ZVEI
Die Elektroindustrie

Roadmap for the

Reduction of SF_6 Emissions from Switchgear and Controlgear

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ZVEI – German Electrical and Electronic Manufacturers' Association

Contents

Core Message of the ZVEI Roadmap

- The replacement of switchgear and controlgear of the first and, possibly, second generation with switchgear and controlgear of the latest generation presents considerable potential for SF_6 reduction in the short and medium term.
- Care should be taken to ensure that all equipment in transmission and distribution networks is not operated for a period exceeding the ordinary useful life as defined in the German Electricity Grid Charge Ordinance (Stromnetzentgeltverordnung − StromNEV).
- The creation of target-oriented incentive systems could promote and strengthen the introduction of SF_6-free alternatives.
- The use of SF_6 must continue to be admissible beyond 2030.
- In ZVEI's opinion, total admissible emissions according to the voluntary self-commitment (17 t p.a. for 2020) can be halved with regard to 2030.

1. Background and Procedure

Sulphur hexafluoride (SF_6) is a gas that, due to its special physical properties, has been used since approx. 1960 for switching and insulating in a variety of applications in electrical equipment for energy transmission and distribution in the voltage range >1 kV. SF_6 is an inert, non-combustible, non-toxic insulation medium that is not ozone depleting and has high global warming potential. In some fields of application, including switchgear and controlgear, it cannot yet be replaced with an equivalent medium.

The ZVEI member companies are working intensively on the further reduction of SF_6 emissions for all areas of application in energy transmission and distribution as well as on the research and development of SF_6 alternatives in electrical equipment >1 kV. This roadmap has been drawn up as a consequence thereof. It particularly describes

measures that contribute to a significant reduction of SF_6 emissions in connection with electrical equipment >1 kV.

Suitable measures to reduce emissions and further reduction potentials can vary considerably for the medium-voltage and high-voltage ranges. Differences exist between systems, and this can lead to differing emission rates. Assuming a comparable total amount of SF_6 installed in the medium- voltage and high-voltage ranges in Germany, the amount in the medium-voltage range is distributed across a large number of individual installations, each with a small filling amount. Switchgear and controlgear in the medium-voltage range are designed as sealed, maintenance-free pressure systems, whereas those in the high-voltage range are constructed as closed pressure systems. Switchgear and controlgear of the first generation are sometimes still available as controlled pressure systems.

In a first step, the following measures could be included in an extension of the German voluntary self-commitment of the associations BDEW – Bundesverband der Energie- und Wasserwirtschaft e. V. (German association of the energy and water industries), VIK – Verband der Industriellen Energie- und Kraftwirtschaft e. V. (German association of the industrial energy and power sector) and ZVEI – Zentralverband Elektrotechnik- und Elektronikindustrie e.V. of 2005.

In a second step, the member states of the European Union (EU) could implement similar voluntary self-commitments. Voluntary agreements are also welcomed by the EU in other areas as a new way of establishing product-specific or technical requirements (Article 17 of the Ecodesign Directive 2009/125/EC[1]). Ultimately, significant reductions of SF_6 emissions could be achieved, as the self-commitments not only in Germany but also in Switzerland and Norway, as examples, show.

[1] Ecodesign Directive: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:en:PDF

2. Measures to Reduce SF_6 Emissions

The extension of measures included in the voluntary self-commitment of 2005 (targets were defined in 2005 for the period up to 2020) must place the focus on the prompt reduction of greenhouse gas emissions.

Besides direct emissions of SF_6, greenhouse gas emissions in the supply of energy, emissions from switchgear construction, installation and disposal, energy generation as well as the operation of electricity grids must also be taken into consideration. Conventional alternatives to SF_6, e.g. air-insulated systems, often show an even higher CO2e[2] than compact SF_6 systems due to the higher material usage. The higher space requirement also contributes to this[3] [4].

Basically, the reduction of the greenhouse gas effect in connection with the use of SF_6 in switchgear and controlgear can be achieved in 2 steps. In the short term, this can be achieved through the replacement of switchgear and controlgear of the first and, possibly, second generation with switchgear and controlgear of the latest generation with practically no measurable emissions; it is irrelevant whether they are filled with SF_6 or alternative gases. In the medium term, a reduction can be achieved through the use of SF6 alternative gases with a lower GWP[5].

