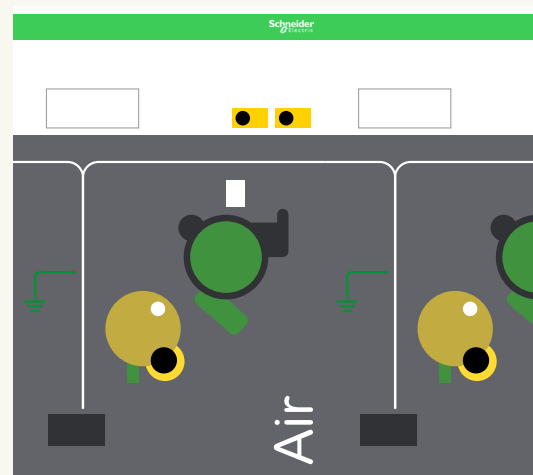
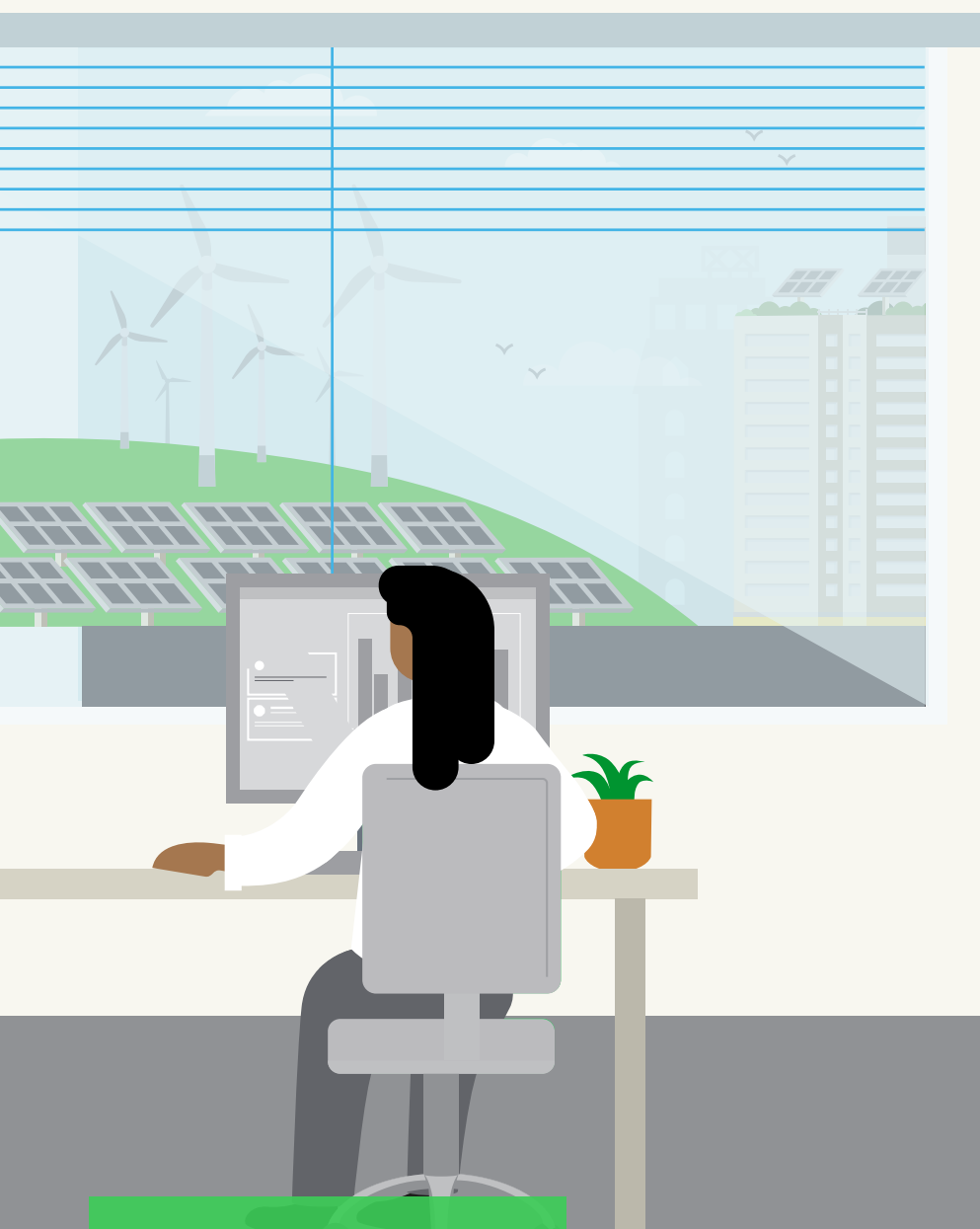


INNOVATION

How SF₆ Alternatives and Digital Technologies Combine to Empower Electricity Decarbonization and Efficiency

