Product Stewardship for SF_6

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Introduction

The manufacturers in the chemical industry are committed to minimizing any health, safety, and environmental risks that may be related to their products and, at the same time, to meeting the needs of their customers and the public for safely usable and environmentally sustainable products. In the framework of their commitment to continuous progress in these matters within the RESPONSIBLE CARE® programme, the concept of PRODUCT STEWARDSHIP has become an important building block toward sustainable development [1]. Product responsibility for SF_6 is materialized in a large number of practical precautions that Solvay Fluor und Derivate has developed and implemented in collaboration with - but always for - the users of SF_6.

Product Stewardship

The following aspects are decisive for the application of product stewardship:

- Anchoring in the company
- Safety and environmental protection as goals
- Communication
- Cooperation

Anchoring in the Solvay Group Company

The Product Stewardship guidelines of the Solvay Group [2] express the commitment of the top management and employees to the following principles:

- Solvay wants the company's products to be useful to people and the environment.
- Solvay wants to account for what happens to the company's products after they have been used.
- Solvay wants to continuously expand its knowledge about the potential environmental, health, and safety impacts of its products and is prepared to engage in open and fair dialogue.

One of the business goals of Solvay Fluor and Derivate also clearly states:

- “Continue to improve the quality of our products and services.”

On the basis of our own commitments, the anchoring is built into the company, which is necessary for the implementation of our RESPONSIBLE CARE commitments.

Safety and Environmental Protection

The commitments of Solvay Fluor und Derivate GmbH to protect people and the environment are demonstrated in many practical activities including SF_6 applications. Since the end of the 1960s, Solvay Fluor und Derivate has been a worldwide supplier of SF_6, particularly for electrical switchgears because this is by far the main application for SF_6 worldwide. In these electrotechnical applications, SF_6 can demonstrate its extraordinary characteristics and advantages, such as chemical stability, substantial thermal stability, and nonflammable nature.

When released in the atmosphere, SF_6 has a long atmospheric lifetime. Because its global warming potential (GWP) is relatively high compared with that of CO_2, handling SF_6 requires a closed cycle, minimizing potential emissions where possible and increasing its reuse potential.

Therefore, as early as in the late 1980s, Solvay Fluor und Derivate started with the development of the SF_6 ReUse Concept [3]. The SF_6 ReUse Concept focuses on reclaiming SF_6 from these applications at the end of their lifetime.

The SF_6 ReUse Concept includes actions at three levels of the SF_6 product cycle. The first option assumes the on-site reclaiming – of the products containing SF_6 – involving the use of appropriate equipment. If on-site reclaiming is not possible, the second option is applied.

In detail, this second option consists of:

1. Support for environmental assessment.
2. Analytical evaluation of the used $SF_{6.}$
3. Providing appropriate packaging and transport of used $SF_{6.}$
4. Reclaiming and reuse.

<u>1. Support for environmental assessment</u>

An example of support for the environmental assessment is the regular Solvay Fluor publication, "SF_6 Newsletter." The goal of this newsletter is to keep SF_6 users updated about changes and evolution in regulatory developments for SF_6 - environmental policy for SF_6 - due to the application of the Kyoto Protocol and to address other related issues of common interest. Another type of support for environmental assessment consists of answering questions from customers or the public directed to Solvay Fluor und Derivate as an SF_6 producer.

<u>2. Analytical services</u>

These services enable our customers to have analyses carried out by Solvay Fluor und Derivate when they have no analysis facilities or too little experience with used SF_6. The necessary equipment (lecture bottle with adapter) is kept on hand.

<u>3. Providing appropriate packaging and transport</u>

Solvay Fluor und Derivate has a permit for a special type of compressed gas container for the transport of used SF_6 from electrical substations. These compressed gas containers are different from the containers for new SF_6 (their walls are thicker, taking into account the presence of larger concentrations of corrosive degradation products). The valves of these SF_6 ReUse compressed gas containers (DIN 477 side connector no. 8) are also different from those used for new SF_6 (DIN 477 side connector no. 6).