Here it is necessary to differentiate between equipment in the medium-voltage range (voltages from >1 kV to 52 kV) and the high-voltage range (>52 kV). The replacement of old switchgear in the high-voltage range, which can have much higher SF_6 emissions than modern high-voltage equipment, offers particular potential for measures to reduce emissions.

Care should always be taken to ensure that all equipment in transmission and distribution networks is not operated for a period exceeding the ordinary useful life as defined in the German Electricity Grid Charge Ordinance (StromNEV)[6]. This ordinance defines the ordinary useful life in the high-voltage range as being 35-45 years, and in the medium range 30-40 years.

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[2] CO2e: CO_2 equivalent

[3] Solvay Management Support: SF_6-GIS technology in energy distribution – medium-voltage. Life Cycle Assessment study commissioned by ABB, AREVA T&D, EnBW Regional, e.on Hanse, RWE, Siemens and Solvay Fluor und Derivate. Solvay: Hanover/Germany
http://www.tdeurope.eu/data/file/LCA-GIS-MV-Summary-1-2003.pdf

[4] Electrical Power Supply using SF_6 Technology – an Ecological Life Cycle Assessment; C3-102, CIGRE Session 2004

[5] GWP: Global Warming Potential

[6] Stromnetzentgeltverordnung (german): http://www.gesetze-im-internet.de/stromnev/

ZVEI suggests the following specific measures to effectively reduce SF_6 emissions:

1) Replacement of switchgear in the high-voltage range according to its emission rate

Cataloguing of high-voltage switchgear is necessary in order to ensure the highest possible level of efficiency of the measure. Within the scope of an overhaul of existing switchgear in operation, old switchgear is listed, for example, on the basis of the actual annual emission rate, and classified into 4 categories

- controlled pressure systems with permanent refill devices and closed systems with an emission rate >1%

- closed systems with an emission rate from 0.5% to <1%

- systems with an emission rate <0.5%

- systems with an emission rate <0.1%.

It is advisable that operators catalogue the installed high-voltage switchgear before the end of 2018.

The replacement programme should begin in the categories with the highest emission rates (as a rule, controlled pressure systems) to achieve a maximum reduction of emissions. A replacement with modern switchgear with practically no measurable SF_6 emission rates or SF_6-free switchgear with a significantly lower GWP than SF_6 is permissible.

IEC standards stipulate maximum leakage rates <0.5% per year per gas compartment in the high-voltage range. Modern SF_6 switchgear remains distinctly below this value.

Such a replacement programme leads to a significant and sustainable emission reduction (as the example of Switzerland shows: emission rate as at 2016: 0.07%[7]; Germany: 0.36%) and also stands up to an economic efficiency analysis as, due to its age, most of the switchgear has already been written off. For systems hat fall under a corresponding replacement programme and have not yet reached their ordinary useful life according to StromNEV, the inclusion of special depreciation of the residual book values plus lost return on capital in the catalogue of permanently

[7] SF_6-Bilanz 2016 – Swissmem (german): https://www.swissmem.ch/fileadmin/user_upload/Swissmem/Industrie___Politik/Energie_Umwelt/2017-04-28_DE_SF6-Bilanz_2016_Meldung_an_das_BAFU.pdf

non-controllable costs (Sec. 11 of the ordinance on incentive regulation) can provide a further incentive for the replacement with systems in the next lower emission category (according to the cataloguing method listed above). This offers operators a financial compensation for the replacement of switchgear which has not yet been written off.

2) Measures concerning old switchgear in the medium-voltage range

Switchgear in the medium-voltage range must be replaced at the end of its useful life and disposed of in a responsible way. Replacement is economically feasible in the case of switchgear that has been written off and shows signs of ageing and declining leak tightness.

The F-Gas Regulation (EU) No. 517/2014 (Article 8 – Recovery) already stipulates the recovery of gas from old switchgear.

3) Recovery of SF_6 in a closed circuit

A sustainable and emission-free process must be ensured for the recovery of F-gases, particularly at the end of the useful life of switchgear and controlgear.

Minimum penalties should be binding throughout Europe for gas that is not disposed of in the proper way in order to ensure the recovery of SF6 in accordance with the F-Gas Regulation (similar to the German Chemicals Climate Protection Ordinance[8]). These penalties should be significantly higher than the disposal costs to make proper disposal more attractive.[9]

High-voltage switchgear is used in a few, controlled professional environments (transformer stations), in which the recovery of SF_6 is ensured. Medium-voltage switchgear is also installed in the private sector, where the recovery of SF_6 is not monitored. Here more can be done through the ZVEI to increase awareness and to draw attention to the specific possibilities for the disposal of medium-voltage switchgear.