by Christophe Prévé



Life Is On

Schneider
Electric

se.com/airset

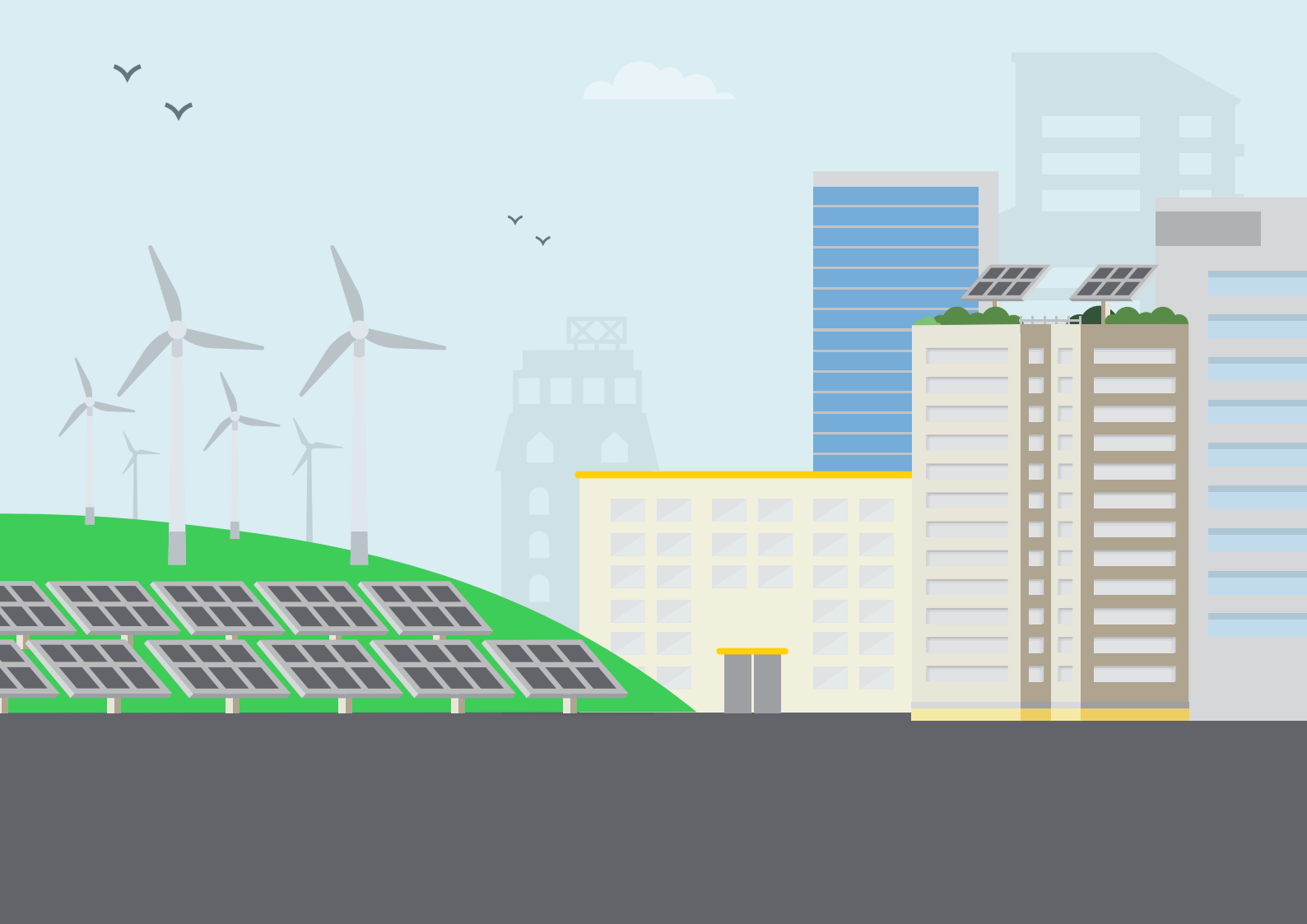


Executive Summary

Against the clear threat of climate change, a society wide focus on sustainability has emerged. Many countries and governments have set strong carbon neutrality targets.

Certain critical industries, such as electrical power infrastructure and large electricity consumers, face especially strong external and internal pressure to decarbonize. The paradox they often face is how to simultaneously reconcile increasing electricity demand in a sustainable and climate friendly manner.

Today, the grid and large grid users, including the emerging energy communities using microgrids, increasingly turn to a growing set of green and digital technologies they can use to directly address this paradox. The combination of removing the sulfur hexafluoride greenhouse gas from networks and the deployment of connected digital technologies makes meaningful progress toward electricity decarbonization and efficiency.



Contents

- Executive Summary** **2**

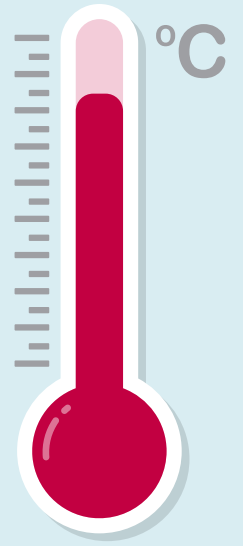
- Electricity systems contribute to global heating and need to decarbonize** **4**
 - Non-renewables are still required6
 - Inefficiency is common6
 - SF₆ greenhouse gas is commonly used in electrical equipment6

- Actions are necessary to achieve greener grids** **7**
 - Grids must integrate more renewables8
 - Grids must become more efficient9
 - MV equipment must transition away from SF₆9

- Today SF₆ alternatives and digital technologies help solve the 3 challenges of non-renewables, inefficiency, and greenhouse gas** **13**
 - Connected Digital Equipment enables more renewable integration14
 - Connected Digital Equipment enables better efficiency15
 - We can end our reliance on SF₆ greenhouse gas16

- Conclusion** **20**
 - Together, SF₆-free and digital are a powerful force for decarbonization and efficiency20

Electricity Systems Contribute to Global Heating and Need to Decarbonize



Electricity systems must improve

Against the backdrop of climate change, building a brighter future, and ensuring strong economic performance, the pursuit of sustainability is currently top of mind for governments, industries, companies, and consumers. Climate inaction is simply unacceptable.

Even the business case for more sustainable energy is embraced by an increasing number of organizations, including some of the world's leading enterprises. One such example is the Climate Group's EP100 initiative, whose member companies have committed to ambitious energy efficiency goals. Another is the RE100, whose members are aggressively pursuing the goal of using 100% renewable in the shortest possible time line. More and more organizations are also publicly setting their own science-based targets to reduce emissions.

Sustainability must be a top priority for the electricity industry as well, without which modern life grinds to a sudden stop. The need for electricity industry decarbonization is amplified by the fact that there is a clear global shift toward greater electrification.

Electric vehicles, for example, are projected to account for 50% of new passenger vehicle sales by 2040.¹ Additionally, the energy demand for cooling is expected to triple between now and 2050, requiring as much electricity as all of China and India use today.² Overall, a 62% increase in total power demand is expected from now to 2050.⁴

Residing among large contributors to global emissions, power grids and large grid users

have the responsibility to decarbonize. According to the IEA³, global energy related CO₂ emissions rose 0.9% to a historic high of 36.8 Gt in 2022. While emissions from all fossil fuels increased, the power sector accounted for nearly two-thirds of emissions growth.

But decarbonization goes beyond emission reduction in the grid and in power generation, it is also tightly linked with the efficient delivery and use of electricity. It means that large grid users, such as electro-intensive industries like oil and gas, food and beverage, cement manufacturers, and data centers have a role to play to improve the efficiency of their electricity systems and reduce their carbon footprint.

To make further progress on this front, these industries can take immediate action to address three obvious problem areas:

- Transition away from non-renewable sources of electricity generation
- Improve the efficiency of existing grids and large grid users
- End reliance on the SF₆ greenhouse gas commonly used in electrical equipment

¹ Bloomberg New Energy Finance: Electric Vehicle Outlook 2020: <https://about.bnef.com/electric-vehicle-outlook/>

² International Energy Agency: The Future of Cooling: <https://www.iea.org/reports/the-future-of-cooling>

³ International Energy Agency: Global Energy & CO₂ emissions in 2022: <https://www.iea.org/reports/co2-emissions-in-2022>



Non-renewables are still required

Despite certain geographies forging a more sustainable future, such as the European Union with its 2050 carbon neutrality goal, BNEF predicts that about a quarter of global electricity generation in 2035 will still come from coal.

