgear. In parallel to this replacement programme, alternative gases and gas mixtures could be further investigated, the relevant standardisation expedited and pilot projects supported.

In addition, a structured discussion process should be established so that appropriate solutions can be discussed during the review pursuant to the F-Gas Regulation, taking all interests into consideration, and finally flow into regulatory provisions.

In the process, it is crucial to bear in mind that an isolated consideration of the SF_6 reduction potential in switchgear in Europe falls short of the mark and has only marginal effects in terms of environmental policy. Emissions of SF_6 are a “global problem” and do not only concern Europe, Germany or the electrical industry. Thus, the primary goal must be to have the appropriate and effective requirements of the exemplary EU F-Gas Regulation as of 2014 incorporated into the applicable laws, also outside the EU.

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About the ZVEI

The ZVEI – German Electrical and Electronic Manufacturers’ Association represents the common interests of the electrical industry and the related service companies in Germany. About 1,600 companies have chosen to become members of the ZVEI.

The industry employs roughly 849,000 employees in Germany and a further 677,000 worldwide. Its turnover in 2015 was 178.5 billion euros. Novel products and systems account for approximately one third of that figure. The industry spends 15.5 billion euros each year on R&D, 6.4 billion euros on investments and two billion euros on initial and continuing vocational training. The original impulse behind every third new development in the manufacturing industry comes from the electrical industry.