4. Reclaiming and reuse

Used SF_6 delivered in the SF_6 ReUse containers is re-fed into the SF_6 production process after a preliminary cleaning phase. The big advantage of this process is that the degradation products of SF_6 are thermically cracked and transformed into new SF_6.

If a residue-free reuse of the used SF_6 is no longer possible, this quality can be disposed of in the framework of the third option of the SF_6 ReUse Concept by means of safe incineration at Solvay Fluor und Derivate. Up until now, this last option has been necessary only once.

Communication

The communication process must be considered as a key element in the application of the SF_6 product stewardship programme. Within this communication process, the knowledge of all the parties involved (manufacturers, shipping companies, professional associations, and users) has to be presented, including the precautionary measures recommended for SF_6 use and the instructions on how to safely handle this product. The success of this communication process depends on providing complete and meaningful written information.

Material safety data sheets (MSDS) and accident reference sheets for SF_6 and used SF_6 are the keys and classical basis documents of information. That is why we are only mentioning here the information folder "*Declaration regarding SF_6 in electrical equipment and switchgears*" [4]. This folder was issued by German Electrical Associations VDEW (Vereinigung Deutscher Elektrizitätswerke e.V.) and ZVEI (Zentralverband Elektrotechnik und Elektroindustrie) in cooperation with switchgear manufacturers, power companies, and one SF_6 producer. In this information folder, all the parties involved voluntarily committed themselves to taking all the steps made possible by the current state of the art to avoid or reduce SF_6 emissions.

Cooperation

The development and introduction of the SF_6 ReUse Concept and the above-mentioned information folder are examples of successful intercompany and cross-industry cooperations.

In the spirit of the principle of product stewardship commitment, a lifecycle assessment study of SF_6 was developed in a joint project, initiated by Solvay Fluor und Derivate, and developed in collaboration with The ABB Group, PreussenElektra Netz GmbH & W.KG, RWE Energie AG, and Siemens AG [5]. This initiative allowed the evaluation of the true environmental impact of SF_6 application and did not limit it to its theoretical potential impact in terms of global warming potential. This lifecycle analysis was based on a realistic power grid for electrical power supply, which was completely analysed by taking into account all relevant criteria such as the primary energy consumption during the lifetime of the application, its space requirements, the global warming effect, the potential contribution to acid rain, and potential eutrophic impact. The objective was to create a platform for a documented environmental discussion and, in addition, to consider various options for additional ecological optimization of the life cycle. The lifecycle assessment study was carried out in compliance with the requirements of the international standard DIN EN ISO 14040 and accompanied and evaluated by an external, independent audit from the TÜV NORD compliance testing agency.

The Lifecycle Assessment Study

The lifecycle assessment study is designed to reflect conditions of the application in Germany; the technologies considered correspond to today's state of the art. The study compares different switchgear technologies with and without the use of SF_6, evaluated at the level of the switch bays as well as at the level of a real city power-supply grid.

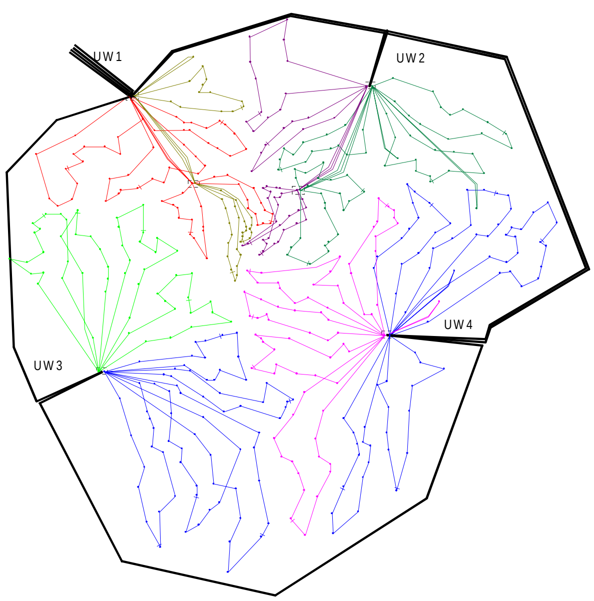
On the level of switch bays, the study examines:

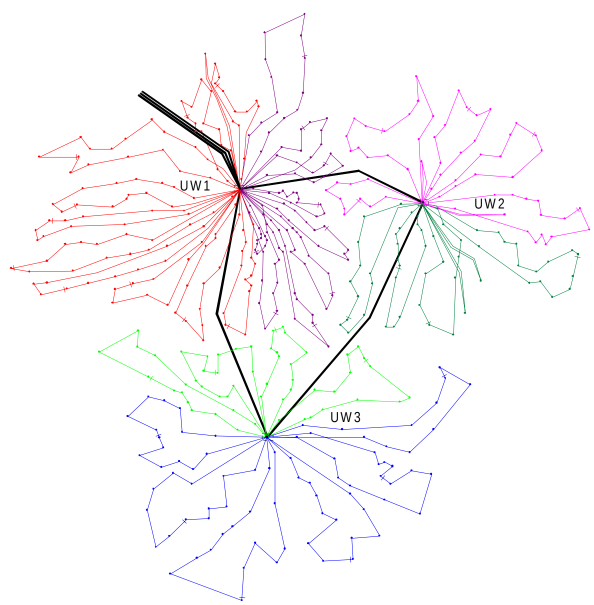
- Conventional weather-protected technology with SF_6-free equipment.
- Weather-protected technology with SF_6 equipment (circuit breakers and transducers).
- SF_6-insulated, metal-encapsulated switch bays.

On the level of the power grids - starting from the given load profile of a German city roughly 40 km² in size with about 130,000 inhabitants, a peak load of 120 MW and consumption of 400 GWh in the first year of the study (annual load growth of 1.5 percent) - two alternative supply models are compared:

- Power is fed into four air-insulated 110/20 kV transforming substations (AIS) at the edge of town with the appropriate amount of space and distributed over the 20 kV network. The 110 kV substations are connected with overhead transmission lines.
- Power is fed through 110 kV cable into three clearly consumer-proximate SF_6 gas-insulated 110/20 kV transforming substations (GIS) and distributed through the 20 kV grid.

In both cases, the power is accepted from the superimposed mixed network in a 380/110 kV transformer substation at the edge of town. Both grids are designed so that the supply quality of the consumers is identical; different failure probabilities of the various operating equipment are taken into account and compensated during the grid layout work. The grid layout is economically optimized in terms of investment volume and costs. The time period of the study corresponds - to treat all the switch bay variations studied adequately - to 30 years of the typical life of air-insulated, high-voltage switchgears. SF_6-insulated switchgears can generally be used at least an additional 10 years.





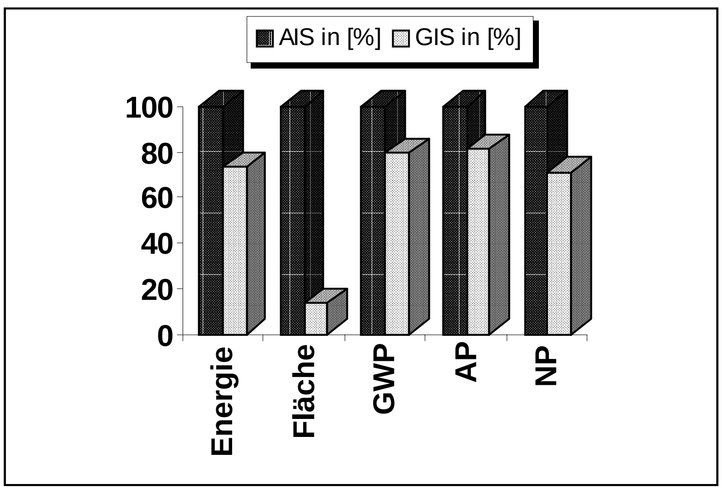
Topology of the grid variants: AIS grid (left) and GIS grid (right). Exemplary for a distribution voltage of 20 kV. TS stands for transformer substation. The left exhibit shows that for AIS variants, the four air-insulated TS's are located on the edge of town. In the GIS variant shown on the right, the three SF_6-insulated TS's are within the city limits and thus arranged near the consumers. Thick lines represent 110 kV high-voltage overhead lines (AIS grid) and cable (GIS grid); thin lines are medium-high voltage cable. While the 110 kV overhead transmission lines of the AIS grid (without SF_6) surround the city, the 110 kV cables of the GIS grid (with SF_6) stretch into the city, resulting in a reduction of transmission losses.