They predict that global electricity generation goes from “two-thirds fossil fuels in 2018 to two-thirds zero-carbon energy by 2050. For wind and solar that’s ‘50-by-50’ – with these technologies supplying almost 50% of world electricity by 2050, ending the era of fossil fuel dominance in the power sector.”⁴ Note that ‘zero-carbon’ and ‘renewable’ do not share the same definition. But in the meantime (and beyond), a world powered by 100% renewable energy is not on the immediate horizon in most geographies.

In the context of the energy crisis global emissions from coal-fired electricity and heat generation grew by 224 Mt or 2.1%⁵. Coal generation would need to fall by 11% per year until 2030 to keep to the Intergovernmental Panel on Climate Change’s median 1.5 degree scenario. This underscores the importance of doing everything possible to reduce emissions now in the ways that are possible today.



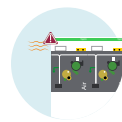
Inefficiency is common

No energy system is without losses, and existing electricity networks are susceptible to inefficiency. The pressure to improve energy efficiency is constant and intense. The burden is particularly high for electric utilities, because

changes to power production and distribution can have a chain effect that impacts the energy efficiency efforts of both utilities and consumers.

The efficiency of electrical distribution is rarely planned or managed, especially by utilities. The unfortunate result is that substantial amounts of electricity is wasted. In fact, annual electricity transmission and distribution losses average 5% in the European Union. That breaks into 24% for transmission and 76% for distribution losses, which represents 5 billion euros in energy wasted every year in medium voltage distribution. This number includes losses in the medium and low voltage networks.

Improving grid efficiency in these networks is clearly a high priority and one that contributes to decarbonization. The more efficiently electricity is transported and used, the less that must be created in the first place.



SF₆ greenhouse gas is commonly used in electrical equipment

Sulfur hexafluoride (SF₆) is a man-made fluorinated gas (F-gas) that has been used for decades in both high voltage (HV) and medium voltage (MV) switchgear. The properties of SF₆ made it very well suited for electrical current breaking and insulation.

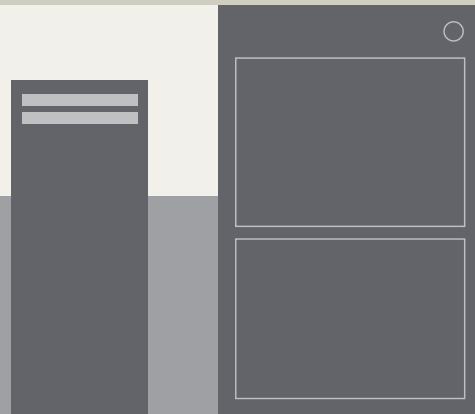
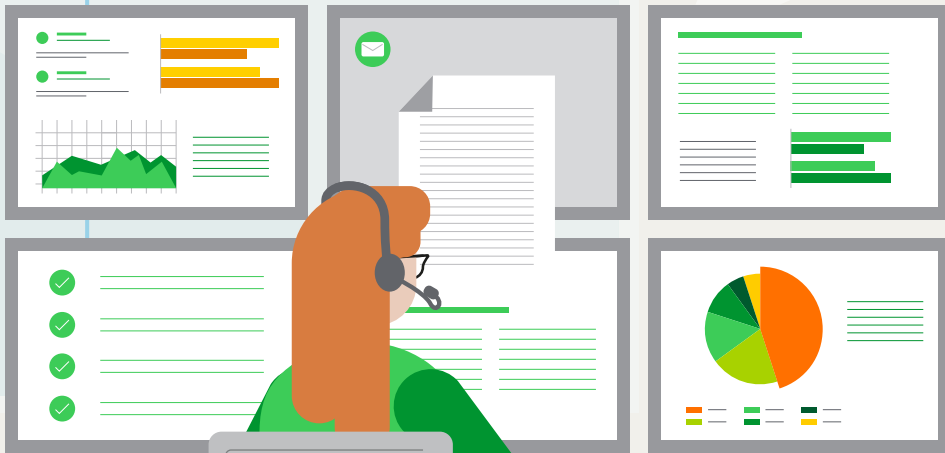
The significantly negative characteristic of SF₆ is its global warming potential. It is 25,200 times stronger than CO₂, making it the single strongest greenhouse gas. The gas is estimated to remain in the atmosphere for over 1,000 years.

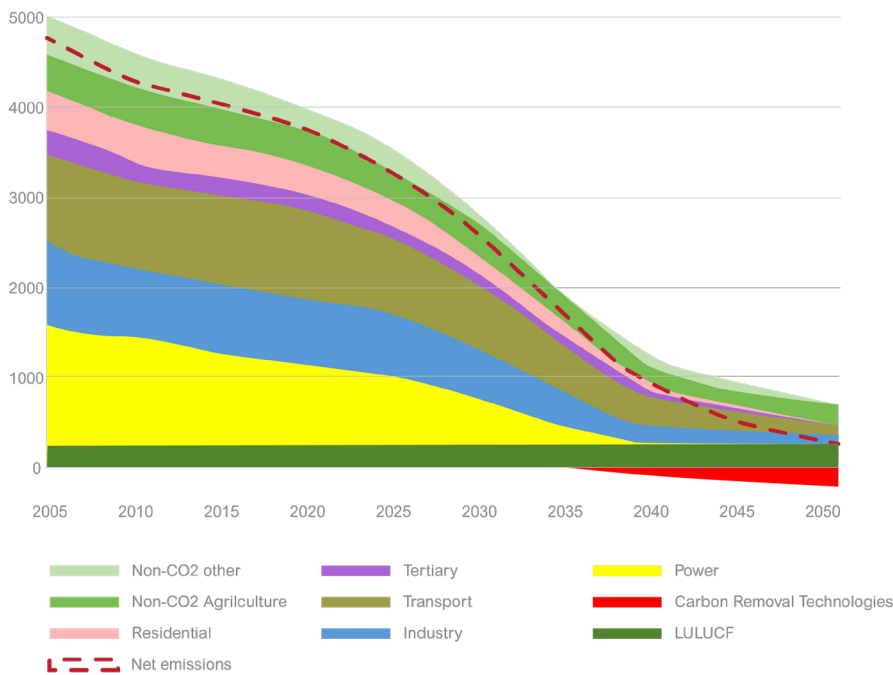
⁵ IEA CO₂ emissions in 2022: <https://www.iea.org/reports/co2-emissions-in-2022>

⁴ Bloomberg New Energy Finance: New Energy Outlook 2019: <https://bnef.turtl.co/story/neo2019?teaser=true>

Actions are Necessary to Achieve Greener Grids

To make progress toward decarbonization and emission reduction, there are certain major industry transformations that must begin or continue. The decision to act on these factors today greatly affects the timeframe at which electricity-related climate goals are reached.