[8] Chemikalienklimaschutzverordnung (german): https://www.gesetze-im-internet.de/chemklimaschutzv/BJNR113900008.html

3. SF_6 Alternatives and Timetables

SF_6 alternatives have already been undergoing tests for some years now; however, these tests are very comprehensive and complex and must also cover long-term operation. The aspects of environmental and health protection, experience made with long-term operation and possible technical risks can only be validated with pilot switchgear and must be evaluated in parallel to technological developments. For example, chemical transformations of the alternative gases during the useful life of the product and after their emission into the atmosphere must be evaluated in order to sustainably rule out a risk to persons or the environment and to ensure positive environmental performance in comparison to SF_6. A specific period for a broad use of these new technologies in relevant products is therefore currently not assessable. A further need for development and investment is required if the areas of application for SF_6 alternatives are to be broadened. The use of SF_6 in new switchgear must remain permissible beyond 2030

Restrictions of the use of SF6 in new switchgear and controlgear announced today could mean a considerable competitive disadvantage for German and European manufacturers on the world market and are therefore not constructive. For this reason, effective incentives should be provided for the introduction of alternatives so that in the end an advantage is created on the global market.

Incentives could be:

- Market introduction programmes or government investment grants, e.g. also staggered according to the GWP of the alternative.
- “Scrapping incentive” for older SF_6 switchgear, in both the high-voltage and medium-voltage range.
- Promotion of the development processes for SF_6-free solutions at the manufacturers and for pilot applications for gaining experience.
- Shorter depreciation periods for SF_6-free alternatives.
- Higher return on capital costs for SF_6-free alternatives.

The objective of the development and availability of targeted incentive systems in the coming 5 years should be to enable the provision of SF_6-free alternatives for customary applications as from 2030.

4. Targets for Emission Reduction

Through the measures named in Chapter 2 “Measures to Reduce SF_6 Emissions” as well as implemented incentive systems, the restriction of total SF_6 emissions to 17 t p.a. by 2020 as set out in the current voluntary self-commitment can turn out to be significantly more ambitious. The results already achieved in Germany are promising and confirm that voluntary self-commitment is a suitable instrument. As regards the new definition of the targets for 2030, a significant reduction of operating emissions for installed switchgear and controlgear in the high-voltage range is imaginable. There is particularly also reduction potential at the manufacturers regarding other equipment (e.g. feedthroughs, instrument transformers, capacitors and gas-insulated lines (GIL)). Altogether, further potential for reductions in SF_6 emissions must be examined at the manufacturers and new targets formulated dynamically, possibly depending on technical progress.

In ZVEI’s opinion, the total admissible emissions according to the voluntary commitment (17 t p.a. for 2020) can be halved with regard to 2030.

5. Conclusion

Our industry is working intensively on the further reduction of SF_6 emissions in switchgear and controlgear to be newly installed. The promotion and strengthening of SF_6-free alternatives at an early stage is of particular interest as electrical systems have an expected useful life of up to 40 years (cf. StromNEV).

New gases and gas mixtures are currently being introduced and tested in pilot applications. Here promising successes have been achieved that would not have been conceivable some years ago. However, it will still take years before the full market maturity of the entire portfolio of switchgear can be guaranteed. Possible incentive systems are described in Chapter 3 “SF_6 Alternatives and Timetables” and are regarded as suitable measures for sustainably promoting the broader use of SF_6-free alternatives.

In the short term, a substantial reduction of SF_6 emissions can be achieved through the implementation of the measures described in Chapter 2 "Measures to Reduce SF_6 Emissions”, particularly through the replacement of old switchgear in the high-voltage range (according to the cataloguing in Chapter 2.1 “Replacement of switchgear in the high-voltage range according to its emission rate”).

The industry itself could implement further measures by extending and updating the targets in the voluntary self-commitment of 2005.

Suitable measures could be anchored at the European level in the future if the European Commission carries out an assessment of the F-Gas Regulation (EU) 517/2014) in 2020. The mechanism of self-regulation according to Article 17 of the Ecodesign Directive 2009/125/EC can provide a suitable starting point and also be applied to the EU F-Gas Regulation. European associations such as T&D Europe can help to establish joint measures within the scope of a self-commitment in the European area. The manufacturing industry (switchgear and gas producers) in Europe has already supported various, partly temporary, commitments in the past.

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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 people 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.