Results of the Ecological Assessment

On the <u>level of switch bays</u>, the use of SF_6 technology always provides advantages in four out of five criteria of the lifecycle assessment study: for primary energy expenditure, space requirements, acidification and nutrification potential. Switchgears with substantial rates of utilization and/or low SF_6 dissipation rates also deliver an ecological advantage in terms of potential global warming.

On the crucially decisive <u>power grid level</u>, the study produces the following picture:

The layout of the power grid using GIS technology (with SF_6) compared with the layout of the same grid using AIS technology (without SF_6) provides a 27 percent reduction in primary energy consumption, roughly 86 percent reduction in space requirements, a reduction in global warming potential (GWP) by some 21 percent, a decrease in acidification potential (AP) by approximately 19 percent and a drop in nutrification potential (NP) by roughly 29 percent. Extensive scenario calculations prove the reliability and applicability of the results.



The use of GIS switchgears in the power grid studied lowers all the potential environmental impacts studied. The graph shows the relative environmental impact potentials in the first year of use of the grid variants (dark bars=AIS variants, light bars=GIS variants).

Thanks to SF_6 technology, an increase in the power capacity of the grid by roughly 50 percent (i.e., an improved exploitation of the grid) leads to an additional 5 percent reduction in the parameters primary energy consumption, global warming potential (GWP), acidification potential, and nutrification potential (NP).

The most important reason for these reductions are: due to the substantially better insulation and electrical arc-extinguishing characteristics of SF_6 in comparison to air, stations and equipment in the GIS variant can be made with less material and energy than those in the AIS alternative. Even more decisive is that, due to the compact construction of the GIS components, the 110/20 kV transforming substations can be erected directly at load centers (inner-city). So the energy is delivered to city centers at high voltage with negligible distribution losses and, from there, through short medium-voltage lines to the consumers.

Conclusion

The use of SF_6 technology leads to clear ecological advantages in comparison with SF_6-free switchgears and equipment. This means that SF_6 technology is also sensible for urban power supply from an ecological point of view. This is conditional on the use of GIS stations, which guarantee correspondingly low SF_6 emissions and, on the other hand, the vigorous use of the SF_6 ReUse Concept for a closed SF_6 cycle. The technical and logistical prerequisites for this are in place.

It is quite apparent that focusing on the global warming potential of one unit by weight of SF_6 is inadequate when assessing SF_6 use in high- and medium-voltage technology. Only an extensive study made of all the relevant environmental criteria in respect to whole power grids with the help of a lifecycle assessment study can provide reliable results - and these results are positive for SF_6.

Summary

PRODUCT STEWARDSHIP as a concept that covers the whole life cycle of products can deliver important contributions to sustainable design development of product systems able to meet future needs. Against the backdrop of the goals set and frameworks provided by society and public policy, the concept achieves solutions through the voluntary cooperation among companies, solutions that will also mean continuous improvements in environmental protection and safety.

The SF_6 ReUse Concept, the "*Declaration regarding SF_6 in electrical equipment and switchgears*," and the developed lifecycle assessment study, "*Electricity supply using SF_6 technology*" demonstrate how PRODUCT STEWARDSHIP can be translated into concrete actions - and which ecological improvements, based on the use of SF_6 technology, are already possible today and will be possible tomorrow. Indeed, evaluation of recent atmospheric measurements indicate a reversed trend in annual emission of SF_6 into the atmosphere by 27 percent between 1995-1998 [6].

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