Source: European Commission⁶



Grids must integrate more renewables

Many governments are driving the transition to a decarbonized future. A prime example is in Europe, where one important goal of the European Union is to become the first climate neutral region in the world by 2050. To achieve that, the European Commission has proposed legislation that would bind its member states to the goal of net-zero emissions by 2050. As part of the European Union's Green Deal, reforms were announced in which the European Commission proposes emissions reductions in all sectors of the economy. The power industry is clearly targeted, and a heavy portion of this decarbonization effort will require the integration of more renewable sources of electricity generation.

The good news is that there is increasing penetration of renewable sources of electricity globally. Wind and solar generation rose by 15% in 2019, or 270 TWh, generating 8% of

the world's electricity⁵. That's up from just 3% in 2013. A strong continued momentum is important because a compound growth rate of 15% of wind and solar generation will be needed every year through 2030 to achieve the goals of the Paris climate agreement and limiting global heating to 1.5 degrees.

Integrating environmentally-friendly renewable energy sources and other types of distributed energy resources (DER), such as electrical vehicles and battery storage, into existing power networks also introduces substantial technical challenges. For example, DER integration highly complicates electrical distribution system operations. Because renewable DERs are variable by nature, they can negatively impact power quality and system reliability.

⁶ European Commission communication: A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, 2018: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN>

To properly manage the increased complexity⁷ that comes with greater DER penetration, electricity systems require far more sophisticated mechanisms for planning and operations, which only connected digital technologies can enable.

Furthermore, as public power grids and private networks integrate these renewable technologies, they also need to accommodate new consumer profiles, as consumers transition from passively consuming electricity to both consuming and producing their own. The so-called prosumer profile will become more common alongside the growing adoption of battery storage, electric vehicles, and photo voltaic (PV). Through digitization, more active and automated grids will possess the flexibility to welcome these new prosumers.



Grids must become more efficient

Often driven by regulations, grid operators and large grid users are under pressure to achieve ambitious energy goals by cutting electricity network losses and enhancing efficiency.

The European Union has committed itself to achieve climate neutrality by 2050 through the European Green Deal. The Green Deal is made of several building blocks, among which is the Clean Energy Package. This package, adopted in 2019, shows the way toward the energy transition and includes several pieces of legislation, two of which address the energy efficiency of electricity networks.

One example is the revised Energy Efficiency Directive 2018/2002, which highlights the energy efficiency savings potential in transmission and distribution grids. In the revised article 15.2 “By 31 December 2020,

the Commission shall, after consulting relevant stakeholders, prepare a common methodology in order to encourage network operators to reduce losses, implement a cost-efficient and energy-efficient infrastructure investment programme and properly account for the energy efficiency and flexibility of the grid.”

The other piece of legislation is the Electricity Directive 2019/944, which introduces in article 59.1 (l) several provisions to improve the energy efficiency of electricity networks: “The regulatory authority shall have the following duties: (...) (l) monitoring and assessing the performance of the transmission system operators and distribution system operators in relation to the development of a smart grid that promotes energy efficiency and the integration of energy from renewable sources based on a limited set of indicators, and publish a national report every two years, including recommendations;”

Both articles call for the introduction of a formal procedure to allow the development of a more energy-efficient and intelligent network.



MV equipment must transition away from SF₆

SF₆-based switchgear is rarely noticed but has a key role in medium voltage switchgear. For example, there are an estimated 15 million MV switchgear units currently operating in the EU28 today, 10 million of which use SF₆. Together they are directly responsible for the reliability of our electricity supply.

This paper focuses solely on SF₆ for MV switchgear applications, which generally describes the voltage level of Europe’s power distribution networks.

⁷ Power Grid International: Utility planning – More complexity requires a more coordinated approach, March 2020: <https://www.power-grid.com/2020/03/25/utility-planning-more-complexity-requires-a-more-coordinated-approach/>

Modeled installed base 2020	Germany	France	Spain	EU28 (extrapolation)
Number of MV switchgear functional units - total (million)	ca. 3,1	ca. 2,0	ca. 1,7	ca. 15
Number of MV switchgear functional units - SF ₆ (million)	ca. 1,4	ca. 2,0	ca. 1,1	ca. 10
SF ₆ banked volume in MV switchgear (t)	1300	1100	1200	8600 (196 million t CO ₂ equiv)
General Data				
Overall yearly electricity demand (TWh)	514	436	240	2700
Total GHG emissions (2017), CO ₂ equivalent (million t)	936	428	357	4483
Power generation GHG emissions (2018) CO ₂ equiv. (million t)				985 (196 - 20%)

Source: Fraunhofer Institute

These millions of MV switchgear units using SF₆ gas represent a climate risk. The Fraunhofer Institute for Energy Economics and Energy System Technology estimates⁸ the installed base, in Europe, of about 10 million MV switchgear units to collectively contain a volume of 8,600 tonnes of SF₆ gas. Were that SF₆ released into the atmosphere, it would have a CO₂ equivalent of 216 million tonnes. As a reference point, passenger cars in Europe are estimated to emit a total of 900 million tonnes of CO₂ per year.

Furthermore, under any future scenario, more MV switchgear is required to be installed in the grid. Fraunhofer's model, for example, estimates a conservative European grid extension scenario between now and 2050 that involves a 42% increase in switchgear. This is mainly due to the expected increase in renewable energy installations. Each of these technologies requires MV switchgear to be installed at its grid connection point. Should the industry-standard SF₆-based MV switchgear technologies remain the go to choice, MV grid carbon neutrality will remain unachievable.



⁸ IMPACT ASSESSMENT OF F-GAS FREE MEDIUM VOLTAGE SWITCHGEAR: Modeling scenarios of MV switchgear installation development and impact on SF₆ emissions, Wolfram Heckmann and Thorsten Reimann, Fraunhofer Institute for Energy Economics and Energy System Technology, IEE, April 2020. https://www.iee.fraunhofer.de/content/dam/iee/energiesystemtechnik/de/Dokumente/Pro-jekte/f-gas-free/SF6_study-public_report-Fraunhofer_IEE-final2.pdf

Banked SF₆ volume MV switchgear, EU28, Business-as-usual, expected development due to grid extension



Source: Fraunhofer Institute

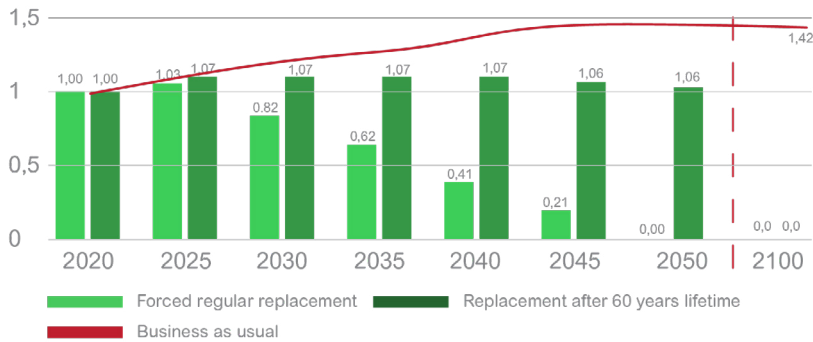
According to Fraunhofer, MV grid carbon neutrality cannot be achieved if SF₆ switchgear are not replaced. There are three reasons for this.

As electrical networks grow, SF₆ will continue to proliferate.

If no action is taken on SF₆, its potential CO₂ equivalent impact is expected to increase because of network expansion, including new renewables. By 2050, this would represent 1.42 times the existing banked volume of SF₆ in operation in MV switchgear in Europe.

Banked SF₆ volume MV switchgear, replacement 100% F-gas free, starting 2025, considering different replacement conditions

2020 banked SF₆ volume: 1 = 8600t
 100% SF₆ replacement with F-gas free
 forced replacement starting 2025



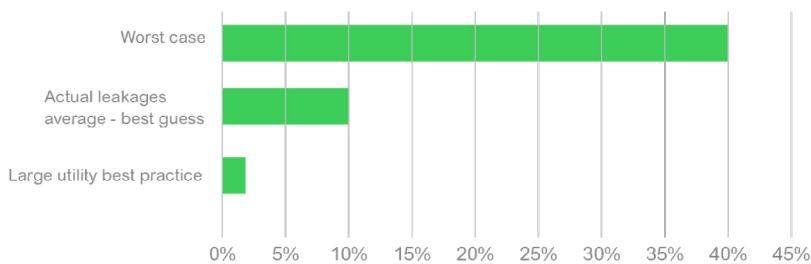
The installed base creates greenhouse gas emissions during operations

It is important to note that once installed, MV switchgear normally remains in service for many decades. Units are commonly operated for a period of 40 years or even longer. During this normal operational lifespan, SF₆ escapes into the environment. This amounts to 0.1% of the unit’s volume per year according to the relevant standards. In the worst cases, switchgear is operated until a major electric fault leads to the destruction of the tank containing the SF₆, in which case the gas is entirely released into the atmosphere.

There is a strong climate impact potential when switchgear reaches its end-of-life

The most climate-damaging driver of SF₆ impacts will come from the potential equipment end-of-life (EoL) emissions. The EoL process for a unit of MV switchgear encompasses the final journey of SF₆ from its extraction from the switchgear to transport to recycling or destruction.

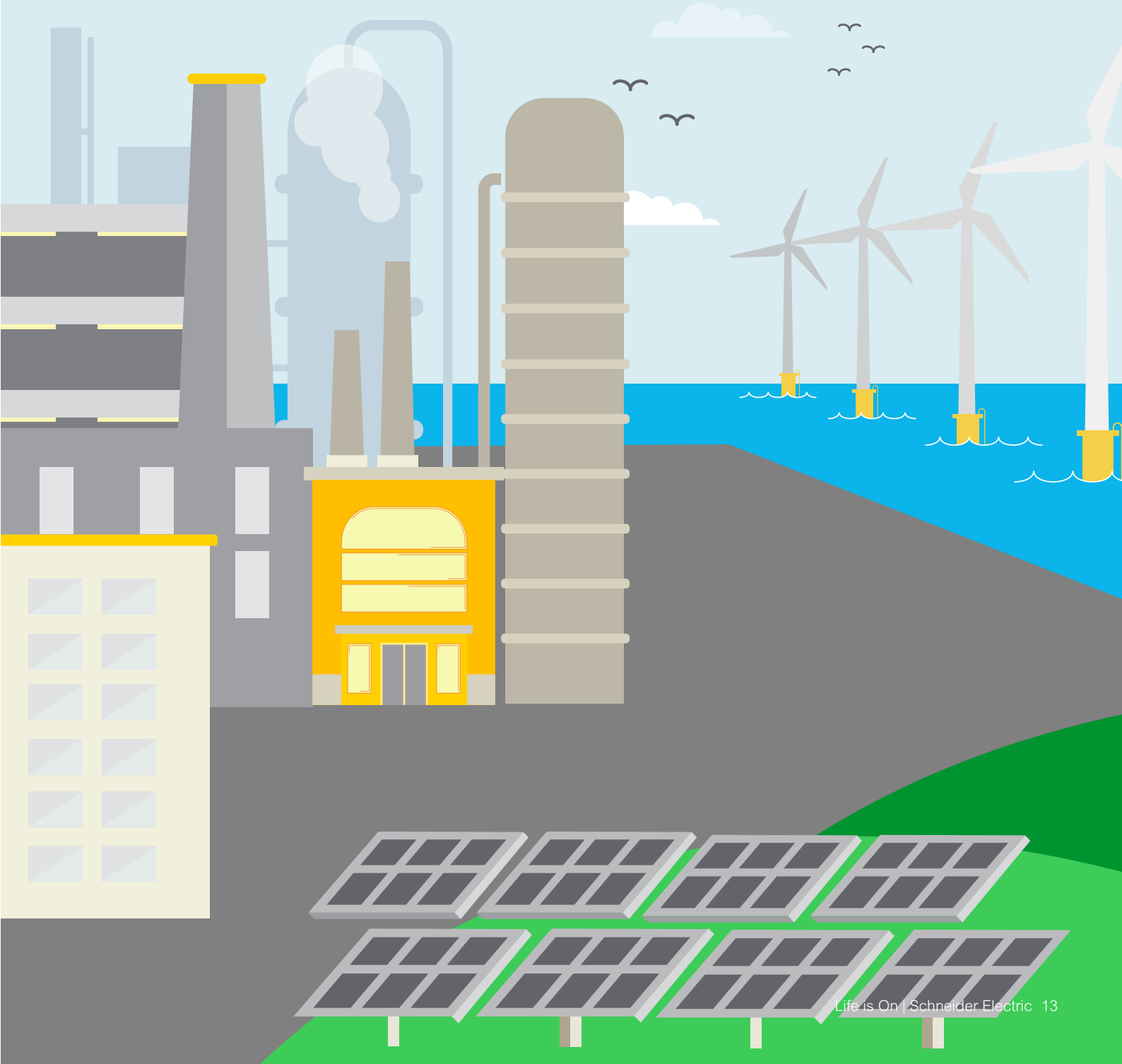
European regulations for SF₆ handling and recovering exist, but implementation of these rules is uncertain. Fraunhofer estimates that different users exhibit a range of quality in their behavior at SF₆ EoL – from good SF₆ handling to negligence – depending on whether the switchgear owner is a large electric utility or a member of the more fractured private market. Fraunhofer estimates the following EoL SF₆ leakages.



Source: Fraunhofer Institute
 Note that saturation is expected by 2050.

SF₆ Alternatives and Digital Technologies Help Solve The 3 Challenges of Non-renewables, Inefficiency, and Greenhouse Gas

Digital technologies, including SF₆ free equipment, are the starting point for achieving better efficiency and decarbonization of power generation, distribution, and consumption. These digital devices and the information they collect and transmit open the door to a host of technical, operational, environmental and economic benefits.





Connected digital equipment enables more renewable integration

As a result of the massive introduction of renewable DER, often local production, power networks are becoming more difficult to manage. This is because many distribution networks are poorly or partially instrumented, especially downstream in the areas of MV/LV substations.

Example: Fine tuning voltage control with smart technology

One of the main responsibilities of utilities around the world is to maintain voltage limits as agreed to via contract with their customers (i.e., within +/- 10% of agreed to target). Voltage control is traditionally performed by transformers, using on-load tap changers (OLTC) and capacitor banks that inject reactive power into the grid at the HV/MV substation level. The grid operator fixes a setpoint and prepares scenarios and ranges based on seasonal load curves, for example.

As more distributed energy resources (DER) are added to a given grid, voltage management becomes a major challenge. Grid operators must now manage situations where voltage may be rising on one part of their grid while decreasing on another part. Thus, grid operators are deploying sensors to monitor the voltage all along feeders, new actuators that can regulate the voltage at different levels, and centralized or distributed intelligence to manage the macro voltage control.

The monitoring of MV equipment in older substations is costly as it requires complex, intrusive methods. Thus, the ability to acquire accurate, real-time voltage measurements requires the deployment of new solutions and sensors to minimize long term global costs.

A number of new digital solutions can be deployed to address this challenge. For example:

- New RTU generation (remote terminal unit) allows user to remotely control the MV/LV substation and to measure MV and LV voltage accurately for voltage level optimization and for load shedding and peak shaving management.
- New smart sensors can today be easily installed on new and existing switchgear and can be connected to the cloud. They allow predictive maintenance and end-of-life management, which are key to reducing long-term global costs. For this purpose, insulation aging and temperature at the cable connection points can be determined.
- Virtual sensors are another option for voltage measurement. They are capable of estimating or modeling the MV voltage based on other data that is easier and cheaper to measure. For instance, MV voltage may be estimated from LV through distribution transformers or from load currents through line impedance modeling. Depending on the level of accuracy required, sensor and installation costs can be drastically reduced.

As digitized equipment enables smarter systems to emerge, the amount of renewable integration can be increased in a manageable way that ensures proper levels of power reliability and availability.



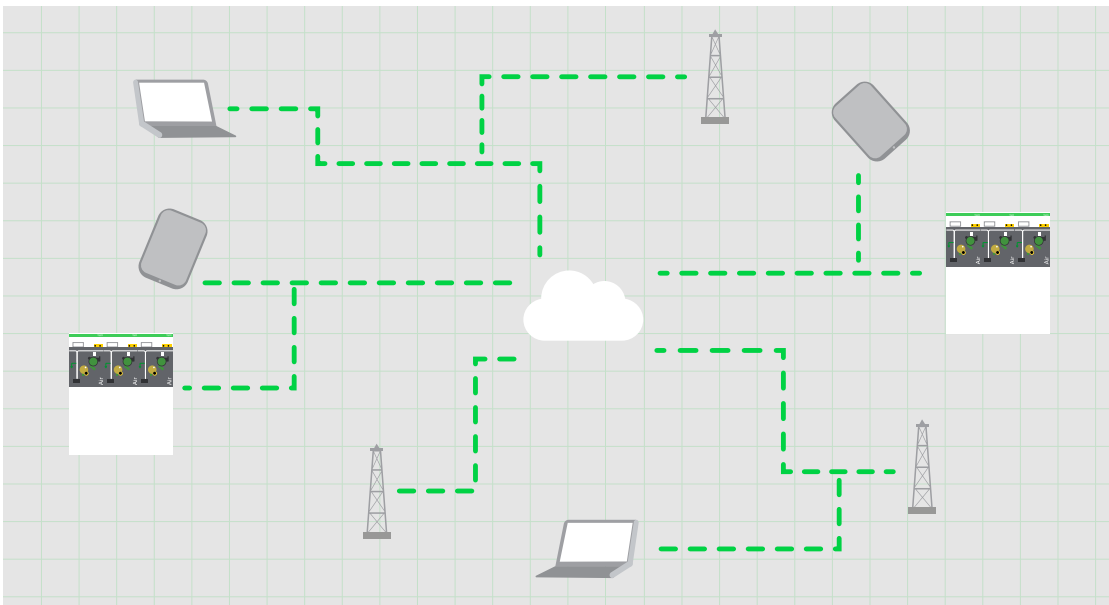
Connected digital equipment enables better efficiency

Electrical distribution network operators are now in a position to improve their networks thanks to digital technologies enhancing energy efficiency. Connected technologies like more accurate and highly networked sensors, actuators, and advanced distribution management systems, for example, unlock the power of data achieving greener electricity systems.

Example: Reducing losses with ADMS

Systems built to estimate losses, like advanced distribution management systems (ADMS), need a real-time network topology, network measurements, load profiles at MV/LV substations, and customer consumption information to determine the optimal location of normal open points. In this environment, when the system operator plans to open or close a switch disconnecter, the ADMS simulates the impact on reliability of supply, losses, and voltage management. Algorithms calculate optimum configurations on an hourly, monthly, seasonal, or yearly basis according to provided load curves, weather forecasts, real-time data coming from sensors, smart meters, and number of switch operations.

Deployment of such a system helps minimize losses, minimize load unbalance in HV/MV substation transformers and feeders, unload overloaded segments of a network, improve voltage quality, and achieve an optimal voltage profile. Some utilities, for example, have already successfully implemented this system. A large European utility has experienced a steady gain of about 4 percent all year round, reconfiguring the grid on a seasonal basis.





We can end our reliance on SF₆ greenhouse gas

For medium voltage applications, there are a strongly encouraging handful of reasons why the transition away from SF₆ is successfully taking shape.

SF₆ free technologies are available now

Alternatives to SF₆ MV switchgear already exist and will soon be widely available.

“In recent years, the technological development of SF₆-free medium voltage switchgear has made very good progress,” according to a briefing paper by Oko Recherche.⁹

The T&D Europe association agrees. They state that their membership, composed mainly of reputable European electrical equipment manufacturers, are intensely engaged in “reducing SF₆-emissions for all applications of electrical power transmission and distribution. These efforts include research, development and installation of alternative technologies for all electrical equipment above 1kV. In recent years, this has also led to the emerging of SF₆-free alternatives.”¹⁰

Indeed, major electrical equipment manufacturers are beginning to offer a variety of environmentally friendly alternative switching technologies whose insulation and breaking mediums have no global warming potential.^{11, 12} That includes major European manufacturers, who are today conducting pilots of SF₆-free MV switch gear at numerous electric utilities and private installations in Europe and around the world.¹³

Existing policies set a precedent

Certain existing regulations in Europe and other parts of the world already address the monitoring, reporting, and recovery of SF₆. SF₆ is one of the six greenhouse gases listed in Kyoto protocol (1997), which is now signed

by 191 countries. Their ratification means they must track or at least evaluate SF₆ emissions into the atmosphere. The reporting of SF₆ emissions is strongly encouraged by states or supranational bodies like the EU. Large utilities and committed manufacturers currently report these data to their respective national environmental agencies.

In some countries, several utilities, grid equipment manufacturers, and SF₆ gas producers have signed voluntary commitments with state environmental ministries or agencies to reduce SF₆ emissions. This is the case in Japan, the USA, Germany, Spain, Switzerland, Norway and France.

Furthermore, the European Union has established the F-gas regulation in 2006, whose goal is to reduce unexpected emissions of SF₆. In its latest revision, EU517/2014, SF₆ is forbidden to be used for any purposes other than switchgear, or for military, medical, and particle accelerator applications. Reporting must comply with EU 1191/2014, which requires the reporting of emissions whenever they occur. The EU’s F-Gas regulation also introduced a mandatory switchgear labeling that must describe the quantity of gas inside the equipment and specifies the need for certified training for people participating in the SF₆ lifecycle (EU 2066/2015).

The mandatory recovery of all remaining SF₆ gas at the end of equipment life is also required in Europe. In other countries, including Korea, New Zealand, the US state of California, and the Canadian provinces of Quebec and Ontario, regulators only request SF₆ recovery at the end of life through an Emission Trading Scheme (ETS). In other countries, however, except for those who have signed a voluntary agreement, there are no legal obligations to recover SF₆.

⁹ Briefing Paper: SF6 and alternatives in electrical switchgear and related equipment, Oko-Recherche & RE-expertise, March 2020: https://ec.europa.eu/clima/sites/clima/files/docs/0106/2020_03_25_sf6_and_alternatives_en.pdf

¹⁰ T&D Europe position paper on SF6 and SF6 alternative technologies: <https://www.tdeurope.eu/component/attachments/attachments.html?id=1421>

¹¹ Siemens: Siemens enables climate-neutral, safe energy distribution with new Clean Air switchgear: <https://press.siemens.com/global/en/pressrelease/siemens-enables-climate-neutral-safe-energy-distribution-new-clean-air-switchgear>

¹² Schneider Electric: SF6-Free MV Switchgear Using Pure Air Nominated for Top Awards: <https://www.se.com/ww/en/about-us/news-room/news/press-releases/sf6-free-mv-switchgear-using-pure-air-nominated-for-top-awards-5efb270412574a776d5ed005>

¹³ EEC Engie Deploys Schneider Electric’s New Medium Voltage SF6-Free Switchgear Technology: <https://www.se.com/ww/en/work/products/medium-voltage-switchgear-and-energy-automation/news/2019/sf6free-ecengie-pilot.jsp>



Markets and regulation are on the move

Certain markets are already moving to transition away from SF₆, supported by business priorities, new legislation and the re-thinking of existing policies.

In the US, California is pioneering legislative action against greenhouse gas emission. In 2016, the California “Clean Air ACT”, SB32 was introduced, requiring a reduction of GHG emissions to 40% below the 1990 level by 2030, and 80% by 2050. The California Air Resource Board (CARB), is mandated to achieve this goal. Among other programs, a phase out of SF₆ has been proposed and discussed since 2017. The regulation is now in the final stage of drafting.

The European Union is making policy changes. In 2022 the European Commission proposed a detailed timeline for SF₆ phase out revisiting the F-gas issue since 2014, as stated in EU regulation No 517/2014: “No later than 1 July 2020, the Commission shall publish a report assessing whether cost-effective, technically feasible, energy-efficient and reliable alternatives exist, which make the replacement of fluorinated greenhouse gases possible in new medium-voltage secondary switchgear and new small single split air-conditioning systems and shall submit, if appropriate, a legislative proposal to the European Parliament and to the Council to amend the list set out in Annex III.”¹⁴ The proposal indicates from 1st January 2026 some new MV installations must be SF₆-free.

And in Germany’s environmental agency, the UBA, issued the following statement on their website in December, 2019: “The Federal Environment Agency is of the opinion that there are adequate alternatives for SF₆ in new medium-voltage switchgear (≤ 24 kV). We will therefore advocate a ban on SF₆ in new medium-voltage secondary switchgear

for these voltage levels with an appropriate transition period as part of the review of Annex III of the EU Regulation 517/2014.”¹⁵

Users of grid equipment are attracted to sustainability and anticipate coming policy changes that transition away from SF₆.

For a technology that has been trusted for decades, it’s important to understand the perception of users and buyers of SF₆-based MV switchgear.

According to a study by the Grenoble Ecole de Management (GEM)¹⁶, market players concur with achieving 2050 MV grid carbon neutrality and “seem to generally anticipate a decrease in the use of SF₆ technology”.

At the same time, the study’s survey respondents expressed interest in the environmental aspects of different MV switchgear technologies. Eco friendliness was identified as one of the most important purchase criteria for MV switchgear.

¹⁴ REGULATION (EU) No 517/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0517&from=EN>

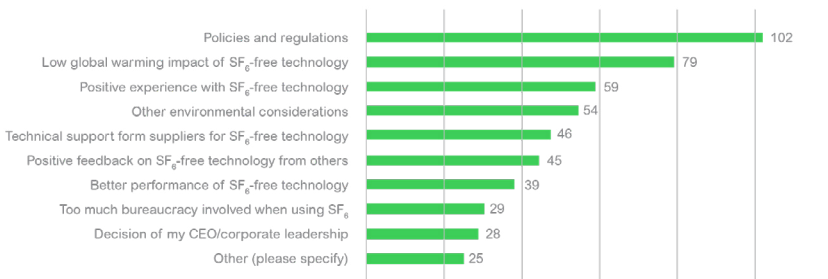
¹⁵ Umweltbundesamt, December 2019: <https://www.umweltbundesamt.de/en/topics/climate-energy/fluorinated-greenhouse-gases-fully-halogenated-cfcs/application-domains-emission-reduction/switchgear>

¹⁶ Empirical study investigating the environmental and socio-economic impact of SF₆ and its alternatives in medium voltage switchgear, Marie-Charlotte Guetlein and Carine Sebi, Grenoble Ecole de Management, May 2020: https://www.iee.fraunhofer.de/content/dam/iee/energiesystemtechnik/de/Dokumente/Projekte/f-gas-free/sf6_report_gem_final2.pdf



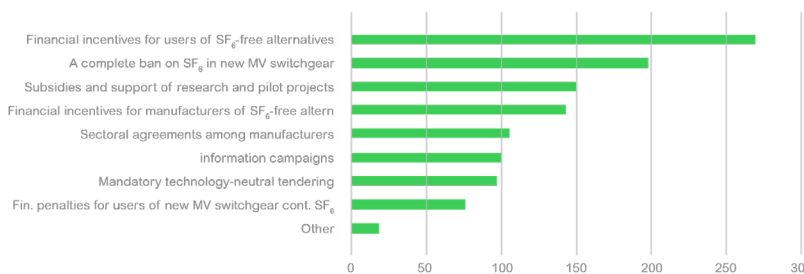
Survey results: Most important purchase criteria
Source: Grenoble Ecole de Management

GEM researchers concluded that European “customers for MV switchgear expect a decrease in use of SF₆ technology in the near future. This decrease, however, is expected to be primarily driven by policies and regulations, rather than technological change or prices.”

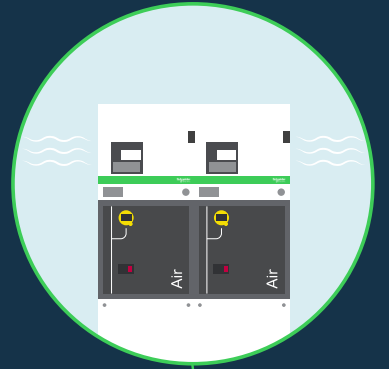


Survey results: Drivers for SF₆-free alternatives
Source: Grenoble Ecole de Management

While SF₆-free technologies are attractive, the study participants expressed concern about the cost premium linked to the environmental benefits of these technologies. Against this background, financial incentives like subsidies for certain users of MV switchgear and a complete ban on SF₆ are considered by respondents to be the two most useful policies to promote SF₆-free MV switchgear.



Survey results: Most useful policy tools in promoting SF₆-free MV switchgear
Source: Grenoble Ecole de Management



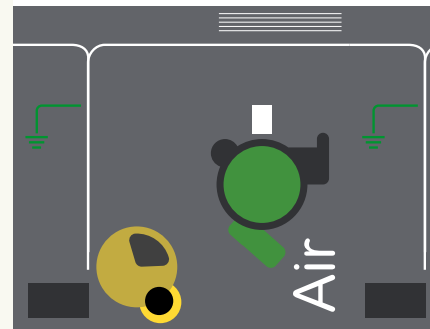
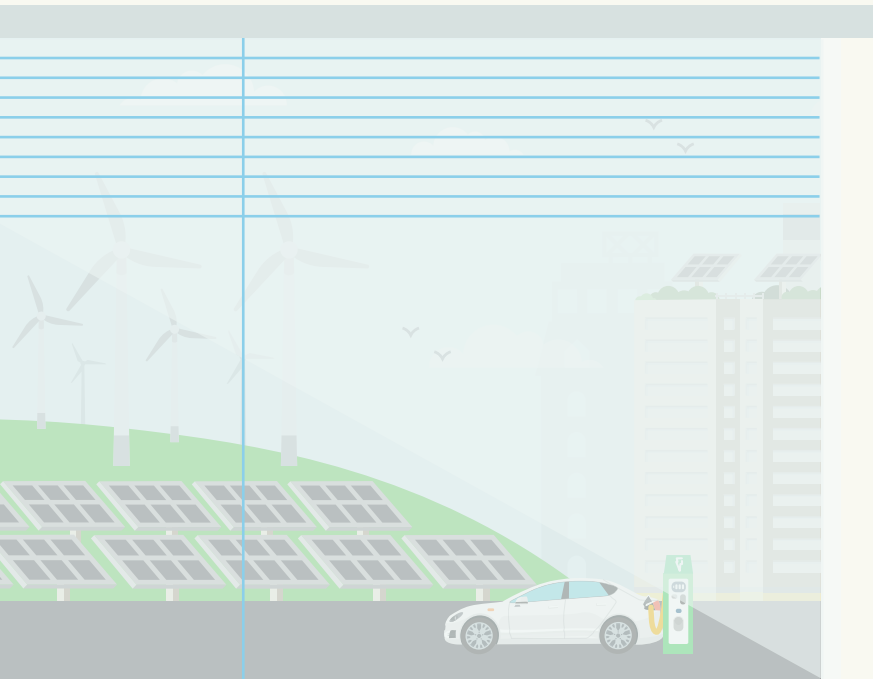
Conclusion

Together, SF₆ free and digital are a powerful force for decarbonization and efficiency

Digital technologies, including smart connected equipment and software, are an enormously impactful pillar of a cleaner future of electricity. Only digital can tame the complexity of modern electricity networks and the increasing levels of renewables and distributed energy resources joining their perimeters.

Furthermore, the transition to an SF₆ free future is now taking shape. The technologies, users, and stakeholders are ready. While a spark is certainly required to achieve the tipping point, this may come from the enabling policy actions that are foreseen, or from societal moves by individuals or communities. New SF₆ free equipment is also itself digital, further supporting the power of data to make networks smarter. By beginning the removal of a problematic greenhouse gas from existing networks, we can ensure that electricity, the most efficient form of energy, is minimizing its contribution to climate change.

Deployed in concert, connected digital technologies and environmentally sound SF₆ alternatives help realize the vision of a sustainable grid by supporting efficiency and grid decarbonization.



About the authors

Christophe Prévé is the Chief Technology officer of MV Switchgear Activity at Schneider Electric. He graduated from the Ecole Supérieure d'Electricité (SUPELEC) in 1988. He began his career at a Grenoble, France utility as an Electrical Network Operator and then as an Electrical Studies Man-ager. He joined Schneider Electric in 1994 in the Protection Relay Department as an Electrical Network Expert. He had the opportunity to write a book on "Protection of Electrical Networks" in Edition Hermès. In 1998, he moved to MV Switchgear Activity where he took different responsibilities in R&D. He is now responsible for new product development and new technology integration. He is also a lecturer at the ENSE3 Engineering School in Grenoble.



EON case study



GreenAlp case study



EEC Engie case study



Renault case study

Life Is  | **Schneider**
 **Electric**

Schneider Electric Industries SAS

35, rue Joseph Monier
CS 30323
92506 Rueil Malmaison Cedex
France

RCS Nanterre 954 503 439
Capital social 896 313 776 €
www.se.com

03-2023
ART960003

© 2023 - Schneider Electric. All Rights Reserved.
All trademarks are owned by Schneider Electric Industries SAS or its affiliated companies.
Document reference: DESW024EN

This document has been
printed on recycled paper

